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Enhancing the Travel Experiences of People with Visual Impairments through Application Design

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When current iOS applications or "apps" have met the basic requirements of visually impaired users, the discussion should be extended to address the higher-order needs such as self-esteem and self-actualisation. Beyond just focusing on the booking and navigation between different tourist sites, this study demonstrates how gamification assists in designing mobile applications that can enhance the tourism experiences of people with visual impairments. The study introduces a "research through design" project that incorporates app experiments, multisensory observations and interviews that are derived from sensory ethnography methodology. This research examines the perspective of applying gamification techniques to travel for people with visual impairments, which provides insights for government entities, social enterprises, and organisations which serve people with visual impairments. Ultimately, the results represent a further step towards developing advanced design research about people with visual impairments by proposing appropriate empathic insights and solutions regarding user experience design (UX), specifically in travel experience design.

School of Design,
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ENHANCING THE TRAVEL EXPERIENCES OF PEOPLE WITH VISUAL IMPAIRMENTS THROUGH APPLICATION DESIGN

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PhD

The Hong Kong Polytechnic University

2020

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School of Design

Enhancing the Travel Experiences of People with Visual Impairments through Application Design

HUANG Lusha

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

July 2019

CERTIFICATE OF ORIGINALITY

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____________________________________ (Signed)

HUANG Lusha (Name of student)

ABSTRACT

While current iOS applications, or “apps”, successfully meet the basic requirements of visually impaired users, the higher-order needs such as self-esteem and self-actualisation have not yet been sufficiently addressed by existing apps. Academic research that focuses on the different areas of psychological needs of people with visual impairments remains in its infancy. One such area is travel and tourism. This study demonstrates how gamification, a means by which game mechanisms are applied to non-game content, can assist in designing mobile applications that enhance the tourism experiences of people with visual impairments beyond merely the booking and navigation between different tourist sites.

The study introduces a “research through design” project that incorporates hybrid empathic design research and methods such as multisensory observations combined with interviews that are derived from sensory ethnography methodology. These methods when combined together have created a more empathic and intuitive application that caters for the tourism interests and needs of people with visual impairments in Hong Kong. Thematic analysis was also conducted, featuring a data analysis method which refers to systematically identifying, organising, and offering insights into patterns of themes among qualitative raw data. The material collected indicated ways in which engagement, motivation, and enjoyment could be increased using gamification elements. Agile app development was then adopted in the researchers’ design practices. The final app user testing session was then conducted in Hong Kong using 30 people with different levels of visual impairment, aged between 18 and 55.

The results of the user testing suggested that adding gamification elements into mobile applications has great potential for enhancing the emotions and experiences of people with visual impairments while travelling. The app experiments are the first to examine the perspective of applying gamification techniques to travel for people with visual impairments.

This research will benefit the visually impaired community by providing its members with more meaningful travel experiences. As such, the research provides insights for government entities, social enterprises, and organisations serving people with visual impairments. The study results represent a further step towards developing advanced design research about people with visual impairments by proposing appropriate empathic insights and solutions in regard to user experience design (UX), and specifically in terms of travel experience design.

Keywords: *Gamification, Travelling Experience Design, Application Design, Empathic Research, Sensory Ethnography*

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as a top ophthalmology professor, has cured thousands of patients' illness with their eyesight.

Lusha Huang

July 2019, Hong Kong

CONTENTS

CHAPTER 1: INTRODUCTION

This chapter offers a brief overview of this research and is organised into six parts. They are my personal motivation for conducting this study; the research questions that identify the problem; the context and scope of this research; the objectives of the research; the contribution and significance of this research to the design of travel applications (apps) for people with visual impairments; and a summary of the major content in each chapter of this dissertation.

1.1 Personal Motivation

There is a specific personal background to this study. I was raised by my grandparents in their home in mainland China. My grandfather was a prominent professor of ophthalmology, specializing in ocular fundus diseases. I witnessed hundreds of patients making a special trip to my grandfather's home, and I continually observed the profound appreciation expressed by his patients after their vision had been restored. It made me realise how critical the faculty of sight is to everyone, and it raised my awareness of the suffering faced by those people with visual impairments.

Having graduated from the School of Visual Arts in New York City with a master's degree in interaction and industrial design, I was previously an industrial designer, creating consumer products for companies such as Belkin and Polycom at Pip Tompkins Studio in Los Angeles. On a business trip to the Consumer Electronics Show (CES) in Las Vegas, I encountered hundreds of electronic products which were being presented at the show. It made me realise that designers have to invest considerable effort into creating products that enhance the quality of life of consumers. However, only a relatively limited number of products are designed specifically for people with visual impairments. Thus, this motivated me to assess the demands of people with visual impairments with a view to bringing enjoyment and fulfilment to them. This would also address the issue of the reduced quality of life they currently have in comparison with sighted individuals.

From a general need perspective, the primary need for visually impaired people is accessing information (Pal et al., 2011). Academic research that focuses on the different areas of psychological needs of people with visual impairments remains in its infancy. One such area is travel and tourism. From a travel need perspective, the crucial need is accessing accurate and reliable information about the destination. The information plays an essential role in planning and having a pleasant trip, such as accessibility of accommodation and accuracy of information (Packer, Mckercher, & Yau, 2007; Marston, 2002).

The assistive technology such as white canes, mobile phones, and screen readers enables people with visual impairments to approach information, with full integration and inclusion in society (Scherer, 2005; Foley & Ferri, 2012). This study focuses on mobile phone application design. There are several reasons to choose mobile assistive technology. Firstly, an application is affordable and accessible for the target users. Secondly, the mobile phone offers information access "almost any time and in any place" (Billi et al., 2010, p. 3). Most importantly, since the Hong Kong Government wishes to foster an inclusive society (GovHK, 2017), a mobile phone that is embedded into a mainstream device can assist individuals to feel less labelled or stigmatised. To study how iOS applications can be better developed and to address the aspirations of the visually impaired, it was necessary to identify the psychological aspects of visual impairment.

One of the most influential theories for understanding human beings' motivations is called the "hierarchy of needs" (Maslow, 1943). Although some studies mention that a small number of Maslow's schemes have an insufficient empirical grounding in underdeveloped and developing countries, according to Fallatah and Syed (2018), Maslow's theory has been widely addressed and practised in developed contexts and organisations. As Hong Kong is highly developed region, ranking 7th on the Human Development Index list (United Nations Development Programme, 2018), Maslow's hierarchy of needs can be considered suitable for this content.

The model proposes five levels of human needs. Maslow claimed that human beings are triggered to fulfil specific demands and that some demands take precedence over others. This hierarchy forms a five-tier model from bottom to top, as seen in *Figure 1.1* below, consisting of physiological, safety, belongingness and love, esteem, and self-actualisation needs.

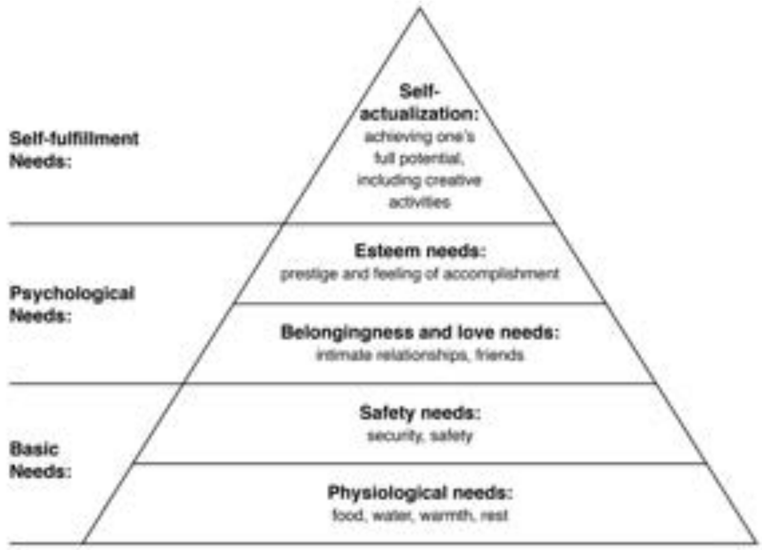


Figure 1.1. Maslow's hierarchy of needs (adopted from Maslow, 1943)

The most basic needs for a human being are physiological needs, which form the first motivation for people's behaviour. People will pursue the next level, once the current level is fulfilled. While current iOS apps successfully meet the basic requirements of visually impaired users (e.g. navigation and object recognition), the higher-order needs (such as their social needs, namely friendship, intimacy, trust and acceptance, offering and receiving love) have not yet been sufficiently fulfilled by such software. In particular, these needs include esteem needs, such as independence, mastery, dominance, achievement, prestige, status, and respect; and their self-actualisation needs such as self-fulfilment, developing personal abilities, and pursuing personal growth. In this domain, studies that focus on the psychological needs of people with visual impairments have so far been insufficient in Hong Kong. The shortcomings of the apps and the challenges will be covered in the Existing Mobile Applications in *Section 2.2*. This research aims to address these insufficient studies in this vital area.

This investigation is substantiated on the ground that people with visual impairments should have an equal quality of life and rights to citizenship as nondisabled people according to the United Nation's Standard Rules on the Equalization of Opportunities for Persons with Disabilities (1993). The United Nations (2006) outlined the rules to include the right to tourism and travel in the Convention on the Rights of People with Disabilities (CRPWD). Based on the UK and Australian anti-discrimination law, the Hong Kong government introduced the Disability Discrimination Ordinance in 1996. As Tourism for All UK (2009) reports "Tourism is important to our lives, giving us something to look forward to, time to enjoy our families, a chance for adventure, we believe that it is the right of disabled people to participate in all areas of community life. Few areas are more important, or valued, than Tourism and Travel - which restore our energies, broaden our minds and serve our deepest human instincts to explore new places and to enjoy and share new experiences."

With the steady growth of Hong Kong's economy as well as in people's living standard, increasing importance has been attached to raising the quality of life in the visually impaired community. Among others, the Hong Kong Government gives special consideration to visually impaired people regarding their requirements and civil rights, is responsible for granting a full range of support services for the disabled, and has endeavoured to build an accessible living environment and promote their full integration into society. In the past few years, the recurrent expenditure has been increased from $16.6 billion in 2007 to $30.7 billion in 2016, an increase of 85% and the recurrent expenditure further increased to $31.5 billion in 2017 (GovHK, 2017). Besides the various departments of the Hong Kong Government, other organisations such as the Hong Kong Jockey Club and individuals are supporting the visually impaired community in Hong Kong, as well as several charity foundations, private donors, along with corporate volunteers. Regarding app development, the Hong Kong government invested HK$0.5 billion in the Innovation and Technology Fund for better living (FBL) to make the daily living of disabled people more convenient, comfortable and safer. Under the Funding Scheme for Digital Inclusion Mobile Apps, there are two apps, namely *SESAMI* (2013) and *Tap My Dish* (2017) that aim at helping people with visual impairments. The *SESAMI* can offer indoor and speech map information. The other app can provide speech augmented food menu information for people with visual impairments funded by the Hong Kong Blind Union. The mentioned two apps only focus on meeting the basic needs, such as navigating and object recognition, of people with visual impairments. Therefore, an app that can fulfil psychological needs, such as travel and tourism, of people with visual impairments, should be developed.

1.2 Research Questions

The key research question is: **How can the travel experience of people with visual impairments be enhanced through a mobile application?** The preliminary research in this area led me to choose travel experience as the main concern of this study. This decision drew on the findings in the literature and preliminary interviews conducted before the main study. Travel appeared to be an activity for which people with visual impairments lack support (see Chapter 4).

The main research question is supplemented with the following four sub-questions:

1. **What is the current situation of people with visual impairments using assistive products in general and travel apps in particular in Hong Kong?**
2. **How can researchers better understand the needs of people with visual impairments?**
3. **How do people with visual impairments use their non-visual senses to engage with the world, particularly when travelling?**
4. **What is the best way to design mobile-assisted apps in order to enhance the travel experience of people with visual impairments?**

1.3 Scope of the Study

Based on a report by the World Health Organisation (2018), there are 1.3 billion people with visual impairments worldwide, consisting of 36 million totally blind while those who have low vision make up 246 million. According to the WHO (2018), visual impairment, also called vision loss, refers to someone who has decreased ability to see, which is not correctable by usual methods, for example spectacles, and using specialised assistive tools in the long run. Notwithstanding this, visual impairments do not include nearsightedness, farsightedness, astigmatism, or presbyopia. There are various levels and groups of vision impairment that are based on measuring visual acuity and visual field. In 2018, the International Classification of Diseases (ICD) 11th Revision identified the following two types of classifications of visual impairments: distance and near presenting visual impairments (see *Table 1.1*).

Table 1.1. Classifications of visual impairment

Distance vision impairment	
Level	Visual Acuity
Blindness	Worse than 3/60, 1/60; no light perception
Severe	Worse than 6/60
Moderate	Worse than 6/18
Mild	6/12 but equal or better than 6/18
Near vision impairment	
Level	Visual Acuity
Near	Worse than N6 or N6 at 40cm* with existing correction

Distance vision impairments:

The subsequent categories of visual impairments depend on the distance over which normally sighted people can see letters on the Snellen chart (see *Figure 1.2*).

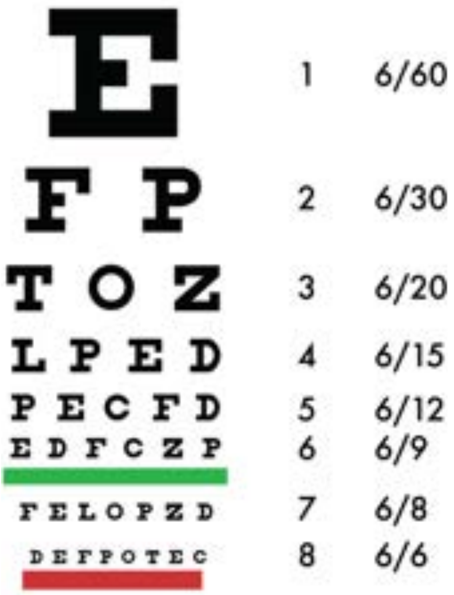


Figure 1.2. Snellen chart

Consequently, the further the distance, the worse the sight condition. Total blindness or total visual impairment means no light perception or visual acuity of less than 3/60. Severe sight impairment equates to visual acuity of less than 6/60 on the Snellen chart. This means that individuals with normal vision can view items from 60 metres, whereas a person with sight impairment can recognise these items within 20 metres. Moderate impairment means visual acuity of less than 6/18. Mild impairment indicates visual acuity of less than 6/12. Near vision impairment indicates a visual acuity of less than M.08 or N6. Low vision, which presents as moderate visual impairment together with severe visual impairment, blindness and low vision are considered visual impairment. Regarding the statistics of people with visual impairments in Hong Kong, built on the Special Topics Report No. 62: Persons with disabilities and chronic diseases announced by the Hong Kong Census and Statistics Department (2014, p. 28), there are about 174,000 people with visual impairments in Hong Kong, comprising 2.4% of the total population (2014) (as shown in *Table 1.2* below).

Table 1.2. Persons with seeing difficulty by the degree of severity in Hong Kong (Hong Kong Census and Statistics Department in 2014)

嚴重程度 Degree of severity	人數 No. of persons ('000)	百分比 %	佔整體人口的百分比 As % of total population
完全失明@ Unable to see at all@	7.8	4.5	0.1
需要配戴特別助視器^才能看得到*# Required a specialised visual aid^ in order to be able to see*#	49.5	28.3	0.7
不需要配戴特別助視器# Not required a specialised visual aid#	117.5	67.2	1.6
總計 Total	174.8	100.0	2.4

註釋：
@ 包括那些只感覺到光或影的視覺有困難人士。
^ 包括低視力眼鏡、放大鏡及望遠鏡等，但不包括一般近視、遠視、散光或老花等眼鏡／隱形眼鏡。
* 包括那些表示配戴特別助視器後情況仍沒有改善的視覺有困難人士。
# 以較好的一隻眼計。

Notes:
@ Including those persons with seeing difficulty who can only perceive light or shadow.
^ Including glasses for low vision, magnifier, telescope, etc, but excluding glasses or contact lenses for nearsightedness, farsightedness, astigmatism or presbyopia.
* Including those persons with seeing difficulty who indicated that no improvement could be made even with a specialised visual aid.
# Referring to the situation of the better eye.

However, it was declared by South China Morning Post (Ngo, 2015), that this number is probably a serious underestimation since the data were collected only through the General Household Survey. Therefore visual impairment arguably concerns a significant growing segment of our population.

Table 1.3. General information of people with visual impairments in Hong Kong

Sex of people with visual impairments		
Male:	71,200 people (40.7%)	
Female:	103,600 people (59.3%)	
Age distribution of people with visual impairments		
Age 15 and under	1,300 people (0.8%)	
Age 15-29	3,100 people (1.7%)	
Age 30-39	1,400 people (0.8%)	
Age 40-49	6,200 people (3.6%)	
Age 50-59	14,200 people (8.1%)	
Age 60-64	14,700 people (8.4%)	
Age 65-69	19,500 people (11.1%)	
Age 70 and above	114,400 people (65.4%)	
Educational attainment of people with visual impairments		
No schooling/ Pre-primary	54,500 people (29.5%)	
Primary	69,500 people (39.8%)	
Secondary/ sixth form	40,700 people (23.3%)	
Post secondary	Non-degree	4,500 people (2.6%)
	Degree	8,600 people (4.9%)
Acitivity status of people with visual impairments		
Economically active	17,500 people (10.1%)	
Economically inactive	156,000 people (89.9%)	
• Retired persons	125,300 people (72.2%)	
• Home-makers	11,700 people (6.7%)	
• Students	1,400 people (0.8%)	
• Others	17,500 people (10.1%)	
Employed person with visual impairments by industry		
Manufacturing	2,000 people (11.7%)	
Construction	700 people (4.2%)	
Import/export trade and wholesale	1,600 people (9.9%)	
Retail, accommodation and food services	3,100 people (18.8%)	
Transport, storage, postal and courier services, information and communication and communications	2,100 people (12.6%)	
Financing, insurance, real estate, professional and business services	3,200 people (19.3%)	
Public administration, social and personal services	3,800 people (23.0%)	
Employed person with visual impairments by monthly employment earnings		
Less than HK$4,000	2,000 people (12.0%)	
HK $,4000 - HK $6,999	2,200 people (13.4%)	
HK $7,000 - HK $9,999	4,200 people (25.3%)	
HK $10,000 - HK $14,999	2,900 people (17.5%)	
HK $15,000 - HK $19,999	1,800 people (10.5%)	
HK$20,000 and above	3,600 people (21.4%)	

Table 1.3 above illustrates that people with visual impairments have poor living conditions, a low level of education, and low income. Although the Hong Kong Government puts effort into increasing the life quality of people with visual impairments, the statistics above reminded me to design affordable products.

The different levels of visual impairments, including blindness, severe, moderate and mild were all considered in this research project. Arguably, however, a person who becomes blind later in life has a different experience with visual impairment than someone who has been blind from birth (Richards, Pritchard, & Morgan, 2010). Sardegna et al. (2002, p. 29) further categorised blindness into two main types, congenital and adventitious, defined as follows: "Congenitally blind refers to an individual blind at birth or during the first five years of life. A congenitally blind child may not have visual memory while adventitiously blind refers to an individual who becomes blind after five years of age. This individual will probably have some visual memory and can use visualization." These two types of blindness are considered in this study, too. Therefore, in the recruiting process, these two types of blindness should be included, and while conducting the interviews, the similarities and differences between these two types of blindness should be sought out.

This study concentrated on people with visual impairments aged between 18 and 55 in Hong Kong. I chose this age range based on the following considerations: 1) they can afford the travel fee, 2) they are likely to go out and travel, 3) they can travel independently, and 4) most of them utilise mobile phones. Therefore, a mobile application was likely to benefit their independent travel.

Google surveyed how 500 people aged between 18 and 64 took their cellular phones when travelling in October 2016. The study found that mobile applications have become a critical guide before, during, and after their travel. There are two insights about how the apps in phones make travel decisions that need to be emphasised. First, smartphones are travel guides. Before and during their trip, more than half of smartphone users generally search for discounts and researching pursuits to do. Second, apps are for convenience and loyalty. Travellers depend on mobile sites and apps with both respective purposes. Mobile sites are applied to explore activities, while apps are often used to access digital boarding passes and record loyalty programmes. The scope will be enhancing visually impaired people's use of mobile app experience in the iOS system to enrich their quality of life by adding encouraging elements. I chose the Apple platform because, compared to Android, the accessibility technology, such as voiceover, is much more advanced. The iOS accessibility features will be introduced later in *Section 2.1.8*. Moreover, an officer in the Hong Kong Blind Union stated that the majority of people with visual impairments in Hong Kong use iPhone. While no official statistics are publicly available, the officer provided a compelling fact that the Hong Kong government announced a subsidy policy for people with visual impairments to encourage them to buy mobile phones. The subsidy policy provides 100 quotas that waive 2,000 Hong Kong Dollars for those people with visual impairments wanting to buy a mobile phone. Ninety people with visual impairments chose to purchase iPhones, and only ten bought Android mobile phones. Since there are more people in this group using iPhones, it is, for instance, easier for the new phone holders to ask their peers for help when facing technical issues. For the range of digital experiences within the scope of my investigation, I will express concerns about the facilitation of travel for people with visual impairments.

"Travel" is defined as leaving home for an unfamiliar place for pleasure locally and abroad (Packer et al., 2007). "Travel experience" in this study focuses on leisure motivation, because business travellers often cannot decide their destinations or activities (Xu, Tian, Buhalis, Weber, & Zhang, 2016) even though business travellers may explore their business destination, too.

"Travel experience" is understood inclusively to contain not only the actual day-to-day events and feelings of the vacation but also the pre-travel period, which includes the planning, purchasing of travel products and anticipation of the event itself. Also, the traveller will, at the end of the vacation, carry with him or her the memories and feelings associated with the journey. Therefore, the travel experience can be divided into five stages: research and planning, booking, transportation, visiting and post-travel. Google (2018) found that mobile app usage spans travellers' entire journey, from booking to shopping, to the ways they utilise portable devices at their destination. Furthermore, the findings reveal that more than 70% of American travellers admit that they "always" use their mobile phones when travelling. Travellers nearly always take their mobile devices to explore attractions or activities, to discover restaurants and shops, or to navigate directions. For the range of travel experiences, the study focuses on the facilitation of travelling for people with visual impairments. In this study, regarding travel, it focuses on the actual visit experiences in particular (see *Figure 1.3*).

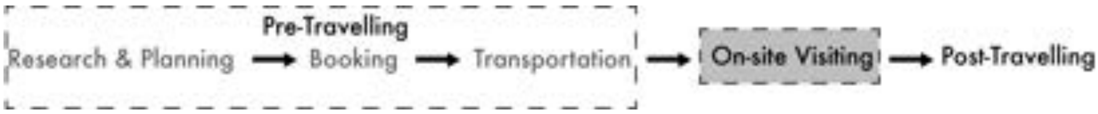


Figure 1.3. The travel experience process

Stephen Kuusisto, the blind-from-birth poet and scholar, often mentions that sighted people love to ask "Why travel anywhere if you cannot see?" (2006: preface, x). This underestimates severely how much pleasure a visually impaired person can derive from a holiday. In his book Eavesdropping, Kuusisto (2006) describes a world of soundscapes, which a sighted person barely notices. He vividly describes how he has used his other senses in places as varied as Venice and Iceland, and although he can only see a little bit, he described clearly how colourful the sensory experience of travel could be for him. Tourism is normally described as a form of pleasures and senses such as sounds, smells, tastes, touches, and sensations. We experience the world by using our sense organs – for example – and research proves that smell and taste are paramount in the tourism experience (Dann & Jacobsen, 2003). Indeed, smells and tastes (both pleasant and unpleasant) evoke memories and are often synonymous with the places people have visited and the tourist experience could be considered as a sequence of embodied activities that involve different senses. The smell of food vendors, the taste of exotic foodstuffs, the call of seafowl, and the coolness of the wind on your skin are all typical memories of holiday moments.

Many visually impaired people can use their remaining vision and compensate it by their other senses (specifically touch and hearing) and their kinaesthetic skills (the capacity to feel and sense). Thus, they can feel the wind and coldness while on holiday in the mountains; experience the sensations of swimming in the sea or a pool; and feel the different textures and surfaces at museums and historic sites. As will be discussed in the following section, however, although there are significant benefits and enjoyment to be gained from travel, there are also genuine problems and challenges that arise when society and the tourism industry, in particular, fail to understand the needs and requirements of individuals who have bodies that differ from mainstream "norms".

Richards, Morgan, Pritchard, and Sedgley (2010) suggest that individuals with visual impairment have three main barriers with respect to tourism. These barriers are:

- individual barriers (independence, emotional, psychological);
- social barriers (decision makers and awareness);
- environmental barriers (transport, accessible information, physical access).

In this study, the main focus was the individual barriers, which means, besides making travel independent for them, the goal is also to assist them to learn about the environment and interacting with the local people independently with more ease. I created two versions of an app for them. I designed the functions of the apps with visually impaired participants in mind, and therefore, applied a model of "participatory design research".

1.4 Objectives of the Research

It is worth remembering that people with visual impairments have the capabilities to do what their sighted counterparts can. For instance, people with visual impairments travel on the Mass Transit Railway (MTR) but need to adopt different cues for moving in space and knowing where to get off. Therefore, it is imperative to enrich the life experience of people with visual impairments and help them to build their perception. In light of the stated research gap and the research questions, the objectives of this research were as follows:

- to help people with visual impairments to improve their quality of life
- to employ the methods from sensory ethnography methodology (Pink, 2015) and empathic design research (McDonagh & Thomas, 2010) to uncover the real-life anecdotes of people with visual impairments and to explore their actual needs in travel contexts
- to develop an empirical approach rooted in sensory ethnography in order to rethink the empathic design research, specifically in people with visual impairment fields
- to assess and determine the needs of people with visual impairments in order to provide creative solutions to enhance the mobile-assisted travel experience of people with visual impairments (the instinctive ability to ascertain the feelings and thoughts of people with visual impairments in order to determine their actual needs and values was fundamental to the success of this research project)
- to offer an empirical method for user experience (UX) and user interface (UI) designers in the accessibility content

1.5 Contribution and Significance of this Research

This investigation provides an exciting opportunity to increase our knowledge of enriching the tourism experience and creating an emotional experience for people with visual impairments. The present study will contribute to filling both the research gap and products gap about people with visual impairments in the field of app design generally and in travel-supporting apps specifically. This new knowledge can contribute to enhancing design research about people with visual impairments in two areas: game design and app design. Ultimately, the findings can contribute to the identification of more suitable empathetic solutions. For instance, hypothetically, it could direct "user interface" (UI) and "user experience" (UX) designers for digital products to use empirical methods that would evoke more appropriate design solutions and enable the products to be more approachable for people with visual impairments.

A further point is that the visually impaired community will derive a benefit in the economic aspect of ensuring digital products are more affordable from this research. These findings are relevant to both policymakers and practitioners who can provide solid empirical confirmation to the government, organisations and social enterprises serving people with visual impairments. In addition, these research results represent a further step towards developing advanced design research for people with visual impairments by providing appropriate empathic insights and solutions. Finally, the findings of the study can make a contribution to the academia in tourism and travel research, gamification research, user experience design research and disability studies. Regarding the research methodology, the research shows how empathic design research and sensory ethnography can be used by people with disabilities.

1.6 Structure of this Dissertation

This dissertation is organised based on the applied research methodology. It is organised into six chapters, namely introduction, related research and applications, methodology, design apps, findings, and conclusion. The following presents a brief outline of each chapter.

Chapter 1 Introduction outlines the research by briefly discussing the personal motivation, which emphasises the knowledge gaps for this study. This is followed by raising the research questions. The scope of the study, objective, and the significance of this research have also been presented.

Chapter 2 Related Research and Applications provides a comprehensive review of key terminologies and further reveals the related research and apps in both theoretical and empirical studies. Related theoretical frameworks, that can be used for designing better-gamified apps will be identified in this chapter.

Chapter 3 Methodology examines the methodological aspects pertaining to this research. This chapter first presents a reflection on the empathic design research approach, and then represents the research methodology design, which is organised into two sections, namely secondary and primary research: research through design.

Chapter 4 Insights into the Target Audience presents an analysis of the findings and discusses issues worthy of concern. This chapter also identifies the potential of gamification for people with visual impairments, as suggested by the findings and analysis. The accessibility guidelines and regulation for designing and developing mobile applications, both internationally and Hong Kong specific, will be presented last.

Chapter 5 App Design Experiments delivers the process of designing the gamified travel apps for visually impaired people, which includes user journey maps, feature design and user interface. This chapter also assesses the principal findings of the interviews with app testing.

Chapter 6 Conclusions summarises the research with a summary of the findings. The significance, implications, and limitations of the study are addressed in this chapter. This chapter also provides potential guidance for future research on the subject matter of designing better app experiences for people with visual impairments.

CHAPTER 2: RELATED RESEARCH AND APPLICATIONS

This chapter establishes the current research gap and links my research with existing research and design practice. This chapter focuses on reviewing and understanding the terminology related to visual impairment. The way in which the theoretical frameworks can be used for designing better applications will also be identified. The literature review links to different parts of this dissertation. References to the research reviewed in this chapter will appear in other chapters when necessary.

2.1 Key terminology

The essential highlight of this chapter is to identify and define the related terminology of this project, which branches out into seven areas of experience, experience design, emotion, motivation, gamification, audio description, and assistive technology, and to discuss the research in these areas.

As Pine and Gilmore (2011) maintain, the tourism industry is primarily an experience industry. As a consequence, literature on experience production could be included in this research project. Studies on experience design will be discussed later. Since gaming and gamification have robust links with psychological theories, motivational and emotional psychology will then be presented respectively. A discussion of defining the term gamification and gamified design process models based on psychological theories will be presented later. Then gamification in tourism will be introduced. The definition of audio description subsequently will be followed. After that, the assistive technology will be discussed. Then assistive technology for people with visual impairments will be discussed. The last section includes an examination of the current mobile applications in the area of people with visual impairments.

2.1.1 Experience

According to Gelter (2006), the word "experience" has a dual meaning. The first meaning, Erfahrung (in German), is used in the sense of "the knowledge or skill acquired by a period of practical experience of something" (Gelter, 2006, p. 25). The second meaning as described by Erlebnis (also in German) refers to "an event or occurrence, which leaves an impression on someone" and "encountering or undergoing an event or occurrence" (Ibid., p. 25). In terms of experience design, this dissertation prefers the latter definition, because the study does not focus on practical knowledge building but enhancing the emotional and psychological feelings of people with visual impairments.

The existing theories of experience have been divided into three categories of discussing experience: "experience", "an experience", and "experience as story" (Forlizzi & Ford, 2000). Firstly, "experience", according to cognitive scientist Carlson's Experienced Cognition theory (1997), is "the constant stream that happens during moments of consciousness". The second way to describe experience is referred to as having "an experience", according to the philosopher Dewey's book *Art as Experience* (2005, p. 30). "This type of experience has a beginning and an end, and changes the user, and sometimes, the context of the experience as a result. An example of an experience is encountering a story that enables us to feel powerful emotions, assesses our system of values, and makes changes in our behaviour." Another way to express experience is to consider "experience as story", a concept proposed by artificial intelligence theorist and cognitive psychologist Schank (1995). "Experience as story" is naturally conversational, and it involves discussing user findings with a research team of different subjects. Therefore, "experience as story" is vital in events as diverse as fantasy gaming. The term "experience" will be used in this project to refer to "an experience", and "experience as story". Later, a paper called "Welcome to the Experience Economy" (Pine & Gilmore, 1998), asserted that the new primary economic offering in advanced industry would be no longer represented by services (as in the service economy), commodities (as in the agrarian economy), or goods (as in the industrial economy), but by staged experiences (see *Figure 2.1*).

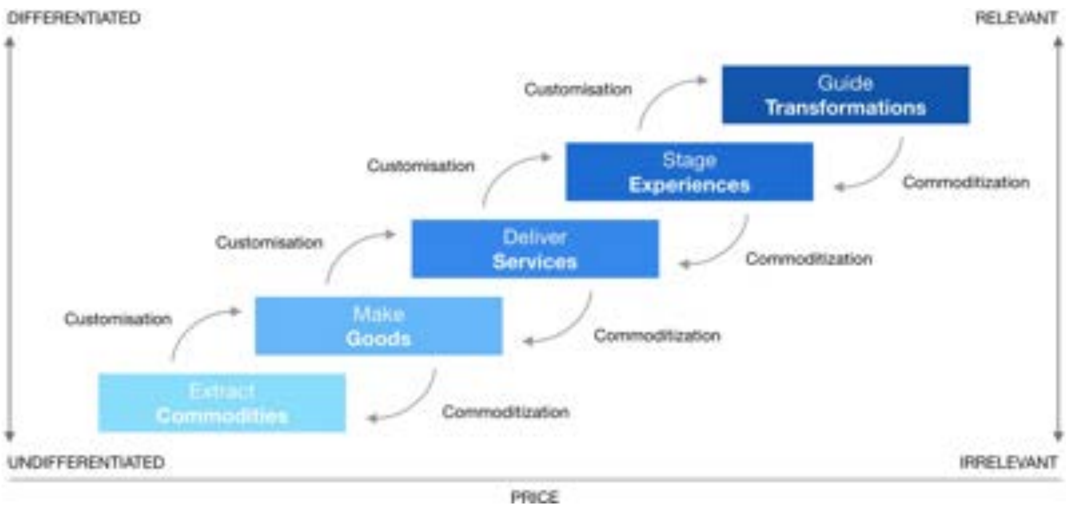


Figure 2.1. The progression of economic value (adapted from Pine and Gilmore, 1998)

There are five principal dimensions of experience economy (Gelter, 2006) as follows:

- the general experience industry: with a focus on development, trends, socio-cultural aspects
- the experience producer: which concentrates on entrepreneurship and product management
- experience production: which studies the production process, such as how to design experiences, product development, and process management
- the experience product: referring to marketing, selling, and pricing
- the experience of the guest: concerning material immaterial aspects of the experience field, and categories and qualities of experiences

From the above five categories, this research emphasised the third component, experience production. The realm of experience production is broad. I will further focus on digital experience, specifically, which is about the interaction between a user and a device that is possible only because of digital technologies. Digital experience is still a broad category that involves many digital channels, including mobile phones, websites, and other smart digital products. In this project, the digital experience in iOS applications will be the primary concern due to the powerful features in the iPhone. Compared with other assistant tools for people with visual impairments, the mobile phone is lightweight and portable, and therefore easy to bring along no matter where one travels.

Travel experience has several steps (as mentioned in *Section 1.3*), and this research mainly examined how people with visual impairments explore their surroundings when they arrive at their destination. In their study to determine the quality of the travel experiences of people with visual impairments, one of the few to categorise these experiences, Small, Darcy and Packer (2012) found that there are four main factors, namely, "the access to information", "the knowledge and attitudes of others", "the experience of wayfinding" and "travelling with a guide dog" (p. 941). One of the most substantial current discussions regarding tourist experiences of visually impaired people is navigation. To fill the knowledge gap, I mainly focus on "the access to information" which contributes towards a positive experience as visually impaired tourists can better engage with tourist attractions (Small et al., 2011, p. 945). Small et al. (2011) also highlighted factors that are associated with comprehending the multi-sensory nature of the tourist experience for visually impaired tourists.

2.1.2 Experience Design

According to the American Interaction Design Foundation (2002), "experience design" is the procedure of designing products that deliver significant as well as appropriate experiences to users. The principal methodology used to create experience design is user-centred design. The term "user experience" or "UX" is related to "user experience design". User experience design refers to creating the ideal experience of using a product or service. In the Human-Computer Interaction (HCI) field, the term user experience design is used on the subject of websites and applications. Over the last few years, the domain of HCI has received increasing interest from the experiential perspective of the evaluation of interactive products rather than product qualities (Hassenzahl, 2010).

Pullman and Gross (2004, p. 551) defined experience design as a method "to create an emotional connection with users through careful planning of tangible and intangible service elements". The prominent experience design expert Norman (2004) emphasises the value of emotion to the user experience design. The description of the emotion in experience design will be introduced in *Section 2.1.4*. Successful experience design has been described as aiming to combine interactivity, emotional content, personal meaning and the five senses together (Moritz, 2005). User experience design and game design are both forms of HCI and centrally concerned with experience design. User experience design and game design becoming intertwined (Ferrara, 2012).

2.1.3 Gamification

Based on MIT professor Malone's research (1980), Deterding, Khaled, Nacke and Dixon (2011) proposed gamification amongst the past experiments of games to adopt games as inspiration for experience design. In addition to this work, Preece, Rogers and Sharp (2015) have proposed from an HCI perspective that products could be emotionally fulfilling, aesthetic, enjoyable, fun, pleasing, and entertaining. In the Adobe UX/UI report, gamification was one of the most critical user experience design trends in 2017 (Babich, 2017).

Persuasive technology is created to change, shape or reinforce the attitude or behaviour or both of users without using the means of deception or coercion (Bogost, 2007). Persuasive applications are often information systems or digital software (Oinas-Kukkonen & Harjumaa, 2008). Currently, gaming and gamification can be regarded as persuasive technologies. Pelling, an owner of a British consultancy for developing game-like interfaces for electronic gadgets, was the first one to introduce the term gamification, as "applying game-like accelerated user interface design to make electronic transactions both enjoyable and fast" (2002, p. 1). A broad and popular definition of gamification is "the use of game design elements in non-game contexts" (Deterding et al., 2011). What is striking in this Google Trends graph is the phenomenal growth of searching queries of gamification worldwide starting from 2010 and remaining popular (see *Figure 2.2*).

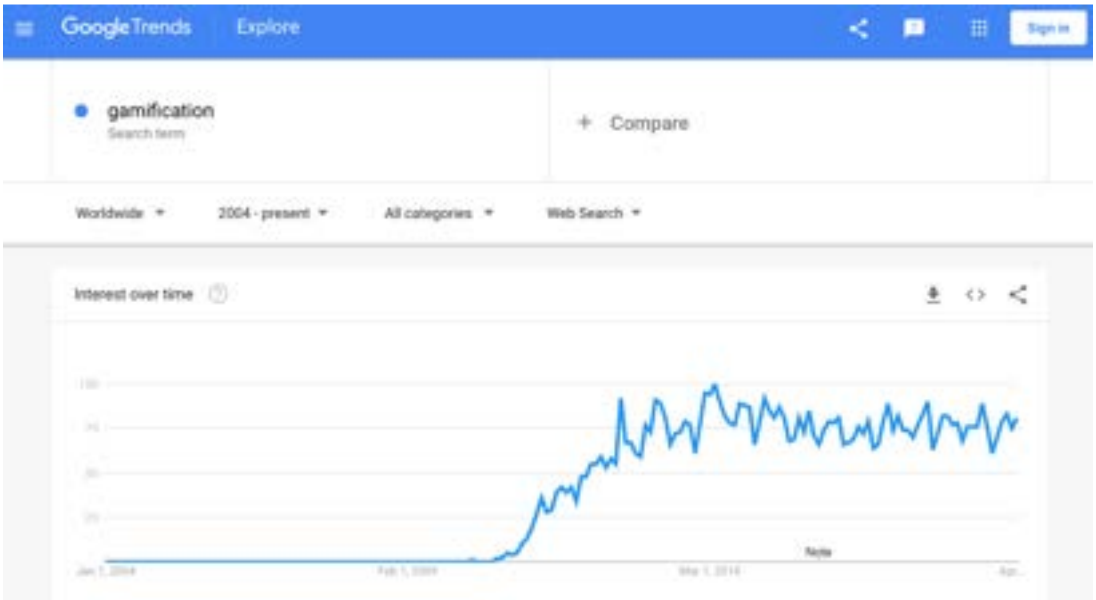


Figure 2.2. Google Trends in gamification

In recent years, gamification has been a trending subject as a way to enhance user engagement and motivation while increasing social interaction (Hamari, 2013). As a consequence, gamification is widely discussed as the next-generation strategy for business, and customer engagement (Zichermann & Cunningham, 2011). It has also been widely adopted in different contexts, for instance, education, wellness and health (Hamari et al., 2014; Seaborn & Fels, 2015). In the educational context, the goal of the gamified systems could be to reinforce students' engagement by encouraging their motivation to read the class materials and participate in class (O'Donovan, Gain, & Marais, 2013). Furthermore, in the wellness and health context, the goal of a gamified application is to raise people's health awareness or physical fitness by motivating them to complete sports exercises (Slomski, 2017; Patel, Benjamin, Volpp, Fox, Small, & Massaro, et al., 2017). For instance, the gamified application *Zombies, Run!* (2012), adopts an engaging story of a zombie chasing the player. In order to escape from the zombie, the player would obtain supplies from different locations.

Gartner Consulting (2011), a global technology research company, argues that over half of innovative enterprises will implement gamification by 2015. McGonigal (2011) posits that compared to the real world, the game spaces can offer a persuasive experience, which people cannot have in real life. There are some debates on the similarities and differences between video games, rewards programmes, serious games, and gamification. Video games, rewards programmes, serious games, and gamification engage people on very different stages, while they have entirely various objectives (see *Figure 2.3*).

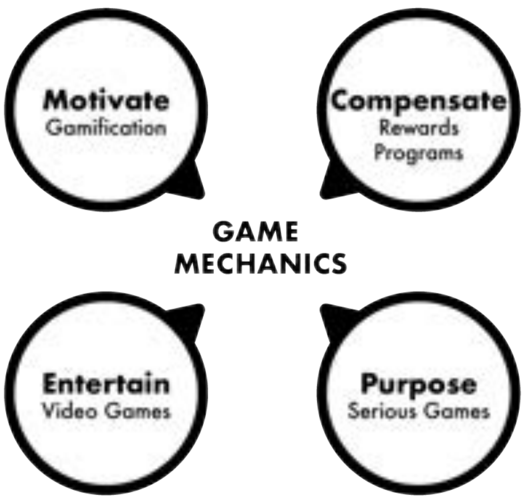


Figure 2.3. Gamification, rewards programmes, video games and serious games (adapted from Bulencea and Egger, 2013)

The key difference between rewards programmes and gamification is that gamification engages the users in a significant way. Typical rewards programmes, such as the airline loyalty programmes, use the same game mechanic (levels and points); however, they mostly engage customers on a transactional level to compensate them, rather than reach people on an emotional level. Video games are fundamentally played on a whimsical level for entertainment. Game can be defined as a rules-based system in which players encounter challenges with quantifiable results (Salen & Zimmerman, 2004). Compared to games, the gamified applications are constructed in non-game contexts that become enhanced via the adoption of some characteristics for games (Deterding et al., 2011). The concept refers that the game elements (such as points or leaderboard) of a gamified application (e.g., "Zombies, Run!") are not needed for the app to meet its main functions (e.g., run tracker), while a game could not exist without the game components (Eppmann, Klein, & Bekk, 2018). Deterding et al. (2011) differentiate the definition of serious games and gamification as "what distinguishes gamification from regular entertainment games and serious games is that they are produced with the intention of a system that includes elements from games, not a full game proper" (p. 4). The implementation of game elements in non-game contexts can change behaviour, enhance engagement, and increase motivation.

Serious games are not created for entertainment, but for a special purpose. Serious games have all the components of a real game but also some defined objectives, outcomes or messages the creators wish to get across to the player (Bulencea & Egger, 2015). Brown, Standen, Evettersby and Shopland (2010) propose the potential of serious games as practical solutions for sensory disabilities.

Gamification applies game mechanics and game-thinking to motivate the users and meets users' needs on an emotional level (Zichermann & Cunningham, 2011). Schell (2014) maintains that gamification will become a redundant term in the future and will be widely accepted as another facet of design for motivation. Gamification is an approach to encourage motivation, engagement, and enjoyment (Seaborn and Fels, 2015). Gamification is defined by Seaborn and Fels (2015, p. 17) as "the intentional use of game elements for a gameful experience of non-game tasks and contexts" in which game components are objects, patterns, principles, methods, and models directly provoked by games. Burke (2014) proposes that gamification, a compelling tool, is used by numerous organisations in their digital engagement strategy to motivate people to achieve their goals.

Next, the principles of gamification will be introduced. One of the most frequently leveraged frameworks for creating gamification experiences is called MDA (Hunicke, LeBlanc, & Zubek, 2004)—which stands for Mechanics, Dynamics and Aesthetics, that provides three fundamentals for creating gamification experience. The MDA framework enables us to use systems-thinking to identify these game elements and apply them to non-game content.

Mechanics form the functional elements of the game. Game mechanics allow designers to control the levels of the game and to lead player actions. As for the subject of gamification, game mechanics can be categorised into seven primary elements: onboarding, badges, leaderboards, levels, challenges, points, and engagement loops (Zichermann & Cunningham, 2011). These game mechanics will be considered in the process of designing gamified applications for this project. Players' engagement with these game mechanics is called dynamics. Mechanics are the instruments adopted to design games whereas dynamics refers to how players interact with game experiences (see *Table 2.1*).

Table 2.1. Game mechanics lead to game dynamics

Game Dynamics / Game Mechanics	Competition	Collaboration	Community	Collection	Achievement	Surprise	Progress (emotional)	Exploration
Points					●		●	
Levels	●			●	●		●	
Missions (individual & team)	●		●		●	●		●
Badges			●	●	●	●	●	●
Leaderboards (individual & team)	●	●	●		●			
Unlocks					●	●		●
Events Feed	●	●	●				●	●
Notifications			●				●	
Quiz	●		●		●		●	
Progress (visual)					●		●	

Finally, the aesthetics stands for the elements that the game enables players feel during game playing. Game aesthetics is the synthesised result of the interaction with dynamics and mechanics.

These aesthetics in MDA refer to eight unique types of fun of playing games: expression, fellowship, submission, narrative, sensation, challenge, fantasy, and discovery as detailed in *Table 2.2*.

Table 2.2. Eight aesthetics in MDA (Hunicke, LeBlanc, & Zubek, 2004)

1. Sensation	2. Fantasy	3. Narrative	4. Challenge
Evoking emotions from player	Game as make-believe	Game as unfolding story	Game as obstacle course
5. Fellowship	**6. Discovery**	**3. Narrative**	**4. Challenge**
Game as social framework	Game as uncharted territory	Game as soap box	Game as mindless pastime

The three levels in the MDA model enable me to start from emotional points, then set the design goals and conceptualise the dynamic user behaviour in the gamified system. Furthermore, the concept of engagement loop discussed by renowned game designer and scholar Kim (Casual Games Association, 2011) would also be considered. The core engagement loop associated with game mechanics associated with feedback loops and positive reinforcement ensure that the user is engaged in the game. The gamification design loop is based on the workflow: a motivating emotion which contributes to the social call to action, which then contributes to player re-engagement, and then feedback or reward. *Figure 2.4* represents this concept.

Figure 2.4. A social engagement loop, designed to maximise player engagement and re-engagement using core product design (adopted from Zichermann and Cunningham, 2011).

Applying game mechanics is the main activity for designing a gamified experience. The further interpretation of game mechanics in gamification will be provided as approriate. As mentioned previously in *Section 2.1.3*, Radoff and Kidhardt (2011) further developed Reiss' 16 basic human motivators employing the list of 42 fun things table. This table offers a fresh perspective of the diversity of fun elements that games can afford as follows (see *Table 2.3*).

Table 2.3. Radoff's 42 fun things table

	Motivator	Power	Curiosity	Independence	Acceptance	Order	Saving	Honor	Idealism	Social contact	Family	Status	Vengeance	Romance	Physical Activity	Tranquility
01-03	#1: Recognizing Patterns		X			X										
04-06	#2: Collecting	X				X	X					X				
07-09	#3: Finding Unexpected Treasure	X					X					X				
10-12	#4: Achieving a Sense of Completion	X		X		X										X
13-14	#5: Gaining Recognition for Achievements				X					X		X				
15-17	#6: Creating Order Out of Chaos					X										X
18-20	#7: Customizing Virtual Worlds			X						X		X				
21-23	#8: Gathering Knowledge		X							X		X				
24-26	#9: Organizing Groups of People					X				X	X	X		X		
27-29	#10: Noticing Insider References				X					X						
30-32	#11: Being the Center of Attention	X										X		X		
33-35	#12: Experiencing Beauty and Culture					X								X		X
36-38	#13: Romance							X			X			X		
39-41	#14: Exchanging Gifts				X			X			X			X		
42	#15: Being a Hero	X		X				X	X	X		X	X	X		
43	#16: Being a Villain	X		X									X			
44	#17: Being a Wise Old Man	X		X	X			X			X	X				
45	#18: Being a rebel	X		X						X		X	X	X		
46	#19: Being the ruler	X				X		X			X	X		X		
47-48	#20: Pretending to Live in a Magical Place		X						X					X		X
49-50	#21: Listening to a Story		X							X						
51-52	#22: Telling Stories	X			X							X				
53-54	#23: Predicting the Future					X										
55-57	#24: Competition	X										X	X		X	
58-59	#25: Psychoanalyzing		X			X										
60-62	#26: Mystery		X											X		
63-65	#27: Mastering a Skill	X		X											X	
66-67	#28: Exacting Justice and Revenge	X											X	X		
68-70	#29: Nurturing			X				X			X	X		X		
71-73	#30: Excitement														X	
74-75	#31: Triumph Over Conflict	X											X			
76-78	#32: Relaxing															X
79-80	#33: Experiencing the Freakish or Bizarre		X													
81-82	#34: Being Silly				X											X
83-84	#35: Laughing														X	X
85-86	#36: Being Scared														X	
87-88	#37: Strengthening a Family Relationship							X		X	X					
89-90	#38: Improving One's Health														X	
91-93	#39: Imagining a Connection with the Past		X			X										
94-96	#40: Exploring a World		X	X												
97-98	#41: Improving Society							X	X			X				
99-00	#42: Enlightenment		X	X												X

Based on Radoff's 42 fun things table, Zichermann and Cunningham (2011) outline 12 motivations for gamification design as *Table 2.4* shows:

Table 2.4. Zichermann and Cunningham's (2011) main gamification mechanics

	Things people like	Example mechanic	Example mechanic	Example mechanic
1	**Pattern Recognition**	Memory-game interactions: items are revealed, then hidden, then combined	Combine like items, as in object-matching games	Earn and burn: learn how to optimize virtual economies
2	**Collecting**	Collectible objects, such as stamps and badges	Scarcity and return: limited-availability items, time-based items	Trading mechanisms with others
3	**Surprise and Unexpected Delight**	Slot machines, variable reinforcement	Easter eggs, geocaching, hidden objects	Unexpected dynamism, such as Foursquare's unique and funny badges
4	**Organizing and Creating Order**	Time/job/throughput challenges, such as in Diner Dash or Chocolatier	Combining like items and/or creating symmetry	Organizing groups of people, like a team
5	**Gifting**	Easily transferrable virtual items	Gift reminders and recommendations	Karma points: only purpose is as a "gift
6	**Flirtation and Romance**	Poking, smiling, flirting: lightweight, easy-toignore interactions	Hot or Not style: choose people from a list/group and express interest	Virtual items or lightweight "props," shout-outs
7	**Recognition for Achievement**	Badges, trophies	Contests, game shows, award shows	Kudos system for reinforcement, e.g., Nike Plus and Lance Armstrong
8	**Leading Others**	Team-based or cooperative challenges	Levels associated with leadership	Long-term, "great" challenges that require multiple players
9	**Fame, Getting Attention**	Leaderboards based on player feedback, scores, and promotion	Award shows, game shows, contests	Large or out-of-scale promotional opportunities, e.g., images on Flickr's home page
10	**Being the Hero**	"Rescue the maiden" challenges	Friends ask for help, you respond with help	MacGruber: things are going to blow up in 10…9…
11	**Gaining Status**	Badges, trophies—especially public ones	Scarce, limited-edition items that are public	Public, obvious scores and leaderboards
12	**Nurturing, Growing**	Tamagotchi style: feed this thing regularly or it will die	Points that expire in the absence of activity, growth	Pyramid scoring, with cumulative scores for teams and leaders

After examining the literature related to game design and gamification literature, Xi and Hamari (2019) observed a similar set of 13 gamification types. These include immersion-related features (narrative, customization features, and avatar profile); achievement-related features (badges, points, status progress bar, virtual currency, levels, leaderboards and rising challenging tasks); and social-related features (social network features, cooperation, and social competition). The gamification features of the three categories are described in *Table 2.5*.

Table 2.5 Brief description of 13 gamification features (Xi and Hamari, 2019)

Category	Features	Description	Source
Immersion-related gamification features	Avatar	Avatars are visual representations of players within the game or gamification environment, which are chosen or even created by the player.	Werbach and Hunter (2012); Kapp (2012)
	Customization/ Personalization	Customization has been defined as activities where users themselves modify some aspect of an interface to a certain degree so as to increase its personal relevance	Marathe and Sundar (2011)
	Narrative/Story	Stories are also an important part in gamification applications, as they can alter the meaning of real-world activities by adding a narrative 'overlay'	Sailer, Hense, Mayr, & Mandl (2017)
Achievement-related gamification features	Badges	Badges are visual representations of achievements, which can be collected within the gamification environment.	Sailer, Hense, Mandl, & Klevers (2013)
	Virtual currency	Virtual currency can be earned through environmentally desirable activities. Participants can also use this virtual currency to buy virtual items	Liu, Alexandrova, & Nakajima (2011)
	Points	Points can be accumulated for certain activities within the gamification environment	Sailer, Hense, Mandl, & Klevers (2013)
	Progress bars	Performance graphs are often used in simulation or strategy games, and provide information about the players' performance compared to their preceding performance during a game	Sailer, Hense, Mandl, & Klevers (2013)
	Levels	A system of advancing in the game by collecting a certain amount of points or carrying out specific actions	Gatautis et al. (2016)
	Leaderboards	Leaderboards rank players according to their relative success, measuring them against a certain success criterion	Costa, Wehbe, Robb, & Nacke (2013)
	Tasks	Quests are little tasks, players have to fulfil within a game.	Sailer, Hense, Mandl, & Klevers (2013)
Social-related gamification features	Social network features	Messages, blogs, chat and connection to social networks	Aparicio, Vela, Sánchez, & Montes (2012)
	Cooperation/Team	Cooperation by introducing teams, i.e. by creating defined groups of players that work together towards a shared objective	Werbach and Hunter (2012)
	Social competition	The desire to challenge and compete with others, leading to the possibility for a player or a group of players to win while others lose	Gatautis et al. (2016)

I regarded these 12 motivations for gamification with related game mechanics as the primary consideration for this project.

With the rapid evolution of mobile technologies, players can play games at any place and at any time (Gentes, Guyot-Mbodji, & Demeure, 2010). Smartphones allow the users to interact with the real world instantly (Hinske, Lampe, Magerkurth, & Röcker, 2007). Blum, Wetzel, McCall, Oppermann, and Broll (2012) maintain that mobile games have shifted players' experiences in various approaches, for instance, the gaming experiences have enlarged the real environment, which possibly enables dynamic interaction between users and environments (Benford, Magerkurth, & Ljungstrand, 2005; Grüter, 2008). Therefore, the next section will introduce the potential of applying gamification for experience development and tourism marketing. The following are the principles when evaluating whether gamification is suitable for a particular intervention or not (Cugelman, 2013).

1. The users
2. The users' social context
3. The behavioural and psychological results that are being achieved
4. How closely the intervention's logic theory or model of change adapts to the persuasive setting of gamification
5. The interactive platform or product that is being developed
6. The interoperability of the interactive product, users, and community with the seven gamification tactics, such as providing feedback on performance, capacity to overcome challenges, goal setting, playfulness, social connections, comparing progress, and reinforcement
7. The interoperability of the interactive users, product and community with gamification strategy

Most notably, the research generated two key directions: 1) qualities of the users, and 2) the role of the context being gamified (Hamari, Koivisto, & Sarsa, 2014).

Based on 17 gamification methods, one of the most prominent guidelines for gamification practices is concluded in *Table 2.6* (Morschheuser, Hamari, Werder, & Abe, 2017). I will follow the following gamification guidelines (see Table 2.6) as my design inspiration.

Table 2.6 Requirements for gamification projects (Morschheuser, Hamari, Werder, & Abe, 2017

Requirements	Literature	%	Interviews	%
1. Understand the user needs, motivation and behavior, as well as the characteristics of the context	5; 6; 7; 8; 10; 11; 17; 27; 33; 34; 36; 37; 39	72	I2; I3; I4; I6; I7; I9; I11; I13; I14; I16-I20; I21-I25	76
2. Identify project objectives and define them clearly	5; 6; 10; 11; 17; 22; 24; 27; 33; 34; 37; 39	67	I3; I8; I11; I13; I16; I19; I21; I22; I24; I25	40
3. Test gamification design ideas as early as possible	5; 6; 7; 17; 22; 33; 36; 37; 39	50	I1; I3; I4; I9; I11; I14; I18; I19; I22; I24	40
4. Follow an iterative design process	6; 7; 10; 22; 27; 28; 33; 36; 39	50	I2; I9; I10; I11; I17; I22; I18; I19	32
5. Profound knowledge in game-design and human psychology	16; 18	11	I1-I4; I6; I9-I16; I18; I20-I22; I25	72
6. Assess if gamification is the right choice to achieve the objectives	6; 10; 16; 17; 34; 39	33	I1; I10; I13; I14 I17; I19; I22; I25	32
7. Stakeholders and organizations must understand and support gamification	6; 17	11	I2; I3; I9; I10; I12; I13; I15-I17; I18; I24; I25	48
8. Focus on user needs during the ideation phase	6; 11; 17; 27; 33; 39	33	I6; I11; I16; I18; I22; I25	24
9. Define and use metrics for the evaluation and monitoring of the success of a gamification approach	6; 7; 10; 11; 17; 27; 33; 37; 39	50	-	0
10. Control for cheating / gaming-the-system	6; 10; 17; 25; 27; 34; 37; 39	44	-	0
11. Manage and monitor to continuously optimize the gamification design	6; 7; 17; 27; 33; 34; 36	39	I19	4
12. Consider legal and ethical constraints in the design phase	10; 17; 27; 39	22	-	0
13. Involve users in the ideation and design phase	-	0	I1; I4; I11; I19; I22	20
% relative proportion to the number of considered sources within the literature or the interviews				

2.1.4 Motivation

The term "gamification" involves a motivational and emotional system which entails understanding facets of psychology and experience design. Game theories associated with gamification have a strong connection with the field of Psychology (Zichermann & Cunningham, 2011). A brilliant gamification design could provide the users explicitly with what they psychologically need with a view to fulfilling them. Therefore, identifying the user's needs are the key to designing a successful gamified application. The largest studies in the review (Hamari, 2013; Jung, Schneider & Valacich, 2010) declared that engagement by gamification can rely on multiple factors, such as the motivation of users (Hamari & Tuunanen, 2014) or the essence of the gamified system. In this manner, identifying player motivation is critical to creating an ideally gamified system.

In psychology, our motivations can be sorted into two categories: intrinsic and extrinsic (Ryan & Deci, 2000). Intrinsic motivation is derived from ourselves and is not driven by the world around us. By contrast, extrinsic motivation is mostly based on the world around us, such as the desire to win a reward or earn money. In the game design field, intrinsic motivation is determined as essential in the process of designing a game. Several researchers on history have addressed the intrinsic motivation over the years. A related method to investigate the positive features of motivation particularly is the flow theory. The flow theory defined as "the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it" (Csikszentmihalyi, 1990). With a total of over 100 studies, Deci and Ryan (2000) formulated the self-determination theory, where they determined the following three factors as intrinsic motivators: autonomy, competence (Mastery), and relatedness. The demand for autonomy is associated with people's willingness to finish particular jobs (Ryan, Rigby, & Przybylski, 2006) and the aspiration for self-development (Wei, Shaffer, Young, & Zakalik, 2005), or someone's actions depend on their own willingness (Rigby & Ryan, 2011; Deci & Vansteenkiste, 2004; Deci & Ryan, 1985). To sum up, autonomy means someone has choice and freedom when taking part in activities (Broeck, Vansteenkiste, Witte, Soenens, & Lens, 2010). Competence is associated with a willingness to feel growth and self-control (Deci & Vansteenkiste, 2004; Ryan et al., 2006; Rigby & Ryan, 2011). Human beings have an instinct to adapt to the environment, challenge various difficulties and develop their abilities (Broeck et al., 2010). Relatedness is associated with a requirement of belonging to a social content (Ryan et al., 2006) and establishing significant social relationships with other people (Sailer, Hense, Mayr, & Mandl, 2017; Deci & Vansteenkiste, 2004; Deci & Ryan, 1985). Individuals hope to be integrated into the social matrix (Broeck et al., 2010; Bowlby, 1969). Therefore, when people develop a close social connection with others, they acquire higher relatedness to fulfil themselves (Deci & Ryan, 2000).

The self-determination theory is regarded as one of the most frequently presented cognitivist theories related to motivation (Werbach & Hunter, 2012). The self-determination theory is also one of the major academic foundations utilised in gamification research (Koivisto & Hamari, 2019; Huotari & Hamari, 2017; Seaborn & Fels, 2015; Rigby, 2015). In a follow-up study, Lazzaro (2004) identified four fundamental reasons as intrinsic motivators, why people play: to destress; to master; to have fun and to socialise. Later on, in his well-known book Drive, Pink (2009) proposed the three similar intrinsic motivators to the self-determination theory — autonomy, mastery, and purpose. Pink emphasises that these three intrinsic motivators are exactly the motivators that the Maslow hierarchy (1943) has in accordance with the self-actualisation needs. Based on a study involving over 6,000 participants, Reiss (2004) suggests that intrinsic motivators be described as the 16 fundamental human motivators (see *Table 2.7*). From a gamification viewpoint, it is especially intriguing to note that Reiss models link with the basic desire for social contact with the needs of the play.

Table 2.7. Reiss' 16 basic human motivators

Motive name	Motive	Animal behavior	Intrinsic feeling
Power	Desire to influence (including leadership; related to mastery)	Dominant animal eats more food	Efficacy
Curiosity	Desire for knowledge	Animal learns to find food more efficiently and learns to avoid prey	Wonder
Independence	Desire to be autonomous	Motivates animal to leave nest, searching for food over larger area	Freedom
Status	Desire for social standing (including desire for attention)	Attention in nest leads to better feedings	Self-importance
Social contact	Desire for peer companionship (desire to play)	Safety in numbers for animals in wild	Fun
Vengeance	Desire to get even (including desire to compete, to win)	Animal fights when threatened	Vindication
Honor	Desire to obey a traditional moral code	Animal runs back to herd when stared at by prey	Loyalty
Idealism	Desire to improve society (including altruism, justice)	Unclear: Do animals show true altruism?	Compassion
Physical exercise	Desire to exercise muscles	Strong animals eat more and are less vulnerable to prey	Vitality
Romance	Desire for sex (including courting)	Reproduction essential for species survival	Lust
Family	Desire to raise own children	Protection of young facilitates survival	Love
Order	Desire to organize (including desire for ritual)	Cleanliness rituals promote health	Stability
Eating	Desire to eat	Nutrition essential for survival	Satiation (avoidance of hunger)
Acceptance	Desire for approval	Unclear: animal self-concept?	Self-confidence
Tranquility	Desire to avoid anxiety, fear	Animal runs away from danger	Safe, relaxed
Saving	Desire to collect, value of frugality	Animal hoards food and other materials	Ownership

By drawing on the concept of Reiss' 16 basic human motivators, Radoff and Kidhardt (2011) match these 16 motivators with a list of 42 enjoyable game mechanisms, called 42 Fun Things Table. The table will be demonstrated in *Section 2.1.5*. The gaming motivations from previous studies have primarily investigated video games as merely recreation (for instance, Ryan et al., 2006). The above research indicated the value of examining players' motivations. A sufficient understanding of the motivations of players will assist designers to create persuasive games to reinforce players' experiences, particularly in the way of tourist players. Following the Self-Determination Theory mentioned earlier, Marczewski (2013) proposed a RAMP motivational model of Relatedness, Autonomy, Mastery and Purpose. Relatedness is associated with a feeling of belonging in a social context. The core concept of autonomy can be regarded as freedom. Mastery is the process of mastering something. It is vital to the human being that individuals feel that their skills are increasing along with the level of challenge. If this is thoroughly balanced, it is often associated with the flow theory (Csikszentmihalyi, 1990). Lastly, purpose refers to our need for there to be meaning to our actions. We need to make sure that there is a reason and some greater meaning when we do something.

After understanding the motivations for game players, it is important to identify the motivations of tourists and their needs concerning tourism services and products to comprehend tourist players' experiences. Based on previous literature, Xu et al. (2016) illustrated the distinction of pure gamers compared with tourists' motivations in mobile games (see *Figure 2.5*).

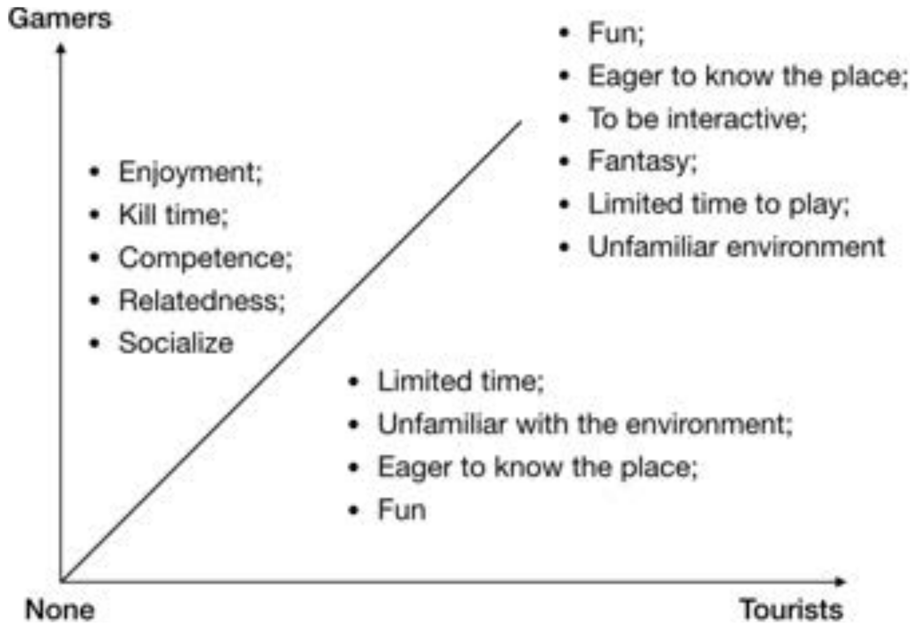


Figure 2.5. The distinction of pure gamers compared with tourists' motivations in mobile games (adopted from Xu, Tian, Buhalis, Jessika Weber and Zhang, 2016)

Figure 2.6 summarises the primary tourists' motivations in mobile games (Xu et al., 2016).

Figure 2.6. Motivation to play tourism games (adopted from Xu, Tian, Buhalis, Jessika Weber and Zhang, 2016)

Figure 2.6 displays curiosity as the fundamental motivation for playing a game for tourism, which can be adopted as an up-to-date means of tourism marketing where tourism organisations facilitate players to explore tourism destinations effectively. Another popular theme is exploring the destination in that mobile applications could provide more information and enjoyment to them while travelling. The reflection on the socialisation motivation is the encounter between tourists in conjunction with local people. It can also spark the co-creation of experiences between local people and travellers. The intrinsic motivations, such as challenge and achievement, and fun and fantasy, could encourage the "flow" in a game. Players hunt for more challenges and fun when they become more experienced, which has been validated in playing general games as well as tourism games. In sum, the participants recognised that games can be considered as a potential strategy for enhancing their tourism experience and recommended that they can engage with tourism destinations during their visit if they are designed well. The pyramid of motivation to play tourism games provides me with a great framework to design the features for later app design.

2.1.5 Emotion

Many studies in the field investigate emotion in the experience design area based on Norman's three levels (2004). Norman (2004, p. 22) proposes reflective, behavioural, and visceral as the three stages of processing emotion. Each affects our experience of the world in a specific manner (see *Figure 2.7*).

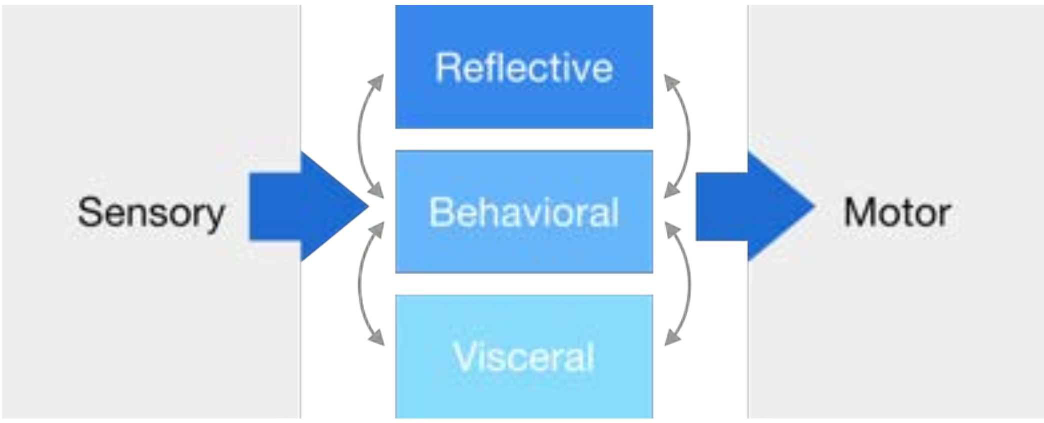


Figure 2.7. Three levels of processing an emotion (adopted from Norman, 2004)

Norman (2004) demonstrates that the visceral level is responsible for the human emotion at the animalistic level, which is nearly all out of our control. The behavioural level concentrates on the regulated human action that develops goal-directed strategies in the shortest time. The reflective level is, as Norman (2004) refers, "the home of reflection, of conscious thought, of learning of new concepts and generalisations about the world" (Ibid., p. 23). To create the overall emotional experience of the world, these three levels of processing emotion, while divided into separate aspects in the emotional scheme, are connected and influenced by each other. The visceral level refers to how the user feels about the product at first glance. The behavioural level means the experience of the product in use. This level focuses on the user's experiences. The reflective level concentrates on the user's views on the product in the entire time, before, during, and after use. The prominent experience design experts Ortony, Norman, and Revelle (2005) affirmed the three emotion levels as one of the most prominent ways to emotion and design. In short, the three levels of emotion can be combined to design the entire user experience.

With an effort to further develop a framework for systematically integrating Norman's three levels theory model into the practice of experience design, Cooper, Reimann, Cronin and Noessel (2014) demonstrated that Norman's visceral, behavioural, and reflective processing levels could be regarded as experience goals, end goals, and life goals respectively. Experience goals are associated with how a user wishes to feel. End goals are associated with what a user is keen to do. Life goals are associated with whom a user wants to be. In this vein, it is of paramount importance to take account of what the product means to the intended user when designing the reflective level in the Three Levels of Processing an Emotion. Therefore, it is of significance that experience designers should always keep users in mind.

Positive emotions are the most valuable element for designers to apply while designing an experience. Tung and Ritchie (2011) investigated that positive emotions including excitement and happiness are a vital part of the memorable tourism experience which includes seven elements of knowledge, novelty, social interactions with locals, refreshment, involvement, meaningfulness, and hedonism (Kim, Ritchie, & McCormick, 2012). Further research on the positive emotions in human flourishing is the theory called positive psychology (Fredrickson, 2001).

Table 2.8. Ten representative positive emotions (Fredrickson, 2013, p. 5)

Emotion label	Appraisal theme	Thought-action tendency	Resources acquired	Emotion adjectives
Joy	safe, familiar, unexpectedly good	play, get involved	skills gained via experiential learning	joyful, glad or happy
Gratitude	receive a gift or benefit	creating urge to be pro-social	skills for showing care, loyalty, social bonds	grateful, appreciative, thankful
Serenity	safe, familiar, low effort	savour and integrate	new priorities, new views of self	serene, content, or peaceful
Interest	safe, novel	explore, learn	knowledge	interested, alert, or curious
Hope	fearing the worst, yearning for better	plan for a better future	resilience; optimism	hopeful, optimistic, or encouraged
Pride	socially valued achievement	dream big	achievement motivation	proud, confident, or self-assured
Amusement	non-serious social incongruity	share joviality, laugh	social bonds	amused, fun-loving, or silly
Inspiration	witness human excellence	strive toward own higher ground	motivation for personal growth	inspired, uplifted, or elevated
Awe	encounter beauty or goodness on a grand scale	absorb and accommodate	new worldviews	awe, wonder, amazement
Love	any/all of the above in an interpersonal connection	any/all of the above with mutual care	any/all of the above, especially social bounds	love, closeness, or trust

Positive psychology (Seligman & Csikszentmihalyi, 2014) aims to conduct scientific methods to perceive what makes life worth living for human beings. Seligman, former president of the American Psychological Association (APA), links the subject of positive psychology to the scientific construct of well-being. He implies that well-being is a "construct which in turn has several measurable elements, each a real thing, each contributing to well-being, but none defining well-being" (Seligman, 2011, p. 15).

Even though well-being cannot be defined, there are five dimensions which contribute to well-being, namely the PERMA model (Seligman, 2011) and Maslow's work (1943). The PERMA model stands for positive emotions (P), engagement and flow (E), relationships (R), meaning and purpose (M) and accomplishment (A) (see *Figure 2.8*).

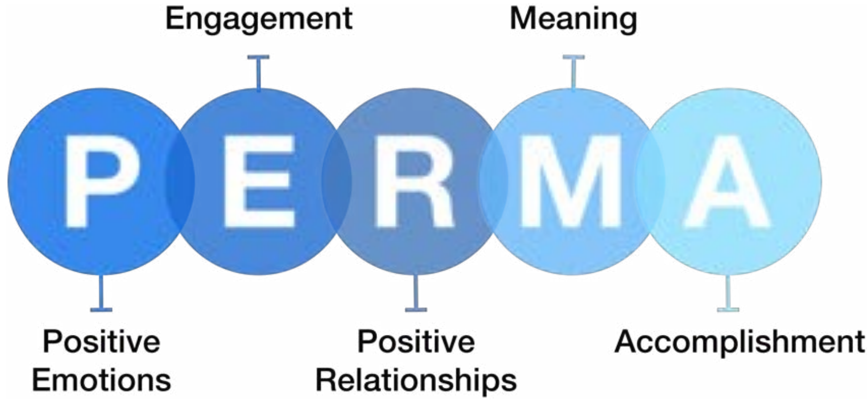


Figure 2.8. PERMA model (adapted from Seligman, 2011)

Radoff and Kidhardt (2011) mentioned that most of those elements of fun in his 43 fun things table to improve the gaming experience (provided in *Section 2.1.3*) are attached to the five positive elements described in the PERMA model on an emotional level.

McGonigal (2011) implies that there is an unprecedented opportunity for collaboration between the fields of game design and positive psychology based on the PERMA model. Followed by McGonigal's proposal, Manrique (2013) uses the PERMA model intending to conceptualise better how to utilise gamification. Kim (2014) outlines that the pertinent points which make a tourism experience memorable also fits the PERMA model very well. Autonomy, relatedness, and competence are part of a theory of human motivation called the self-determination theory (Ryan & Deci, 2000) which is also related to the PERMA model. In this vein, the PERMA model can be deemed the central part of the memorable, and engaging travel experience, and it corresponds with why people engage with games (see *Table 2.9*). Therefore, this study can utilise the PERMA model as a framework for designing memorable experiences in tourism using the principles of game design.

Table 2.9. PERMA model fit

Author(s)	Positive emotions	Engagement	Relationships	Meaning	Accomplishment
What pushes people to travel?					
Crompton (1979)	Relaxation		Enhancement of kinship relationships, Social interaction	Self-evaluation, Exploration	Prestige
Yuan and McDonald (1990)	Relaxation, Hobbies	Escape, Novelty	Enhancement of kinship relationships		Prestige
Fodness (1994)	Punishment avoidance		Social adjustive	Value expression	Knowledge, Reward maximisation, Ego enhancement
Turnbull and Uysal (1995)		Sports, escape	Re-experiencing family togetherness	Cultural experience	Prestige
Oh, Uysal, and Weaver (1995)	Entertainment, Rest	Novelty, Adventure, Sports, Escape	Kinship, Social interaction		Knowledge, Intellectual, Prestige
Cha, McCleay and Uysal (1995)	Relaxation	Adventure, sports	Family		Knowledge, Travel bragging
Klenosky (2002)	Excitement, Relax, Rest,	Novelty, Escape, Thrill, Challenges	Socialise, Meet people, Date more		Look good, Look healthy, Learn more, Know, Be more productive)
Pearce and Lee U. (2005)	Relax	Novelty, Simulation, Escape	Romance, Relationship, Recognition	Self-actualize, Isolation, Nostalgia	Self-development
What makes a tourism experience memorable?					
Kim, J. (2014)	Hedonism, Refreshment	Novelty, Involvement	Social interaction with locals	Meaning-fulness	Knowledge
Why are video games engaging?					
Rigby and Ryan (2011)		Competence	Relatedness	Autonomy	Competence
Lazzaro (2004)	Easy fun	Hard Fun	People Fun	Serious Fun	Hard Fun, Serious Fun

After identifying over 30 emotions involved in gameplay, Lazzaro, an authority on emotion and the player experience and her teammates (2004) contended that people play games to create moment-to-moment experiences. Building on the research of Csikszentmihalyi (1990) on flow theory, Ekman (2003) on emotion, and Norman (2004) on affective computing, Lazzaro (2004) outlines four different kinds of fun. Lazzaro's four fun theory stands for hard fun that a player is making an effort to be a winner in the game; easy fun, where a player is aiming to explore the game; altered states fun, in which the game alters the way the player feels; social fun, during which the player makes connection with others. Lazzaro's four kinds of fun concept directly assisted me to design a better-gamified experience from the psychological perspective for this project. Till now, the psychological facts that make the gamified system an effective tool in the manner of triggering motivation and engagement have been clarified.

2.1.6 Gamification in Tourism

Some tourism organisations adopt gaming, a pioneering and useful tool, to enhance dynamic engagement with tourists and for marketing. As a recent strategy to facilitate tourism destinations, gaming offers destination marketers and tourism companies a chance to build entertaining and informative content for communication, interaction, and successful branding. The tourism industry can be regarded as an experience industry (Pine & Gilmore, 2011); it has potential for gamification, or "gaming" as they called it, as a technological tool to assist in developing experiences and enhancing engagement. For instance, location-based games could be a means of enhancing the interests of tourists employing a treasure hunt. As Linaza, Gutierrez, and Garcia (2013, p. 498) state, "Tourists can follow a list of recommendations given by a mobile game and can learn something about their environment by solving mini-games related to their experiences".

With the aim of developing a holistic perspective on the subject matter, I reviewed the insights from in both academia and industry. Games are about enjoyment and active participation, and are currently considered a powerful strategy for marketing (Zichermann & Linder, 2010). Hence, games can offer an innovative and compelling approach of engagement and interaction in a rewarding and joyful way. In 2011, the World Travel Market Global Trend Report inferred that gamification would become one of the prevalent developments in tourism. Xu et al. (2016), researchers in the game experience of tourists, foresee that utilising a mobile phone to play in the tourism destination will be an increasingly growing trend in the next couple of years. The gaming research company called M2 Research reported that the gamification market would grow to around US$3 billion by 2016 (Everson, 2015). As such, the worldwide gamification market was estimated at close to 2,000 million US dollars in 2017 and will be valued at around USD20 billion by 2023 (Mordor Intelligence, 2018).

The current tourism industry adopts gamification which can be categorised into two groups, in the following way:

1) Social games (play before travel), usually created by destination management organisations for destination marketing purposes. These games are rooted in social media like Facebook, which are primarily adopted to attract potential customers, to strengthen brand awareness, and to enhance a company or a destination's image, for example: Ireland (Tourism Ireland, 2011) and Thailand (Smile Land Game, 2012).
2) Waltz and Ballagas (2007) stated that location-based mobile games (play at the destination) are primarily adopted to improve

tourists' experiences at the destination with deeper enjoyment and in an informative way and to increase more engagement at the destination. Nonetheless, Linaza et al. (2013, p. 498) maintain that "a tourist destination is an extremely rich source of information, supplying tourists at each moment with a continuous flow of images, sounds and feelings that cannot be fully simulated by computers". Currently, the majority of the tourism destination games adopt the techniques from the traditional treasure hunt. For example, the United Nations Educational, Scientific and Cultural Organisation developed REXplorer, which facilitates tourists to learn the history of Regensburg, a world heritage site in Germany (Waltz & Ballagas, 2007). A Norwegian game called Amazing City aims to persuade tourists to participate in a quiz show tour by completing missions at various places (Wu & Wang, 2011). Mashable (2011) maintains that augmented reality (AR), the frontier technology, allows a mix between real and virtual world environments (Yovcheva, Buhalis, Gatzidis, & van Elzakker, 2014), which can be adopted in location-based tourist games to enhance immersive experiences at the destination.

In this project, I will focus on location-based gamified mobile games in regard to travel experiences, as several earlier examples can be given in more detail as follows.

Foursquare (2009), designed by Crowley and Selvadurai, is a location-based social network application (see *Figure 2.9*). It allows the user to check-in at real-world locations, gaining badges and rewards while the user uses the app.

Figure 2.9. Foursquare screenshots

In her book, *Realty is Broken*, McGonigal (2011) claims reasons why the social life in *Foursquare* is better than regular social life. Users can enjoy their life more by using the app because the app enables users to go to the places they have not ever been, try things they have not tried before, and hang out more often with friends. In brief, *Foursquare* can be considered as a "game" that rewards users for trying new things and encouraging users to spare no effort to be social.

Stockholm Sounds (2013), an audio-based information app, enables visitors to explore Stockholm through its sounds. There are several built-in sound guide games that visitors can play by earning points while they explore the capital city of Sweden (see *Figure 2.10*).

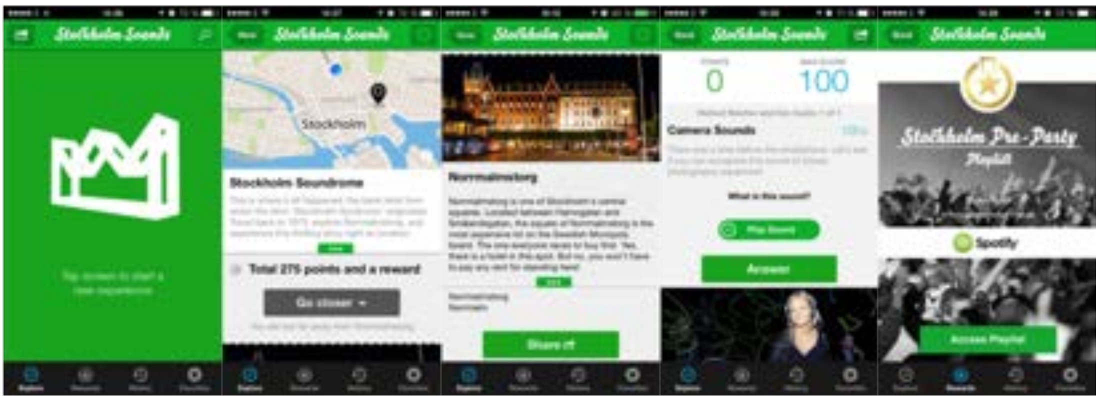


Figure 2.10. Stockholm sounds screenshots

Bulencea (2013) shows how the implementation of a gamified experience involving five senses impacted the visitors in a beer museum. Compared to the traditional visiting experience, visitors remembered the experience better, felt more engaged, and were more satisfied. Meanwhile, *Stray Boots* (2013), an app designed by an Israeli company utilises gamification to build scavenger hunts which involves completing several missions and earning points for users to interact with the city (see *Figure 2.11*). It not only provides an experience for city exploration but helps to build activities, creating group adventures and assisting in building team cooperation as well.

Figure 2.11. Stray boots screenshots

However, gaming is in its infancy in tourism, and remarkably few satisfying projects have been developed so far; there are only two types of applications: cultural heritage and treasure hunts. Gaming in tourism is the latest and rising topic. Admittedly, it is very challenging on four sides. Firstly, compared to conventional games, tourism games need considerable specific information of the destination, which might be difficult to add into the games. Secondly, the business model of these games requires to be developed and examined further. Thirdly, from the game designers' perspective, they should comprehend both the gamers' desires and the tourists' needs and then combine them seamlessly to offer, fun, engaging and memorable gaming experiences. Lastly, game developers face certain technical problems such as accuracy to create a location-based tourism game (Xu et al., 2016).

The examples above are about how gamification can be used in applications for sighted people while they are travelling. Previous studies of applying gamification to people with visual impairments have not dealt explicitly with the period when they are travelling. However, an example of the research on gamification in regard to people with visual impairments is presented below.

Balata, Franc, Mikovec, and Slavik (2014) developed a navigation platform to encourage people with visual impairments to collaborate. They conducted research to gain inspiration on the issue of communication among people with visual impairments while finding their way around an unfamiliar place. Their assumptions were confirmed by a study with a sample of around 55 visually impaired subjects. The outcomes indicated that most people with visual impairments have already collaborated on navigation and consider a surrounding description from other people with visual impairments to be adequate for efficient and safe navigation. The outcome shows that the proposed collaborative navigation system is based on the natural behaviour of people with visual impairments.

Furthermore, a study by Balata et al. (2014) reported that a network of regular routes could expand the urban area in which people with visual impairments can navigate safely and efficiently. Balata et al. (2016) suggest the idea of gamification as the process of adopting game elements to devise solutions to serious issues, such as healthcare or social challenges and business problems. Meanwhile, Balata et al. (2016) also suggest that people with visual impairments can navigate collaboratively by integrating game components and game-development methods.

After examining 15 mobile games in tourism, Celtek (2010) revealed that games seldom offer information about the destination except *Geocaching* and *VeGame*. With a technical background, the game developer sometimes ignores tourists' requirements. Hence, a user-centred method in game design is vital (Yovcheva et al., 2014; Ermi & Mäyrä, 2005). Chou (2016) points out that a variety of designers only focus on developing the superficial layer of gamification. When they design a gamification experience, they often employ PBLs (Points, Badges, and Leaderboards) in the belief that by using these three elements, they can make boring products automatically exciting and engaging. Following from Chou, this research proposes to go beyond the PBLs system. The most important aspect to keep in researchers' minds is a focus on their user experiences and motivations rather than simply using popular game mechanics and game elements. Chow suggests that after designers understand users' feelings, they can start to think about what kind of game elements could be adopted in the gamification system. When designers create a gamification application, they should test the interactions to seek a balance between boredom and anxiety.

Lowenfeld (1964) claims that people with visual impairments who have lost their sight seem to have other stronger senses. Nevertheless, the only reason people with visual impairments have sensory compensation is that they use non-vision senses frequently. The sound design is a vital element when designing apps or games for the blind. The IEZA model (Huibert & van Tol, 2009) categorised sound in games as follows:

- Interface refers to sounds used for providing sonic feedback to the player
- Effect, which is sounds cognitively linked to sources within the gameworld
- Zone, utilised for ambience and environmental sounds originating within the gameworld
- Affect, sounds utilised to strengthen emotions or create atmosphere, music being the most important element.

The tourism industry offers multifaceted and multidimensional experiences (Neuhofer, Buhalis, & Ladkin, 2012; Kim, Ritchie, & McCormick, 2012). Scholars recommend that leisure experiences are 2313szx entertainment (Farber & Hall, 2007), surprise and innovation (Duman & Mattila, 2005), relaxation and escape (Beard & Ragheb, 1983), enjoyment, feeling, and fantasy (Holbrook & Hirschman, 1982). It thus seems that the interests of tourism research and game design research overlap, and both can be studied through a similar approach. The willingness to keep playing to challenge one's own abilities (Brown & Vaughn, 2011), the various types of emotion, for example aspiration and enjoyment (Zichermann & Cunningham, 2011), and the happiness derived from playing (Klimmt, 2003) all contribute to a deep involvement in game play, and engaging with tourism destinations. A comprehensive understanding of tourist players' motivations will be beneficial in the creation of these games. Though there are studies on game player motivations, they did not demonstrate tourists in particular, and hence fail to understand tourists' desires. Most notably, Yovcheva et al. (2014) advocate that tourists have information demands which are contrary to other players; tourists generally are unfamiliar with the location and have limited time while travelling (Fernandes et al., 2013). Hence, tasks need to be less challenging and less ambiguous when designing games. There are fundamental aspects of game design, for instance, what kind of games they like, when they play, and of most concern, why tourists play games.

2.1.7 Audio Description

"Audio description" (AD) was vital for this study because the goal was to design the travel app similar to a local companion for people with visual impairments. The American Council of the Blind (2003) maintains that audio descriptions while travelling could provide people who have visual impairments with a verbal description of the visual subject to assist them to access knowledge and information. Sighted people should describe the entire travel experience when accompanying people with visual impairments. Audio description initially refers to the practice of making TV programmes, movies, and theatre accessible to people with visual impairments: a supplementary narration service describes all of the visual components such as the action, facial expressions, body language, scenery, and costumes. The audio-description is as old as sighted people describing to people with visual impairments about visual events happening in the world around them. The service of audio description has later been expanded to museum visits and landscape descriptions or other descriptions for any visual medium. According to the Description Tip Sheet by the U.S. Department of Education (2012), the principles for audio description are as follows:

1. Describe the visual elements that are the most fundamental
2. Describe from general to specific

3. Describe additional details if time allows
4. Describe shape, size, texture, or colour by comparison to objects that are familiar
5. Describe actions and expressive gestures
6. Describe in active voice, present tense, and in third-person
7. Describe objectively, without comment

The above guidelines are more suitable for audio description on TV and in movie theatres. Little research has been published providing frameworks or guidelines about audio descriptions for outdoor travel specifically. In this vein, I contacted the Hong Kong Audio Description Association and held an expert interview with Dr Dawning Leung, the CEO and founder of the Audio Description Association (Hong Kong). The following Audio Description Guidelines were written by Leung for "Audio Description Training Course (Outdoor Activities)" (not published, internal data).

- From General to specific: describe the overview first and then go into details
- Describe colours: Be specific! Use more words to describe a colour, e.g. do not only say "red" 紅色, but say "wine-red" 酒紅色, "blood-red" 血紅色 or "brick-red" 磚紅色
- Use similes: e.g. Do not say "tall", but say "it is as tall as a door" or you can describe an object from the audience's perspective: e.g. "Look up and you'll find..."
- Describe materials: materials and texture should be included in the AD

- Use sound, touch and smell: an audio-described tour should be multi-sensory. Use touch and smell as complements.

These two guidelines on audio description were used for this project.

In Leung's dissertation (2018, p. 250), she also mentioned the implications and suggestions for Chinese AD Guidelines. Further details can be included in the AD (e.g. colour/material): time permitting, descriptions should include information about colours, the materials and any further description of the visuals that may be relevant to set the scene. In the clip used in this experiment, from the film Z Storm, detailed descriptions such as "Angel in a peachpuff silk bathrobe" and "Wong Sir pulls off Angel's bathrobe" are used. Her fair skin proved to be the most popular among the majority of the participants. One respondent, for instance, commented that these descriptions helped him better imagine the scene; a sentiment also shared by another interviewee, who pointed out that this type of detail helped him visualise the scene better and understand it more easily.

According to Leung's study, among the 44 participants, the top priorities for future AD service development were 'for programmes other than films on TV' (27), 'in cinemas' (22) and 'on outings/visits' (18). The fact that the development of more AD services 'on outings/visits' was ranked so highly by the participants clearly signals that many of them have a strong desire to go outside and have more contact with nature. This study also provided a substantial evidence of the importance to study the travel experience of people with visual impairments.

For sighted people, several apps available in the market adopt audio techniques for travel. Although these apps use audio to talk about the travel stories, they do not provide any description of visual elements. *Just*

Ahead: Audio Travel Guides (2014) can turn user's iPhones into a friendly audio tour guide that allows users to enjoy the narrated audio tour (*Figure 2.12*).

Figure 2.12. Just ahead: audio travel guide screenshots

The road to *Hana Maui GyPSy Guide* (2015) allows users to enjoy a sightseeing trip on Maui while on a driving tour on the Road to Hana in Hawaii. There are more than 140 "audio points" along the journey that will play automatically, featuring what to see, the related stories, travel tips and helpful advice (*Figure 2.13*).

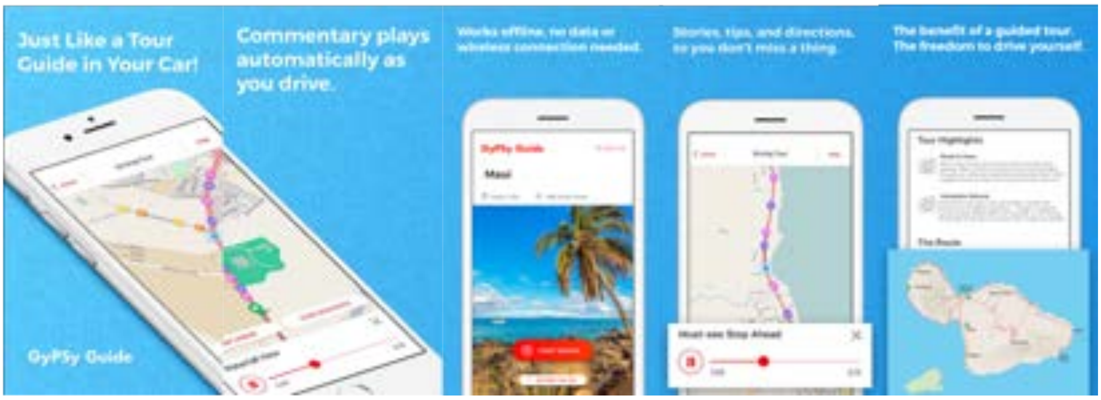


Figure 2.13. Road to Hana Maui GyPSy Guide screenshots

The mentioned apps adopt simple audio descriptions but do not describe the visual elements in detail, because sighted people can see the scenery. However, the interface design, the app experience design and audio features, including the storytelling in the applications, serve as valuable examples of existing solutions for this PhD project.

Along this line of consideration, *Traveleyes* (2004), an Italian company, offers a cooperation service for people with visual impairments and for sighted tourists who accompany those with visual impairment. Small (2015) exemplifies some tentative initial evidence that visually impaired people and sighted people are facilitated in the cooperation. The methods of study were questionnaire survey and autoethnography in an effort to explore the experiences of both tourist groups. The findings demonstrate that, from sighted people's angle, the partnership can offer them new expereiences of travelling. From the perspective of people with visual impairments, this collaboration enables them to access the rights to citizenship and make their life experience better. These findings might assist me to consider the partnership between these two groups of stakeholders.

2.1.8 Assistive Technology

From one point of view, a travel app for people with visual impairments could be considered an assistive technology. According to the WHO (2018), the definition of assistive technology is "the application of organised knowledge skills related to assistive products, including systems and services. Assistive technology is a subset of health technology". The targeted groups with regard to assistive technologies are disabled people. Hence, the definition of assistive technology is tailored to the model of disability (Hersh & Johnson, 2010). There are two essential types – the medical and social models. The medical approach of disability emphasises the categorisation of "impairment" proposed by the World Health Organisation (WHO, 1980). The WHO elucidated "impairment" as "any loss or abnormality of psychological, physical or anatomical structure or function". In this vein, the medical model regards disability as individual and concentrates on the people's impairments as the reason for disadvantages leading to the methods of rehabilitation.

The social model is based on the social and physical barriers experienced by disabled groups (Swain, French, & Cameron, 2003) instead of their impairments, and regards the issue of being in society instead of the disabled individual. The Union of the Physically Impaired Against Segregation (UPIAS, 1976) first proposed the social model. Later, the Disabled People International (DPI) (Barnes, 1991) developed the social model. The model is two-fold with the two ideas of disability and impairment. "Disability" is defined as the reduction or loss of opportunities to join normal life in society on an equal level with others on account of social, physical, or environmental barriers. "Impairment" is then defined as the functional loss caused by sensory, mental, or physical impairments.

The social model of disability has a crucial role to play in changing societal attitudes towards people with disabilities and accessibility and in creating rights and new services for people with disabilities (Hersh & Johnson, 2010). However, in the social model, disability is considered to be only part of human diversity, whereas in the social model, disability is considered to be caused by social and community environments that are not designed with the needs of people with disabilities in mind. In this vein, as a researcher in the design field, this project focuses on assistive technology in the social model facet. Generally speaking, the social model of disability is more appropriate for this study, design and development of assistive technology, as the objectives of assistive technology devices and products should aim to eliminate barriers and provide more chances. The social model of disability can be adopted to ascertain the following two aspects of responsibilities for designers and engineers as well (Hersh & Johnson, 2010):

1. Design for all, that is, designing devices and making environments to be accessible by the entirety of the population consisting of disabled people.
2. Design of assistive technology systems, for example, the design of assistive technology products to break down social and environmental barriers, hence offering options and opportunities to disabled people.

Regarding the social model, assistive technology aims to bridge the gap between what people with disabilities aspire to do and what the existing social infrastructure enables them to do. It contains devices, systems, and equipment, which could be adopted to defeat the infrastructure, social, and other barriers experienced by disabled people and that ensure their equal and full participation in the community.

2.1.9 Technologies for People with Visual Impairments

"Assistive technologies" include essential products and services that aid people with visual impairments to access daily household goods, to enter safe environments, especially public spaces, and to ensure independent travel and easy mobility (World Blind Union, 2018). The central assistive technology in mobile phones is text to speech, i.e. VoiceOver in iPhone and Talkback in Android. This research project focuses on iPhones, so I will mainly address their assistive technology in this section.

When the iPhone was announced in 2007, it used a flat touchscreen that had no physical differentiation for people with visual impairments to feel with their hands. Later, Apple introduced VoiceOver, the most powerful function for people with visual impairments in the iPhone. The voiceover is a gesture touch-based screen reader that allows people to use the iPhone even if the user cannot read the screen. Therefore, the principal function of this PhD project was using the iPhone's built-in accessibility feature - VoiceOver. The iOS user can turn on the VoiceOver function by triple-clicking the home button. The user can hear a hint of everything happening on their screen, from who is calling to battery level to which app the user's finger is on. The user can also adjust the speed of speaking. Since VoiceOver was built in iOS, it works well with all the built-in iPhone apps. When VoiceOver is enabled, every element on the keyboard is read aloud when people with visual impairments touch it, and again when people with visual impairments enter it. The user can edit precisely by flicking up or down to move the cursor. Aiming to assist visually impaired people to type more accurately and quickly, iOS supports different character input methods, such as handwriting, and corrects misspelt words. By enabling text-to-speech, the user can hear a sound effect and the suggested word spoken. Designer and developers should create custom labels for each button in any app, including third-party apps. Also, Apple is actively working with the iOS developers to ensure more apps are compatible with VoiceOver.

IOS 10 was released by Apple on 13 September 2016. The new operating system enhanced the accessibility functions for people with visual impairments. IOS applies 11 billion analyses per image to depict what items are in the image and turn this into audible contexts. Also, iOS can analyse the face in a user's image and then compare the image in the user's mobile address book to recognise people automatically. It helps visually impaired individuals substantially (Apple, 2016).

Most importantly, these all take place at the level of the iPhone itself, not a remote server. There is another enhancement called the Voice Mail Transcription in iOS 10. The iPhone can assist users to transcribe voice to text. The voice to text function also supports braille and voice-over. However, the transcription has a deficiency since it is not entirely accurate. The voiceover setting can be customised to the user's preferences. Under VoiceOver settings, there is a new sub-menu called "Verbosity". "Emoji Suffix" is an updated function under "Verbosity", which says the word 'Emoji' after describing the emoji. The "magnifier" feature can help the low vision user to make the word bigger to read. Jordyn Castor, also visually impaired herself, works as a software engineer at Apple. She implemented her experience to assist Apple to design accessible digital products for visually impaired individuals. Apple created the accessibility features as standard, not specialised (Dupere, 2016). Herrlinger, the senior director for Global Accessibility Policy and Initiatives at Apple, observed that "By being built-in, they are also free. Historically, for the blind and visually impaired community, there are additional things you have to buy or things that you have to do to be able to use technology" (Dupere, 2016). Apple won the American Council of the Blind's Robert S. Bray Award on 4th July 2016 due to the progress in accessibility and its dedication to accessible innovation for visually impaired users. The iOS 12 added some new accessibility features which include display accommodations and accessibility shortcuts.

2.2 Existing Mobile Applications

The mobile applications developed specifically for visually impaired people can be classified into three main categories: navigation assistance, object recognition, and others, including entertainment, news, and education. In this vein, the category of navigation assistance and object recognition are the most developed applications available on the Apple store. A detailed list of the applications designed for people with visual impairments categorised by country, description, and URL was made. A full list is included in Appendix 1.

2.2.1 Navigation Assistance

BackMap (2017), from the USA, is a navigation assistant that vibrates to enable the user to notice when to turn left or turn right without holding the phone in their hands. Each strap contains a vibration motor that indicates the respective side when the user is required to change direction. Both straps vibrate when the user receives a push notification (see *Figure 2.14*).

Figure 2.14. BackMap screenshots

OverTHERE (2016) is an app developed based on Smith-Kettlewell's Virtual Talking Signs Project. It is an accessibility app that supports people with visual impairments explore the surrounding environment using virtual audible hints. *OverTHERE* employs a unique algorithm that enables users to hold their phones in any direction to hear the virtual signs. Users can use VoiceOver to check the list of signs around them. They can access details about a location such as its phone number, address, or website by selecting a sign from the list. *OverTHERE* also allows users to customise their virtual talking signs, so users can save particular spots that might be hard to find next time. This app has received positive reviews from people with visual impairments in Hong Kong because it can receive a strong signal even though users are far away from the city and climbing a mountain or visiting an island in Hong Kong (see *Figure 2.15*).

Figure 2.15. OverTHERE screenshots

Locally in Hong Kong, Kowloon Motor Bus' *KMB* (2016) app not only announces each stop, but also alerts users two stops in advance before their final stop (see *Figure 2.16*).

Figure 2.16. KMB screenshots

VoiceMapHK (2016), a digital mobile map app, offers users an easy way to gain geospatial information in Hong Kong, which includes building information and detailed digital maps supported by the Lands Department, and integrated information about public facilities maintained by different government departments. The VoiceOver feature facilitates visually impaired users to receive location information. The unique functions are as follows. The "My Location" feature enables users to locate their current location. The "Nearby Environment" feature enables users to search the nearby facilities, MTR accesses, buildings, bus stops, and so on. English and Chinese versions are available in this app (see *Figure 2.17*).

Figure 2.17. VoiceMapHK screenshots

2.2.2 Object Recognition

DuLight (2016), developed by a Chinese company Baidu, applies image recognition to enhance the quality of life for visually impaired people. It uses a camera that captures the user's surroundings and shows the data on the user's smartphone. The accompanying application on the user's smartphone will then process that information and narrate its interpretations. So, using image recognition algorithms similar to those that are used by Google search to help the user search images, Baidu can understand a *DuLight* user's environment and then help the user understand that output in real time (see *Figure 2.18*).

Figure 2.18. DuLight screenshots

Aipoly Vision (2016), a smartphone application developed by a USA-based company, allows users to know their surroundings through object and colour recognition (see *Figure 2.19*).

Figure 2.19. Aipoly Vision screenshots

Be My Eyes (2013), developed by a Danish start-up company, is an app that connects people with visual impairments with sighted helpers from around the world through a live connection (see *Figure 2.20*).

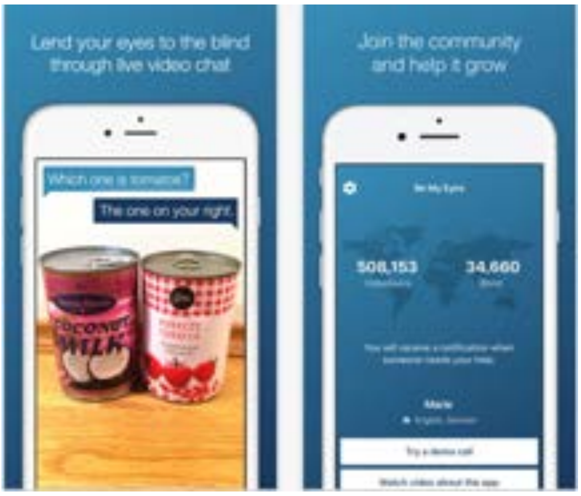


Figure 2.20. Be My Eyes screenshots

BlindSquare (2012), developed by a Finnish company, describes user surroundings and announces points of interest as the user travels. Free of charge, third-party navigation apps, such as *Foursquare* and *Open Street Map* can be plugged in as a powerful tool providing most of the information people with visual impairments require to travel independently (see *Figure 2.21*).

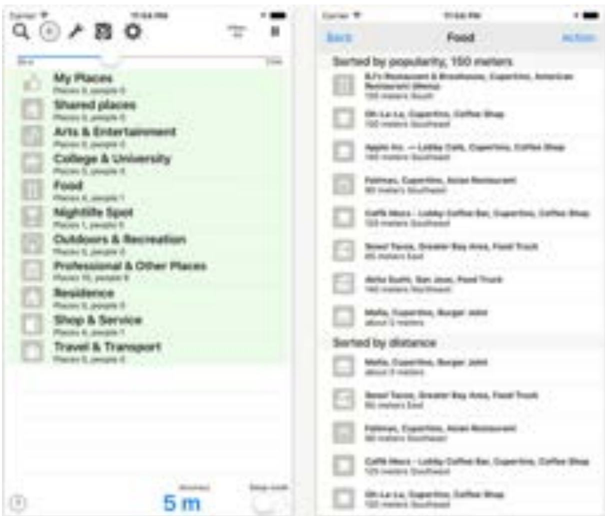


Figure 2.21. BlindSquare screenshots

2.2.3 Others

Education

On 21 August 2017, there was a total solar eclipse in the United States. For people with visual impairments or others who cannot see the eclipse with their own eyes, the *Eclipse Soundscapes Project* provided a multisensory experience of this intriguing celestial event. This service, delivered by NASA's Heliophysics Education Consortium, features real-time reporting of audio descriptions of the eclipse and records changes in environmental sounds during the eclipse. The *Eclipse Soundscapes* app (2017), is an interactive "rumble map" application that lets visually impaired users use touch to visualise the eclipse. It adopts a smartphone's touchscreen and vibrational feature to indicate the movement of an eclipse. The rumble map shows images of the movement of the eclipse at different phases. The app recognises the greyscale of a pixel underneath their finger and vibrates the phone with a strength based on the brightness of the area, when users touch the photo. The smartphone will vibrate more, while users move their fingers around the sun on the touchscreen. The vibration will diminish and disappear as users move their fingers to the dark spaces blocked by the moon (see *Figure 2.22*).

Figure 2.22. The Eclipse Soundscapes app screenshots

Entertainment

A Blind Legend (2015), created by a French company called DOWINO, is the first-ever mobile action-adventure game without video or any interface or graphics, as it uses audio only. This game uses an innovative technology: binaural sound. In this game, players are guided simply by 3D sound and take part in the adventure by controlling their character with multi-point gestures. However, this game does not offer a Chinese language version (see *Figure 2.23*).

Figure 2.23. A blind legend screenshots

Generally speaking, from the accessibility assistance perspective, the VoiceOver feature in iPhones facilitates visually impaired users to receive a variety of information. From a feature perspective, some apps (such as *OverTHERE*) use the vibration function as the indicator which is useful for visually impaired users. The effective audio description and sound effects are essential for the visually impaired. The notification features can also assist the visually impaired to acquire information better. The concept of collaboration between sighted people and visually impaired is also a proven idea that could be considered in my project. From the interface perspective, generally speaking, some of the interfaces of these applications are bold font and relatively clear, such as *Aipoly Vision*, from which I received inspiration for my app. However, some interfaces contain some redundant information with small text, which highlights the needs for conciseness.

2.3 Summary

This chapter has presented a summary of the literature, including the seven pivotal concepts used in this research: experience, experience design, emotion, motivation, gamification, audio description, and assistive technology. It has further discussed assistive technology for people with visual impairments as well as existing mobile applications.

Based on the literature review presented, I can confirm that such studies remain narrow in focus dealing only with meeting the basic needs such as navigating and object recognition for people with visual impairments. Therefore, this study aims to determine the quality of the tourism experience of people with visual impairments. As most current research and public discussion focus on navigation, tourism is about gaining information, to open new areas for research, our interest lies in "access to information" through smartphones (Small et al., 2012, p. 941). Additionally, tourism experience is the actual day-to-day matters and feelings of the vacation. It is generally accepted that tourists carry their associated memories and feelings at the end of a journey. According to Small (2007), any travel experience is a collection of subtle, personal, clustered emotional moments that form an embodied perception, and a memory afterwards. In the same vein, regarding tourism, people with visual impairments focus on sensation encounters, which involve a series of emotional, embodied, and visual appreciation (Richards et al., 2010). The perceptual and emotional aspects are evident in those studies that unravel the intimate nature of the travel experience (Small, 2007). Consequently, enjoyment is one of the traditional motivational factors of the tourism experience, including tourists with visual impediments (Allan, 2013).

The overwhelming majority of visually impaired people who had travelled spoke of the many joys and benefits they gained from holidays and trips away from home. Their experiences had much in common with those of sighted people and included social interaction, warmer climates, relaxation, the experience of other countries and cultures, and a change from routine contexts (Richards et al., 2010). However, travel is not always a practical option, and many individuals with special needs have difficulty accessing and using mainstream or even specialist tourism providers. Richards et al. (2010) suggest that individuals with visual impairment have three main barriers concerning tourism. These barriers are individual barriers (independence, emotional, psychological); social barriers (decision-makers and awareness); and environmental barriers (transport, accessible information, physical access). Among these, Yau et al. (2004) state that the process of active travel is crucial for people with disabilities. In this study, as being active, they tend to have to overcome their individual barriers, the goal is to assist them in learning about the environment and interacting more easily with the local people. This will likely enhance their travelling experience on an emotional and psychological level. There are tools available which can enhance emotional engagement and provide a memorable tourism experience.

Such tools, including gamification strategy as this might increase tourists' interest in the destination, offering knowledge and engaging experiences. Building a connection between locals and other players can enhance the travel experience and influence how people interact with destinations (Xu et al., 2016). However, to my knowledge, there is no literature that addresses visually impaired people's psychological needs in the design of gamified travel apps. Furthermore, to be effective, the application for this research needed to include specific components such as audio description, gamification, and collaboration. Therefore, suitable elements from previous research were incorporated into this project. The partnership between these two group stakeholders between sighted people and people with visual impairments while travelling could assist the thesis in the development of a better travel app.

In this chapter, I have clarified what makes gamification particularly powerful. It is the tight relationship it has with human psychology - a relationship supported and demonstrated by a list of trustworthy and contrasted frameworks such as Marcszewski's (2013) RAMP motivational profile, LeBlanc's (2004) 8 Kinds of Fun, or 16 Basic Desires by Reiss (2000).

Applying gamification to trigger psychological schemas such as motivation and engagement has become a growing trend. Therefore, considering the motivational and positive psychology of visually impaired people in the process of designing is fundamental. Based on Reiss' 16 basic desires (2000), the model such as 42 fun elements (Radoff, 2011), PERMA model (Seligman, 2011), MDA framework (Hunicke, LeBlanc, & Zubek, 2004), Lazzaro's four kinds of fun concept, and the social engagement loop (Zichermann & Cunningham, 2011) were applied to the design process later. The following chapter presents the methodology adopted in this project.

CHAPTER 3: RESEARCH METHODOLOGY

After understanding the terminology associated with visual impairment and reviewing the current mobile applications for visually impaired people in the previous chapter, this chapter is concerned with the methodology employed in this study. I explain the strategies and techniques that were implemented to achieve the aims of the study. With the objective of developing a holistic perspective on the subject matter as well as deriving the corresponding requirements, the methodology mainly includes hybrid empathic design research and methods derived from the sensory ethnography methodology to discover the real-life stories and potential needs of people with visual impairments. The study adopted the qualitative research approach that offered the researcher an in-depth understanding of something in ways that are impossible to reduce to number. The research methodology design is organised into four sections, namely, empathic design research, secondary research, primary research and agile app development (as illustrated in *Figure 3.1*).

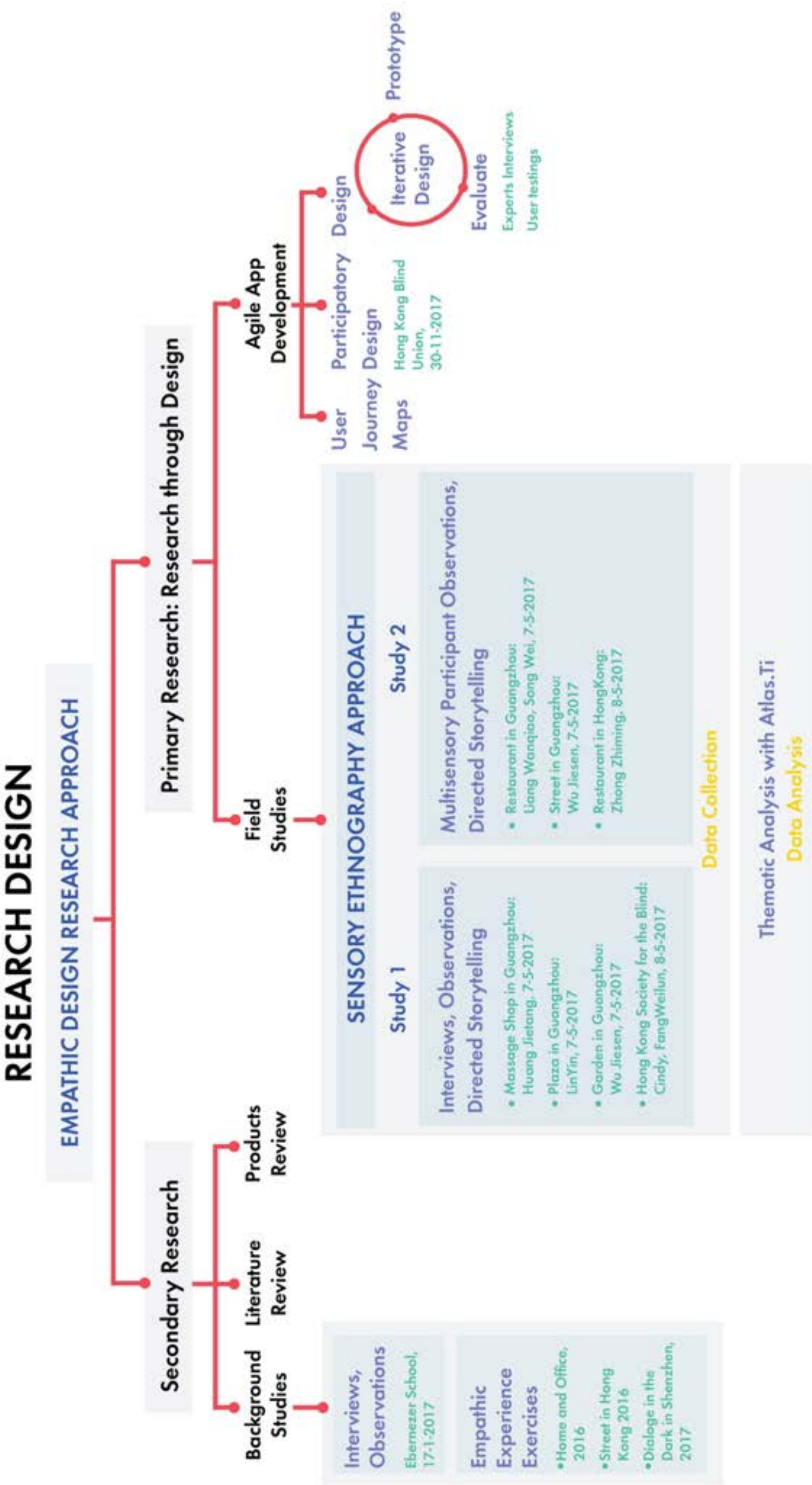


Figure 3.1. Overview of the research methodology utilised

Firstly, I draw upon literature from the disciplines of "empathic design research". In particular, I focus on further developing empathic design research version – "sensory ethnography". Secondly, I present the studies I conducted to establish a solid understanding of visually impaired people and the challenges they face when using digital technologies. These background studies include interviews, observations, and "empathic experience" exercises. Both the literature review and product review are also presented in this section. Thirdly, in *Section 3.3*, I demonstrate the primary research of the project. To gather this material, I applied a "research through design approach" explained in detail in *Section 3.3*. I then illustrate the data collection of two field studies. The methods in field studies applied the conventional qualitative research such as interviews, observation, and directed storytelling, as well as explicitly using the methods of sensory ethnography associated with multisensory participant observations as well. The first study mainly incorporated the techniques of interviews, observations, and directed storytelling. The second study primarily applied methods such as multisensory participant observation and directed storytelling. Subsequently, a thematic analysis approach was implemented in the data analysis section. Following this, in *Section 3.3.2*, I present agile app development related to user journey maps, participatory design and iterative prototyping. In the final part of this chapter, a summary is presented to conclude this chapter.

3.1 Empathic Design Research Approach

Thanks to the training experience in IDEO New York, I am familiar with utilising an empathic design research approach to become familiar with the unique needs and interests of stakeholders who were initially unknown to me. Since I have no visual impairment, empathic design research assisted me as a researcher and designer to empathise with other people (Buchenau & Fulton, 2000). Within this project, empathy refers to an approach that asks people with visual impairments to consider different aspects associated with their thoughts, feelings and stories. These can assist the researcher to understand people with visual impairments from their perspectives. The approach is widely adopted concerning marginal groups and audiences, and when working with people with disabilities (Thomas & McDonagh, 2013).

Cosnier (1997, p. 25) defines empathy based on its separation from sympathy by suggesting that "empathy expresses itself through the perceiving of other's intentions, the sharing of emotion without feeling it ourselves, contagious behaviours, the feeling of connection towards a person with whom we share values". In this vein, empathy is the ability that enables researchers to consider the feelings and thoughts of someone and put themselves in other people's 'shoes'. Empathy is defined by Brown (2009, p. 49) as "the mental habit that moves us beyond thinking of people as laboratory rats or standard deviations". Similarly, Köppen and Meinel (2012) regard empathy as the capacity to build connections with the emotional experiences of other people. Leonard and Rayport (1997) claimed that empathic design research is also an efficient approach to understand target users' needs with low risk and modest cost.

From the design process and product development perspective, empathy can be seen as a primary point that enables designers to build concepts, products, services, systems and strategies that are innovative and associated with actual users' desires (Black, 1998). Empathic design method enables the identification of user needs and inspire relevant insights at the inception of the design process (Köppen & Meinel, 2012; Postma, Zwartkruis-Pelgrim, Daemen, & Du, 2012; Leonard & Rayport, 1997). Empathy conveys crucial intangible elements such as emotions, aspirations, feelings, imagination, and anxieties to designers. It gives them critical cues, prompts, and incentives that deepen their understanding of users to make apps or websites more accessible. It also assists designers to understand individuals' needs, to seek unexpected insights and to test hypotheses throughout the whole process. Moreover, empathic design enables designers and researchers to develop a design project (Köppen & Meinel, 2012; Kimbell, 2011).

There are several advantages to this empathic design research; for instance, it can avoid creating services and products that are valueless to people because they do not fulfil the target users' needs (Thomas & McDonagh, 2013). Compared to conventional market research, which emphasises image and profits, empathic design targets the exact requirements, explores target audience segments, and adopts scripted interviews (McDonagh, 2010). This method can meet both the emotional and functional needs of individuals (Thomas & McDonagh, 2013).

Empathic research techniques incorporate empathy, ethnography, shared language, and collaboration. Empathic modelling is a strategy of experiencing others' physical situations that assists in feeling a person's empathic horizons. Designers do not have the capacity to fully participate in an experience, so it is beneficial to utilise simulations to provide relevant insights. There are different levels in the empathic experiences: receiving a surface understanding of another people, building a more in-depth understanding via an empathic modelling procedure, obtaining empathy with the others, and building an emotional relationship with other people. The empathic experience exercises applying a simulation method will be presented in *Section 3.2.1.3* Empathic Experience Exercises. Empathic research methods include common ethnographic research methods such as interviews, observation, and interaction with target subjects. Shared language is associated with researchers establishing an understanding based on language (such as visuals, body language, and text), that enables communication beyond the superficial. Creating a shared working language assists to define terms and language to reduce the need for translation between collaborators. This process is both beneficial and challenging as teams work to design "with" the users rather than "for" the users. This ensures the designers and users are "on the same page". This is specifically vital when individuals come from different backgrounds or disciplines.

3.1.1 Sensory Ethnography

Tourism involves a series of emotional, embodied, sensual encounters, and visual appreciation is unquestionably part of this experience (Richards et al., 2010). Visually impaired people have to overcome the broadly held perception since they cannot see, and they cannot enjoy travel fully (Small et al., 2012). Consequently, it is critical to offer effective experiences through various senses (Figueiredo, Eusébio, & Kastenholz, 2012). Intending to empathise better, sensory ethnography is a further development that is based on empathy design research. Hoey (2008) characterises the intention of ethnography as providing a deep understanding and holistic explanation of everyday life and practice.

Sensory ethnography, meanwhile, is not simply ethnographic research about the senses. Sensory ethnography is about reflection of the ethnographic approach, with a focus on sensory perceptions and experiences (Pink, 2005). Based on social anthropology, sensory ethnography primarily explores how knowing and experiencing are integral in the sensory ways of the lives of individuals in the research and how the ethnographer proceeds with their craft.

In the 1980s, Howes (2003) first referred to the anthropology of the senses. Later (1991), he expanded the definition on the anthropology of the senses, appealing to the reflection of this domain by focusing on the senses. Howes (2003) referred to the term "sensorial turn" regarding the anthropology of the senses. "Sensorial turn" across disciplines has produced understandings of experience, practice and knowledge as multisensory. In 2015, Pink noted that sensory ethnography is the latest ethnography method to be used across practice-based and applied disciplines.

Sensory ethnography goes beyond traditional ethnography in different ways:

- An understanding of interwoven senses is required to do the research.
- New methods, such as using cutting-edge media, are needed in addition to listening and writing.
- The representation of sensory ethnography is beyond writing and reading, and it can be a video, an installation or even art practices.

- New ways of understanding the products of ethnographic methods are available, ranging from collecting data to producing knowledge in practice.
- A move from textual to the tacit, unspoken, non-verbal and from writing to documentary film and photography.
- Shifting agendas from academic research to applied ethnography, to public ethnography, requiring new means of interacting with research participants.

The following is the figure I created to better understand the structure of the sensory ethnography as embedded into my own project (*Figure 3.2*):

Principles:
1. Embodiment
2. Multisensoriality
3. Emplacement

Methods:
1. Multisensory Observation
    - The ethnographer as sensory apprentice
    - Eating together
    - Walking together
2. Multisensory Interview

Figure 3.2. The basic structure of sensory ethnography

I followed the above principles and methods in this study.

There are three principles of sensory ethnography, which are embodiment, multi-sensoriality, and emplacement.

Embodiment is about deconstructing the concept of a mind or body, to explain the mind not merely as a medium of activity and experience. Compared with any traditional methodology, the sensory ethnographic approach emphasises experience as more embodied, due to the requirement of learning and knowing through one's entire bodily experience, which is recognised in methodological articles across the ethnographic disciplines. According to Pink (2015), the centre of a sensory ethnography is experiencing, knowing and emplacing the body. Ethnographic practice enables our multi-sensorial embodied engagements with the others (by exploring their understandings or participation in activities in part verbally).

According to Cytowic (2010, p.46), "the five senses do not travel along separate channels but interact to a degree few scientists would have believed only a decade ago". When conducting sensory ethnography, considering the interconnections between the senses can help researchers link the research participants' experiences and their interactions easily. Pink (2014) gives an example of how she examined one of her study participants on the experience of dirt. She kept asking the participants about multisensoriality in his experience and attempted to understand how her research participants were experiencing the dirt.

Pink (2015) suggests further investigating the connection between the study of places and senses, to examine how the notions of place provide a structure for rethinking the ethnographic procedure. She questioned the latest major philosophical, and anthropological, and ethnography to develop this kind of framework. The starting point is anthropological literature on the critique of spatial assumptions that is linked to a rethinking of ethnographic processes and practice. She later considered how the phenomenology of the place assists researchers in the understanding of these ethnographic activities.

In brief, to build empathy between researchers and people with visual impairments, we could create a correspondence between researchers and people with visual impairments through embodiment, multi-sensoriality and emplacement. In practice, this means dining and walking with visually impaired participants to experience their daily life spontaneously. The empathic design and sensory ethnography enable the researcher to inspire new ideas and uncover latent needs. A further point is that they assist the researcher to focus on individuals and behaviours more. I have described my application of empathic design research in the following sections.

3.2 Secondary Research

Secondary research involves data collected and synthesised from existing research, instead of original material sourced via primary research with subjects. The secondary research materials in this project include background studies, a literature review, and a product review. While human-centred design normally implies primary research with target stakeholders, secondary research can also be a crucial part of a study, gathering comparison data, understanding what has already been done and what has not, and assisting in providing a research direction that could be utilised in the current research. Secondary research is valuable as a relatively low-cost method, although it can be time-consuming (Martin & Hanington, 2012).

3.2.1 Background Studies

The background studies aim to gain a comprehensive understanding and a shared language of the situation of people with visual impairments such as their daily life, their aspirations and the challenges they are facing. At the same time, the background studies enabled me to find out the insights and opportunities, which assisted me in defining this project. As mentioned earlier, in particular, a shared language is one of the essential techniques in empathic design research. The shared common language offers a focus for all the users and builds on the synergy of the relationships that is developed between individuals (Khuri, 2004). I endeavoured to understand the shared language by gaining knowledge from the text, interviewing experts and stakeholders, and observing the specific area.

3.2.1.1 Interviews

According to Spradley (2016), interviews are crucial to most design research since they enable a rich and in-depth view of people's behaviours. They are frequently adopted to look into the individual's view on a provided topic rather than by interviewing them. To know how people with visual impairments can be educated to learn how to live independently, I conducted interviews and observations at the Ebenezer School, a unique school for people with visual impairments in Hong Kong in February 2017 (see *Figure 3.3*). I conducted individual interviews and expert interviews. Talking to experts could provide a valuable perspective in a systems-level view of the project area (Spradley, 2016). The principal, a social worker, a PE teacher and an IT teacher were interviewed. The questions were all open-ended questions, for the purpose of not limiting their answers, as follows:

- Can you please introduce yourself?
- Do you have any difficulty in teaching?
- Can you tell me the most fun moment for students?

- Can you tell me the least fun moment for students?
- Could you tell me five key things we need to know about visual impairment?

All interviews adopted dynamic communication instead of following a script.

Figure 3.3. Ebenezer school

3.2.1.2 Observation

Besides interviews, I spent three days observing how the students with visual impairments work and live at the Ebenezer School by conducting unobtrusive measures and "Fly-on-the-wall" observation. The unobtrusive approach is utilised to gain information without directly interacting with participants, through observations, nonreactive physical traces, and archives (Martin & Hanington, 2012). Firstly, I conducted unobtrusive measures which involve walking, observing, taking photos and taking notes around the entire school. The observation covered different floors, the playground, and vacant classrooms. The social worker accompanied and showed me the tools and other must-know techniques. During the observation, the social worker answered various questions from me. I conducted “Fly-on-the-wall” observation, which means looking through the window when students were having a class or taking an examination in the classroom. “Fly-on-the-wall” observation was chosen because it enables researchers to acquire information unobtrusively through observing and listening without interfering with the individuals or behaviours being observed (Martin & Hanington, 2012).

3.2.1.3 Empathic Experience Exercises

Empathic experience exercises refer to researchers completing daily tasks that provide them with the opportunity to develop greater insights, diminishing the gap between researchers and people with disabilities (Thomas & McDonagh, 2013). The empathic experience exercises are necessary for researchers who have never experienced such impairments to share the same page with people with visual impairments. Indeed, I was not able to imagine life without eyesight until I participated in the simulation exercises by putting a blindfold on my eyes. The empathic experience exercises for my study were conducted in three phases: in-door simulation, out-door exercise and a dark environment immersion called “Dialogue in the Dark”. The in-door simulation and out-door exercise were video-taped recordings. I watched the video after empathic experience exercises and wrote down all my thoughts.

In the first phase, I put a blindfold over my eyes in the office and my house. I attempted to do several daily tasks as usual such as getting water from the water dispenser, playing music using my iPhone and going to the toilet. I had to move very slowly and use a white cane, a special tool made for visually impaired users to scan their surroundings for obstacles, to prevent me from hitting the objects in the room. However, it was difficult for me to access the toilet without a guide.

In the second phase, I went further and experienced the difficulties that visually impaired people face. In this regard, I required a guide to protect me from danger. There was a social worker with low vision at the Hong Kong Blind Society. She told me to cover my eyes to simulate visual impairment while she as a low-vision person acted as my guide.

We walked from the Hong Kong Blind Society to the metro station. While I covered my eyes, there were several challenges for me to face, especially the stairs. Even when she held my arm, I still felt unsafe. She tried to explain to me how blind people navigate, for example, by touching still objects to recognise directions.

In the third phase, I participated in Dialogue in the Dark in Shenzhen, China. Dialogue in the Dark, a social enterprise originally from Germany, was founded in 1988 by Heinecke. It endeavours to advocate equality in public by adopting a sustainable business model. The experience began with a white cane and a nerve-wracking walk into complete and utter darkness. In the darkness, we met our guide, Petty, who would look after us for one hour as we struggled to find our way by adopting only four senses. We went through different scenarios in daily lives with a white cane such as crossing the road during a time of heavy traffic and buying vegetables and fruit in the market. During the dark journey, there were many things we needed to recognise without seeing them. We even needed to write a postcard and find the mailbox to send it in the dark. At the end of the journey, we were sitting in a dark bar and having some drinks. One of the participants asked the guide whether she navigated well in the dark because she was wearing night vision goggles. The guide told us she did not wear night vision goggles because she had a visual impairment and could easily find the path.

These simulations were enlightening experiences for me. I could not only feel the immediate frustrations, but also their abilities, fears, limitations, hopes, reasoning, and goals. In sum, the empathic exercises assisted me to understand how it feels in daily life without being able to see and rely on a guide. I realise I started putting great effort into using my other senses to become more acutely aware of the informational potential from my other senses.

3.2.2 Literature Review

I conducted a literature review to understand the terminology associated with visual impairment and gamification and to define an empirical approach to answer the research questions. Based on the keywords: gamification, people with visual impairments, and user experience design, I searched the literature on Google Scholar and One Search Platform provided by the Hong Kong Polytechnic University. I started reviewing the highest citation rated paper, then checked the related references. I reviewed books, reports, journals, literature reviews, and textbooks (global and local data) published in the past 20 years from 1997-2018. Finally, I categorised them primarily into the following eight groups: experience, experience design, emotion, motivation, gamification, audio description, assistive technology, assistive technology for people with visual impairments, and existing mobile applications.

3.2.3 Product Review

I reviewed the existing or established mobile applications designed for visually impaired people worldwide. I pointed out the benefits and disadvantages of these products to gain insights for my own design. I asked at least 20 people with visual impairments from the United States, Mainland China and Hong Kong what the most useful or playful applications for them are. I also asked which applications they think should be better enhanced. I later downloaded them in Apple Store. Most importantly, the items are provided by different regions, so I had to change to a different Apple account in order to download them. Most of the applications are free, and I only downloaded the free versions of the applications. I also created an Excel form to mark down their detailed information, such as the year, the country, the company, the price, and the review. After downloading the applications, I started to try them with the "VoiceOver" function enabled. I reviewed and assessed each application from four main aspects: the pain-point solved for the app, the user interface, the accessibility, and the user experience.

3.3 Primary Research: Research through Design

Frayling (1993) distinguished three types of design research: "research for design", "research into design", and "research through design". "Research for design" focuses on assisting, developing, and guiding design practice. The researchers record the procedure and consider professional designers, and their practice as the subject of their study. "Research into design" is the most common form, aiming at a scientific discipline studying design, such as objects, history and phenomena of design. "Research through design" is established by the design process itself, consisting of materials study, development work, and the major act of communicating the phases, prototypes, and iterations of design. In this vein, this study laid emphasis on "research through design", the latest name which is "constructive design research" (Koskinen, Zimmerman, Binder, Redstrom, & Wensveen, 2011) methodology since this methodology "allows interaction designers to make research contributions based on their strength in addressing under-constrained problems" (Zimmerman, Forlizzi, & Evenson, 2007, p. 1).

Fallman (2008) assesses that the interaction design researcher should be involved in designing and building prototypes as a designer with an appropriate research question in mind to determine a research contribution. That is because design-oriented research can target the tacit knowledge as well as the competencies that are associated with the discussions and critiques that eventually result in a final prototype. Research through design, as a way to interaction design, integrates theoretical grounds with technical expertise in the design process (Zimmerman et al., 2007). Scholars in design have pointed out the existing gap between the development of design methods in academia and its final adoption in practice. This has been extensively studied in the HCI field over the last few years (Rogers, 2005; Stolterman, 2008; Roedl & Stolterman, 2013; Gray, Stolterman, & Siegel, 2014). I was trained to be a designer at design schools and worked in a company for several years. My vision for this PhD project is to fully use my own skillset in design and to build knowledge in a pragmatic way to support design practice. Moreover, I aimed to apply my design speciality to facilitate and validate my assumptions. Designing apps for people with special needs requires careful consideration of the high number of "accessibility" features needed. This study not only provides the implications but also adopts them in the final design to test the actual users and real contents, which are more useful and provable. Notably, research through design methodology is very similar to that in a regular design project. However, the goals are different. Regarding the research through design methodology, the goal is knowledge and understanding, not the artefact itself. In addition, documentation of the process is a main concern for researchers adopting this approach (Koskinen et al., 2011).

3.3.1 Field Studies

Study 1 recruited four people with visual impairments in Hong Kong and five in Guangzhou with different groups of participants in Study 2. They were all iPhone users. The field studies were conducted by using methods such as interviews, observation, directed storytelling, and multisensory participant observation. The purpose of Study 1 and Study 2 was to gain a detailed understanding their daily lives, travelling experience, general needs, and special needs for app design of people with visual impairments. The small sample allowed me to put effort into fully concentrating the indepth interviews, instead of pursuing the numbers of interviewees without gaining the detailed information. As Baker and Edwards (2018, p. 23) emphasise, "A small sample can produce a study with depth and significance depending on the initial and emergent research questions and how the researcher conducted the study and constructed the analysis". Instead of trying to imitate a quantitative representative rationale, the aim was to gain thoroughly qualitative insights. This study mainly focused on the individuals and behaviours in detail rather than general demographics. The eighteen participants provided me enough insights to have an understanding of their daily lives, travelling experience, general needs, and special needs for app design of people with visual impairments. The insights reached 'saturation', where new data collection was not expected to generate anything substantially new, and the range of perspectives appeared well covered (Morgan, 1997)."

3.3.1.1 Interviews

The first study conducted observations, interviews, and directed storytelling in Guangzhou and Hong Kong (see *Figure 3.4*). They were five people with visual impairments, three males and two females, aged 20 to 50.

Recruiting participants can be regarded as one of the most challenging parts of this project. Because people with visual impairments are a special group of people, I could not just post the research participant recruitment on the school's information wall. Therefore, a snowball sampling tactic was applied in this research. Snowball sampling refers to the researcher accessing interviewees through other interviewees (Noy, 2008). The recruiting process in Guangzhou first started with one of my friends who worked at the Department of Social Work at Guangdong University of Technology. Then she introduced me to a high-level board member of the Association of the Blind. He later helped me to recruit people with visual impairments in Guangzhou.

I interviewed Subject A on 7 May 2017 at the Massage Shop, where he worked in Guangzhou. I interviewed Subject B on May 2017, who works as a librarian at Guangzhou University, at a plaza in Guangzhou. I interviewed Subject C on 7 May 2017 at the Garden in Guangzhou. The whole-day interview lasted for around six hours, from 9 am to 3 pm in three sections. Each in-depth interview lasted one and a half hours.

The recruiting process in Hong Kong started by writing a request email to the Hong Kong Society for the Blind, the biggest blind community supported by the Hong Kong Government. After waiting for one week without receiving any response. I called them, and a communication officer at the Hong Kong Society for the Blind helped me to arrange four visually impaired members at their community to attend my in-depth interview. Also, I, as a volunteer, participated in several events to not only make contact with the target user groups but also gain knowledge from being involved.

I conducted interviews respectively with Subject D and Subject E in the conference room at the Hong Kong Society for the Blind, on 8 May 2017. I also conducted interviews individually with Subject F and Subject G in the library at the Hong Kong Society for the Blind on 23 May 2017.

Figure 3.4. Study 1 — interview observation and directed storytelling

3.3.1.2 Observation

I conducted a fly-on-the-wall observation at the Hong Kong Society for the Blind, most in the technology equipment showroom and the library. As explained in *Section 3.2.1.2*, it is clear that fly-on-the-wall observation enables the researcher to unobtrusively collect information by observing without direct interference or participation with the people with behaviours being observed. Fly-on-the-wall observation is different from other kinds of observation research methods, such as participant observation because it intentionally removes the researcher from direct engagement with the people or activities in the study. There were several assistive tools with a detailed description being shown in the technology equipment showroom. I also observed the visually impaired people in the library to understand their behaviours and what they could do in their leisure time. The method is limited in terms of researchers' direct interaction with participants but provides a suitable starting point for studying a new group of people. For me, the first task was to observe and to focus on note-taking in the early phase of the research.

3.3.1.3 Directed Storytelling

Directed storytelling enables researchers to easily collect rich empirical data from interviewees, applying a considerable number of prompting and framing questions in interviews (Evenson, 2006). During the interviews, one of the techniques was to encourage the interviewees to share their stories directly. I kept asking questions starting with a prompt such as: "*Tell me a story about the last time you...*". To ensure that the conversation runs smoothly and naturally, dining and walking with the interviewees was very helpful because it could assist the researcher to raise the questions and also assist the participants to recall their memories naturally. This method was extremely useful to learn about the target groups' actual lives, especially the subjects I was unfamiliar with. In addition, the storytelling allowed the participants to feel relaxed and make them feel as if they were casually chatting with me.

3.3.1.4 Multisensory Participant Observation

The primary traditional ethnographic methods are participant observation and interview. These conventional ethnography methods might be inappropriate and impractical to implement. Therefore, Pink (2015) suggested that we rethink both participant observation and the interview.

To a certain extent, there is no difference between multisensory participation and original participation, according to the basic definition of ethnography. However, multisensory participation adds new elements of appreciating and engagement with participants. Rethinking participant observation is about shifting from participant observation to multisensory participation.

Multisensory participation constitutes an essential shift from traditional ethnographic approaches, which have tended to insist that "the visual is the primary mode of understanding" (Atkinson et al., 2008, p. 180). Instead, it builds on phenomenological disputes that experience is multi-sensorial and neither dominated by nor reducible to the visual. Pink (2004) believes that ethnography is far beyond observational practice, and involves emplaced, sensorial, embodied and empathetic elements.

There are three innovative methods in multisensory participation:

- the ethnographer as a sensory apprentice,
- walking with, and
- eating with, sensing with users.

The ethnographer as a sensory apprentice is one of the most discussed methods in the sensory ethnography literature. Apprenticeship requires involvement with the practices and identities. It contains rethinking and self-awareness about the learning process, making the connection between sensory experience, philosophical, moral and other value discussions, and relating these to academic scholarship. Ethnographers have used different approaches of participating as apprentices and of documenting their experiences of apprenticeship, including visual methods (Pink, 2015).

- The ethnographer dining with participants

David Sutton gave an example of sharing a meal together method. At the time he researched in Kalymnos (Greece) local people repeatedly told him to "Eat, to remember Kalymnos" (Sutton, 2001, p. 2). Over time Sutton realised that, as he puts it: "telling me to use the transitory and repetitive act of eating as a medium for the more enduring act of remembering, they were, in fact, telling me to act like a Kalymnian" (2001,

p. 2) since in this particular cultural context foods formed a fundamental. The relationship between food, the textures and tastes, and memory is crucial to the sensory ethnographer in two aspects. Firstly, when researchers are trying to understand the memories of others, sharing the tastes in which these memories are embedded could serve as a starting point for recall. Secondly, taste memories are part of our biographies.

- The ethnographer walking with participants

Ethnographers have long acknowledged that walking with others means sharing their steps, style and rhythm to create empathy or a sense of belonging with them. Pink (2015) emphasised the importance of the encounter in doing sensory ethnography. Indeed, examples of how ethnographers have walked or run in harmony with research participants were already developed in some classic ethnographies of the twentieth century. More recently, both a more systematic interrogation of the role of walking in ethnography and a focus on the ethnography of walking has been developed (e.g. Ingold & Vergunst, 2008). Moreover, this work recognises the multisensoriality of walking.

- Multisensory Interview

The rethinking interview is about regarding the interview as a multisensory event and as a way of probing sensory categories. The traditional approach focuses on vision, and the interview concentrates on talking – conceptualising the interview as a kind of conversation. However, the sensory ethnography approach rethinks the interview as a multisensory encounter, and as part of a particular environment. Talking and conversation are still of interest, but these are situated within ecologies of place and embodied practices.

Pink (2015) made a comparison between the traditional interview and multisensory interview, which has two main variations. Firstly, Pink reframed multisensory interview as a context of emplaced knowing and as a multisensory event. Secondly, researchers through interviews will embody how they convey their thoughts, behaviours, values, and other things. Though it is evident that talking is essential in the interview, the multisensory interview is not only about talking; it requires one to employ other sensorial materials, including touching, body contact, sound, smell, and taste (such as offering researchers food or drink to try). Pink (2005) points out that using video and short film and other art practices to present gives ethnographers a more vivid and embodied understanding of the participants.

There is an example of how Pink develops a method rooted in sensory ethnography in the HCI field to understand how and why people use energy at home. Video Tour is a crucial strategy for sensory ethnography: an intangible notion cannot be described but can be re-enacted as a sensory experience. During the video tour, there was a focus on “comfort”, which often relates to the idea of achieving the proper temperature. After conducting sensory ethnography, Pink found that comfort is not directly linked to temperature but to a sense of relaxation, such as taking a bath on a weekend night, putting on pyjamas and lying in bed. Finally, they designed an application that set the default home temperature as 18°C. When the user feels cold and tries to turn the heater up by using this application, the application will pop up a notification to just grab a cosy blanket to keep warm. It is a digital intervention of this to adjust the ways their home feels comfortable. In the meantime, this intervention can save energy.

In-depth multisensory participant observation and semi-structured interviews have been leveraged at the Hong Kong Society for the Blind. I have engaged in sensorial observations through people with visual impairments participating in real environments. Furthermore, I have sought to understand their living environments and everyday activities. This process encompasses the material, digital, social, invisible, and intangible aspects. Multisensory participation, which spans from textures and sounds to unanticipated smells and unexpected sensory experiences, can enhance the researcher's empathy towards the target users of this research (Pink, 2015). Questions relating to their feelings, opinions and different ways of using their body and senses were asked to participants.

Additionally, I observed the participants undertaking activities together, such as walking, having dinner, and perceiving five-sense experiences in natural contexts, rather than in controlled settings, taking video in the research procedure that enables researchers to investigate the material and sensory qualities. During the video tour, I encouraged participants to express and show how they explore a new location using their multiple senses and utilising various materials as props and prompts. Certain participants will actually feel, sense and engage in a multi-sensory way with objects in the surroundings as a way of advocating their sensory qualities while engaging in the verbal decision-making procedure as well as explaining their meanings (Pink, 2015). The video will encourage the participants to utilise their whole bodies to demonstrate their multi-sensorial experiences via these behaviours. Compared to conventional ethnography, which only represents findings through text, representations of sensory ethnography are not only for academia but also for public audiences (Pink, 2015). New practices for communicating the results of sensory ethnography are emerging, which sometimes take the form of academic writing, ethnographic filmmaking or collaborations with artists (Pink, 2015). The outputs have shifted from text to video, photography and art. Consequently, the researcher will consider, as a designer, how to best utilise design skills to showcase the findings of this research.

The second study adopted multisensory participant observation and directed storytelling methods which were conducted in restaurants in both Guangzhou and Hong Kong (see *Figure 3.5*). The recruitment methods were the same as in the first study. The interviewees were five visually impaired individuals, three males and two females, aged 20 to 50, and each in-depth interview lasted approximately one and a half hours. I dined with the participants both in Guangzhou and Hong Kong.

Figure 3.5. Study 2 — interview observation and directed storytelling

3.3.1.5 Ethical Issues

Because the subjects of this study were visually impaired, it was of paramount importance to consider the ethical issues carefully. The

Human Subjects Ethics Application (HSEARS20161006001) (Appendix 3) was approved by the chair of the Departmental Research Committee of PolyU Design on 17 October 2016. In most studies, a helper was needed to take a video for the interview, which allowed the researcher's full participation. I informed the participants who would be in the interview and observation the day before the interview. Before each interview started, I read the information sheet (Appendix 4) and consent form (Appendix 5) out loud in Cantonese to indicate their rights. The information sheet included the following issues:

1. The investigator's information and contact information.
2. The procedure to be adopted.
3. The time duration.
4. Possible risks to the participant (none in this study).
5. Potential benefits.
6. Voluntary participation.
7. Their rights to refuse to answer any questions or actions in any way.

The consent sheet contains the following information:

1. How the anonymity and confidentiality of their participation are ensured.
2. How the data will be utilised.

All participants were invited to sign the informed consent explaining the aim of the study and assuring them of confidentiality if their experiences were reported in subsequent publications. Since the subjects could not see the forms when they needed to sign the forms, I sent the digital version to their email, and they found their family members or friends who are sighted people to check the form for them. Then they printed out the forms with their signatures and took the forms to me. Most of the time, there was at least one social worker in our interview to make sure the interview was conducted properly. Each participant gained a certain number of supermarket coupons depending on their time consumed. Before I conducted the observation and took photos there, I promised the principal at the Ebenezer school that I would never expose the children's faces in public. While I was conducting the observation at the Ebenezer school, there were some matters that needed to be considered as the sense of hearing of students at Ebenezer school is very sensitive, such as I had to wear shoes that do make too much noise. Also, when I conducted interviews or observation I should never wear perfume, as the senses of the subjects in the study are delicate and sensitive. Also, while conducting the studies, the participants were always punctual, even arriving at least ten minutes before. While asking them why they were so punctual, they mentioned that owing to their disabilities, they tried to leave home earlier to make sure they would not be late. Therefore, it is better to keep "being on time" in mind. Since the final app design requires users to input their information in the app platform, data privacy is another critical thing that needs to be considered carefully. While submitting the app to the Apple Store, a Privacy Policy agreement was submitted as well.

3.3.1.6 Thematic Analysis

There are several main approaches to analyse qualitative analysis data, for instance, thematic analysis (Braun & Clarke, 2013), grounded theory (Strauss & Corbin, 1998; Glaser, 1992), discourse analysis (Willig, 2003; Burman & Parker, 1993; Potter & Wetherell, 1987;), and conversation analysis (Hutchby & Wooffifit, 1998). Qualitative methods are especially subtle, synthetic, and diverse (Holloway & Todres, 2003). I conducted thematic analysis for this project due to the fact that thematic analysis is a foundational, helpful and flexible method for qualitative analysis (Braun & Clarke, 2013).

Thematic analysis is a data analysis method for systematically identifying, organising, and providing insights, and patterns of meaning (themes) among the qualitative raw data. Thematic analysis assists the researcher to identify unique and specific meanings and experiences that are common to the way a subject is written about or talked, through focusing on meaning in the dataset (Braun & Clarke, 2006). Themes or patterns within data can be identified in one of two primary methods in a theoretical or deductive or "top-down" way (Boyatzis, 1998), or in thematic analysis in an inductive or "bottom-up" way (Frith & Gleeson, 2004) (see *Figure 3.6*). Deductive analysis means data analyses to test whether data are in accordance with previous hypotheses, theories, and assumptions, identified or constructed by researchers. Inductive is the analytical methods that mainly adopt interpretation of the raw data to derive ideas, models, and themes by researchers. This understanding of inductive analysis further supports the idea of Strauss and Corbin's (1998, p.12) statement: "The researcher begins with an area of study and allows the theory to emerge from the data."

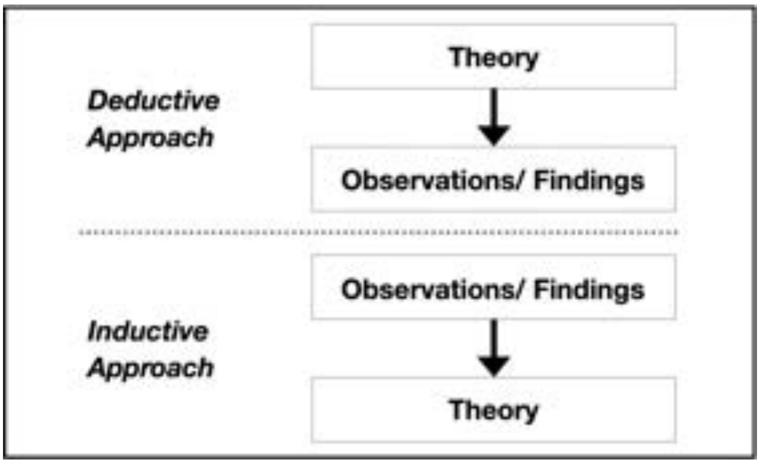


Figure 3.6. The deductive and inductive approach (adapted from Bryman, 2004)

Many studies adopt a combination of deductive and inductive analysis. A comprehensive thematic analysis ensures that the interpretations of the data are in line with the theoretical groundwork (Braun & Clarke, 2013). I adopted the thematic analysis method with inductive analysis, which allowed me to use both for exploratory research, where I had no clear idea of what patterns I was expecting. And I conducted the deductive analysis method, where I know exactly what I am interested in such as positive emotions, experience design and anything related to enhancing the psychological experiences of people with visual impairments. I followed the six steps which were outlined by Braun and Clarke (2006, p.87) as follows:

1. Phase 1: Familiarising yourself with the data
2. Phase 2: Generating initial codes
3. Phase 3: Searching for themes
4. Phase 4: Reviewing potential themes
5. Phase 5: Identifying and titling themes
6. Phase 6: Producing the report

Phase 1 is about organizing and transcribing the data. The audio-recorded interviews were conducted in Cantonese and subsequently translated into English. Then I uploaded all the transcripts, notes and photos into the qualitative research computer program ATLAS.ti. ATLAS.ti is a tool that can be used for coding and analysing transcripts and field notes and creating network diagrams. Then phases 2 to 5 were about the coding process. Creswell (2002) illustrated the model of the coding process in qualitative research, which is illustrated in the following *Figure 3.7*.

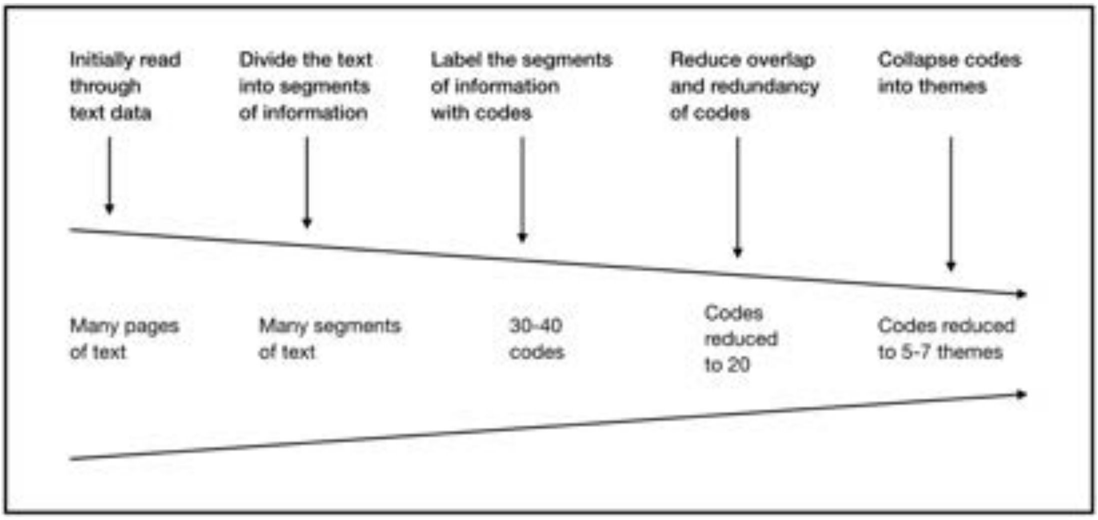


Figure 3.7. A Visual Model of the Coding Process in Qualitative Research (adapted from Creswell, 2002, p. 244)

After organising and analysing their answers, they were organised into themes that emerged from within several categories. Extracts from the raw text illustrated the meaning of the category. The categories are attitude as aspiration, training, sensory compensation, interests, difficulties in everyday life, accessibility issues, design inspiration and app design. In a nutshell, Thematic analysis involves searching a data set - whether it is several interviews or observations, or a list of memos - to identify overlapping patterns of meaning (Braun & Clarke, 2006). In phase 6, researchers write the report that interprets and summarises the findings to make sense of the data. The finding report could include the researcher's personal reflections and comparisons in relation to the literature (Creswell, 2002). The summary categories in the findings are used as the main headings and the specific categories as subheadings. The results of the study also include a detailed description of the categories, with appropriate citations from the text to describe the meaning of the categories (Thomas, 2006). Significant insights were generated from the interview which could be adopted for the final app design. The preliminary study assisted in defining the research scope and focus of the main study.

3.3.2 Agile App Development

As stated before, this research adopted a research through design approach to develop an app to invalidate the research assumption. An agile app development strategy was used in this study. Agile app development is a methodology for approaching complex problems involved in developing applications. Agile mobile app development is one of the most effective ways for all app development businesses; it ensures effective communication, which assists both the app developers and stakeholders to build the ideal mobile application. I followed the four basic values and 12 principles of the Manifesto for Agile Software Development, a reiteration guide to programming development from the Agile Manifesto proposed by Agile Alliance (2001). The agile approach emphasises the human aspects of software engineering more than the perspective processes, thus adopting human interaction rather than implements and processes. The Agile Manifesto developed a standard series of principles and values for all of the individual agile methodologies (Flora & Chande, 2013). It identified four critical significances for ensuring efficiency and high-performance outcomes:

1. Individuals and their interactions
2. Delivering working application
3. Cilent collaboration
4. Responding to changes.

These fundamental principles are further developed by 12 principles that inspire the Agile Manifesto, including:

1. Cilent Satisfaction through early and frequent delivery
2. Scope for changes even at a later stage in the project
3. Short delivery cycle (for example, every several weeks)
4. Collaboration between developers and business people
5. Motivation among individuals
6. Face to face communication
7. Working software-Primary measure of progress
8. Promoting sustainable development pace
9. Continuous focus on technical excellence and superb design
10. Simplicity
11. Self-Organisation to obtain best results
12. Self-improvement.

The above 12 principles guided this study while developing the app. Agile is successful only when the value for the end-users is driving decisions and prioritisation of efforts (Newbery & Farnham, 2013). After the qualitative research data collection, I proposed the app features and sketched the prototype at the very beginning. In order to polish the app to be better, I always showed it to users, including visually impaired, experts in the related areas and interaction designers in order to obtain their suggestions and test it with them.

During the entire development process, this project tested all the accessibility features according to the international guidelines as well as local Hong Kong guidelines and suggested further amendments. My expertise is in designing the interaction and experience, which focuses on the front-end development. In this project, I, as the researcher and designer, outsourced application development to an external person, an expert iOS developer, who entered the project with his own skills, background, and coding methods. Although I had the experience in collaboration closely with mobile developers before in previous projects, it was a distinctly new experience to develop an app from scratch involving native iOS development and fully considering accessibility.

Despite the iOS developer having extensive experience in developing iOS applications, it was also the first time for him to fully consider the accessibility function when developing the iOS application. It is worth describing the collaboration between the researcher and the external developer who became a part of the design project. At the beginning of the development, as a researcher, I shared the findings with the developer to enable him to better comprehend users' needs. As an interface and experience designer, I explained the design files to the developer to assist him in programming the app function. Then, I assisted in collecting and reading through all the essential guidelines for developing an iOS application both internationally and locally, and shared them with the developer. This learning process is crucial because it enabled me to communicate with the developer effectively. The iterative development process that invited end-users to test the app enabled us to discover the potential errors and to better enhance the accessibility features. Also, the app testing allowed me to note all ambiguous guidelines with detailed examples. There was communication and negotiation between the researcher and the developer when he utilised his handiwork to produce the digital 'craft'. Thanks to the experience gained from previous app development, I could easily communicate with the iOS developer. I sent the product requirement document with all the detailed information of development to the developer back and forth in the iterative development process and we amended every detail in the app based on the feedback from the app user testing. While writing the product requirement document, I would always explain the reasons and the importance so the developer could understand the issues. In this study, the developed app meets nearly all accessibility requirements of the target group. Besides the fully working app, the most important thing was that the app was published in the Apple store, further taking this research to another stage, which means real users can use real content. The project also shows how digital design can work as a university-industry collaboration, from which research and developed 'craft' can emerge organically.

3.3.2.1 User Journey Maps

User journey maps offer a visualisation of the experience users have when interacting with products or services. Aiming to construct a "journey", an engaging story formulated on their experience, the touchpoints where users interact with the service are commonly applied. This story elaborates their service interactions and accompanying emotions in a highly palpable way to such an extent that each moment can be individually evaluated and improved (Stickdorn, Schneider, Andrews, & Lawrence, 2011). A user journey map describes a story about an individual's actions, perceptions, feelings and frame of mind—including the neutral, positive, and negative moments. By analysing the list of stories and interactions that an individual experience, the user journey map can shift researchers or designers' focus from an operational perspective to the larger context in which services and products are adopted in real life. It also enables to distinguish moments that elicit strong emotional points and for redesign and enhancement. The user journey map can help to develop a shared vision about ways to more effectively augment existing user behaviour in their actual contexts of interaction (Martin & Hanington, 2012). The user journey map of this project will be elaborated in *Section 5.1*.

3.3.2.2 Participatory Design

Martin and Hanington (2012) insist that "participatory design" is a human-centred method promoting active stakeholder and user engagement throughout all steps of the research and design process, including co-design activities.

Based on the conclusions drawn from the preliminary research, I endeavour to design the features in the travel app for visually impaired users. To better design the app, I employed an in-depth interview and participatory design method with three visually impaired people in the Hong Kong Blind Union in December 2017 (see *Figure 3.8*). The Hong Kong Blind Union is the first and biggest self-help community organised and managed by visually impaired staff in Hong Kong. There are two leading organisations that serve people with visual impairments. One is the Hong Kong Blind Society, at which I carried out studies, and the other one is the Hong Kong Blind Union. Therefore, I was determined to contact them to carry out the research there. I recruited participants by directly calling the organisation. A project manager at the Hong Kong Blind Union assisted in finding the proper participants based on my requirements. These three visually impaired participants all work at the Hong Kong Blind Union and are highly educated. They specialise in technology, mobility training and travel planning. As they were not only the target users but also have experience of serving people with visual impairments, I could obtain better benefit from their dual roles. Their specialisation assisted me to elicit better ideas during the participatory section. At the beginning of the participatory design process, I explained the purpose of the investigation and let each participant endorse a consent form of anonymity and confidentiality (Creswell, 2008). During the in-depth interview and participatory design session, I asked about their ideas of what features should be included in this app. I also prompted some features related to gamification elements in travel mobile applications to them, which encouraged them to give feedback and make recommendations. Since all the participants knew each other very well, they felt very comfortable in the discussion. The interaction between the three interviewees indicated that they could aid one another to generate new ideas.

Figure 3.8. The participating design

3.3.2.3 Exploratory Design Workshop

An exploratory design workshop lasting two hours with ten PhD students in the design field was conducted in March 2019 (see *Figure 3.9*). The ten PhD students were from different design areas such as game design, urban design, interaction design, and service design. Since the travel experience design involved different design areas, the knowledge from different design fields could contribute to this study. The workshop can be regarded as a brainstorming practice. The exploratory workshop did not involve the target visually impaired users because it was hard to manage them, and it was hard to make sure the two groups were on the same page. And since people with visual impairment requirements and insights were collected from the previous background studies and field studies, their requirements and selected quotations were presented in the workshop. The goal of the design workshop was to come up with various creative features and ideas about travel experience apps. At the beginning of the design workshop, a short introduction was given by the researcher. This included the goal, the background, the aspirations of visually impaired people, the gamification techniques such as the definition, the examples, and the models (around half an hour). Then, ten designers were divided into several groups, with each group having two or three people. They followed the gamification design models and proposed several ideas (around half an hour). Lastly, every team presented their ideas, and held a discussion between all the participants (around one hour). The outcomes from the design workshop were valuable and productive. The game designer could share the game mechanisms knowledge, the urban designers shared their ideas around "city walk" and how a spatial environment and visually impaired people interact with each other. The interaction designer contributed his knowledge to the app experience design. Last but not least, the service designer put her effort into the service design in general to see how the system works between the stakeholders and the elements around them. The ideas generated from the exploratory design workshop can be seen in *Figure 3.10*.

Figure 3.9. Exploratory design workshop

Figure 3.10. The Ideas generated from the exploratory design workshop

3.3.2.4 Iterative Prototyping

An iterative approach involving prototyping and testing enabled me together with the participants to explore different optional designs without pressure to design the perfect interfaces. Since the series of testing plays a crucial role in the design progress, designers expected their designs to evolve continually. This benefits designers in two ways: first, designers did not spend too much time on developing the early version perfectly, and second, the time for testing and iterating was built into the project timeline in the early stage.

Usability testing enables developer teams to make live improvements to maximise user feedback. This method also provides the chance for researchers to conduct usability tests and later promptly change the design according to the feedback. Enhancing the design during the test enables the designer to gain more feedback in a short amount of time. Designers can quickly know whether or not it works when they change a design. This process facilitates designers to pay close attention to the layouts that receive more positive feedback. The "Think Aloud" Protocol was utilised to conduct the user testing. Ericsson and Simon (1984) first introduced the Think Aloud Protocol (TAP) as a means of encouraging users' feedback, opinions and actual reactions while conducting interaction testing (Goodman, Kuniavsky & Moed, 2012). Users are literally asked to "Think Aloud" during or after the testing (Makri, Blandford, & Cox, 2011). It could be carried out to understand the user's "natural behaviours" (Makri et al., 2011).

In the process of the iterative design, I not only show the app design to the stakeholders but also demonstrate the app design to related experts, while conducting expert interviews. Through the expert interviews, I gained valuable feedback by interviewing experts who offer a holistic view on this study and offer the perspectives of organisations, for example, NGOs and social enterprises. In particular, the officers who work in social enterprises encouraged me to consider the business model of the app. Selected of the experts involved in the project are shown in *Figure 3.11*. *Table 3.1* displays the list of experts I interviewed.

Figure 3.11. The expert interviews

Table 3.1 Expert interviews

	Time	Location	Title	Organisation/ Social Enterprises
Richard CHUI	November, 2016	Hong Kong	Founder	Searching & Exploring with Speech Augmented Map Information App
Remy WONG	January, 2017	Hong Kong	Principal	Ebenezer School
Polly	January, 2017	Hong Kong	Social Worker	Ebenezer School
Lai Sir	January, 2017	Hong Kong	Vice principal	Ebenezer School
Chris	January, 2017	Hong Kong	IT / Mobilty	Ebenezer School
Michael FUNG	October, 2017	Hong Kong	Founder & CEO	iSEE Mobile Apps
Rico CHAN	February, 2018	Hong Kong	Founder & CEO	Beyond Vision Projects
John Sharp	April, 2018	New York City	Professor in Game Design	Games + Learning School of Art, Media + Technology Parsons School of Design
Gus Chalkias	April, 2018	New York City	Assistive Technology Specialist	Helen Keller Services
Marie Landais	April, 2018	New York City	Orientation & Mobility Specialist	Helen Keller Services
Peter WONG	May, 2018	Hong Kong	Principal IT Consultant	Hong Kong Blind Union
Cora CHU	May, 2018	Hong Kong	Chief Executive Officer	Dialogue in the Dark
Haidi	November, 2018	Guangzhou	Founder	The Robins Accessibility Travel Agency
Sean FONG	December, 2018	Hong Kong	Manager	Factory for the Blind
Dr. Dawning LEUNG	January, 2019	Hong Kong	CEO & Principal Trainer	Audio Description Association (Hong Kong)

3.4 Summary of the chapter

This chapter has examined the research methodology related to the study. In the first section, the empathic design research was discussed, which involved the literature review and the empathic experience exercises in the study. I conducted different empathic research strategies at the very beginning stage of this research because of empathic exercises about problem-finding instead of solution-seeking (Battarbee, Suri, & Howard, 2014). Then, based on the empathic design research, the sensory ethnography methodology was addressed. The data collection, including background research and studies, was also explained, followed by the data analysis. With in-depth understanding, people with visual impairments, methods such as empathic design research and sensory ethnographic methods can assist the researcher to leave behind preconceived thinking.

CHAPTER 4: INSIGHTS INTO THE TARGET AUDIENCE

After presenting the three methodological approaches adopted in the research design, this chapter focuses on presenting the findings from the first two approaches, namely, secondary research and field studies. The qualitative research results generated from interviews and observations shed light on the practical aspirations of visually impaired people concerning being a target audience for app design. The accessibility guidelines for designing and developing mobile applications are summarised based on the secondary research.

This chapter is organised into five parts. The first part presents the everyday life of visually impaired people, whereas the second describes the general needs of visually impaired people. The third section is devoted to the target audience's special needs for app design, and in the fourth part, the guidelines and regulations for designing apps in both Hong Kong and internationally will be presented. How the analysis of existing app design relates to visual impairment and other fields informed that the final app design would be addressed in the last part. These five parts justify and explain the function and features of the app design in *Chapter 5* App Design Experiments.

The findings in the first, second and third part are all derived from the thematic analysis of interviews and observations conducted in Guangzhou and Hong Kong. As I wrote previously in *Section 3.3.1.6*, Thematic Analysis offers a useful and flexible approach for me to analyse the rich, complex and intensive data from the interviews and observations

(Braun & Clarke, 2006). The analysis was executed adopting the ATLAS.ti, the qualitative data analysis computer software. I was open to seeking findings that had not been demonstrated in the past investigation; hence, the method was conduct coding by following the "bottom-up" inductive in which data are gathered and a theory established as a result of data analysis used in this project and the "top-down" deductive approaches which develop or follow a theory and hypothesis (Saunders, Lewis, & Thornhill, 2007). I followed the six steps of thematic analysis (Braun & Clarke, 2013) described in *Section 3.3.1.5*. After organising and analysing the observations, interview materials and photographs, they were categorised into eight themes.

Actual quotations from the participants generated the following categories of the research. The coding scheme consists of the following eight categories, with themes in each category (*Table 4.1*).

Table 4.1. Categories and themes

Section	Categories	Themes
4.1	Attitude as aspiration	1. meaningful life, 2. eagerness to learn, 3. challenging oneself, 4. sharpening one's skills, 5. accepting reality
	Training	1. navigation training, 2. self-navigation skill, 3. clock position training, 4. training to become independent, 5. cognitive training
	Sensory compensation	
4.2	Interests	1.relaxation activities, 2. social activities, 3. travelling, 4. others
	Difficulties in everyday life	1. the need to be accompanied, 2. inadequate audio description training, 3. obstruction of tactile guide paths
	Accessibility Issues	1. regional differences, 2. government assistance, 3. assistive technology, 4. public assistance, 5. special design
4.3	Design inspiration	app design suggestions
	App design	1. app advantages, 2. iPhone's functions, 3. limitations in apps, 4. limitations in games, 5. difficulty of use

The first three categories in the table above, namely, 'attitude as aspiration', 'sensory compensation', and 'training' will be discussed in *Section 4.1*. *Section 4.2* covers the categories of 'interests', 'difficulties in everyday life' and 'accessibility'. The last two categories of 'design inspiration', and 'app design' will be discussed in *Section 4.3*. All citations appear in quotation marks in the body of the text or, if extensive, in indented blocks for ease of reading. Excerpts from interviews are included to provide actual-voice to the interviewees and have been selected as instances that represent the collective themes.

4.1 Everyday Life of People with Visual Impairments

There are three categories in this section: ‘attitude as aspiration’, ‘sensory compensation’ and ‘training’. Despite the difficulties that people with visual impairments may face, they still live positively in general. They are trained to employ their other senses, like the sense of hearing, smell, touch, and taste to perceive the world when they studied at school when they were young.

4.1.1 Attitude as Aspiration

The data suggest that people with visual impairments generally have a positive attitude towards life. This section focuses on this positive mindset, which will be demonstrated in the five themes below:

- ‘meaningful life’
- ‘eagerness to learn’
- ‘challenging oneself’
- ‘sharpening one’s skills’
- ‘facing facts’

In this context, ‘meaningful’ means they can take part in activities which seem impossible because they are visual such as watching television, doing artworks and travelling from their sighted peers’ point of view.

The interviews highlighted the capacity and ability of people with visual impairments, and a social worker at the Ebenezer School said that: *“What you can do, they can also do”*, and gave an example: “They ‘watch’ TV through listening to the sound to understand the content and they ‘watch’ movies through the audio description.

The following *Figure 4.1* photographs show the examples of how students at Ebenezer school participate in a range of activities regardless of their impairments.

Figure 4.1. Ebenezer school students participate in various activities

Every interviewee highlighted how smartphones have made their life better. The social worker in the Ebenezer School stressed that people with visual impairments can enjoy their life much more because of smartphones: *"The lives of people with visual impairments are quite meaningful and fun"* and suggested that this is because of their access to smartphones (see *Figure 4.2*).

Figure 4.2. People with visual impairments using smartphones

Similar to travelling, sighted people may think it is pointless for people with visual impairments to travel because they cannot see at all. However, as expressed by one visually impaired respondent: *"I can 'see' the scene by experiencing the atmosphere."*

She shared her travelling experience when she travelled to Nepal to exemplify this point:

> *In Nepal, I was "watching" students leaving school. Firstly, there were junior-grade students leaving school; they were running and jumping out from school happily. Then, there were intermediate grade students coming out from school, who tried to act mature and not show how happy they were. Finally, senior-grade students were coming out from school, who behaved like adults, just chatting with each other.*

During the observations at the Ebenezer School and Hong Kong Blind Union, I noted that even though people with visual impairments lack the ability to see well, they put effort into learning through their laptops and books (see *Figure 4.3*).

Figure 4.3. Ebenezer School students studying from books and using laptops

When students with visual impairment study at school, they are encouraged to take care of themselves. *Figure 4.4* shows a poster from the Challenge Themselves campaign poster. It was posted on the wall at the school. The poster suggests that students challenge themselves, such as take off/put on clothes, organise their clothes, and do the housework. If they challenge successfully, they can get two stamps, and if not, they can get one stamp. When they successfully challenge themselves, they can join the peer challenges; the winner can get two stamps. Four stamps can be exchanged for a secret reward (see *Figure 4.4*).

Figure 4.4. Challenge themselves campaign poster at Ebenezer School

The majority of the interviewees emphasised the fact that they wish to challenge themselves even though they understood how difficult it would be. One of the interviewees conveyed his wish saying:

Yes, I really want to travel abroad by myself. I have never tried it before. I would love to try to travel abroad by myself. No matter how difficult or what the result is, I would like to have this experience at least once.

The interviews suggested that many people with visual impairments be eager to sharpen their skills instead of stay at home in their comfort zone. A 38-year-old male said that he loves travelling because it allows him to challenge himself and learn something new.

Another respondent accentuated that:

I think I want to fit into non-disabled people's lives. I mean we can do things together that make me feel satisfied. We can do what you can do. Not just things you can do with sight, but that I can do even though I cannot see.

While willing to learn and cope, they may be concerned about other people's attitudes. For example, a 40-year-old Hong Kong interviewee suggested that:

Some people do not know much about us; they try to make us happy. However, what we need are people to say things to us directly, which can make us grow. Please do not try to make us happy by hiding the truth. Please tell us the truth otherwise it will make us stop growing.

He provided a detailed description of the importance of facing the facts:

[…] *For example, when I was young, I thought we had more advantages than sighted people. We could not see therefore our sense of hearing should be excellent. My teacher corrected us and told us this is a shallow idea. If so, people with visual impairments could just use a stethoscope to check a patient's body. However, only doctors had the ability to do it.*

Another interviewee placed emphasis on this fact, too.

My teachers clarified to us that the other senses of visually impaired are not stronger than normal people. The only reason we can use our other senses better is that we use them frequently. For example, there are seldom famous musicians who are visually impaired.

The principal at Ebenezer School also stated the following fact that when they teach students at school: *"Visually impaired students have lost their sight, but their other senses are trained to be greater."*

During the interviews, all participants mentioned their travel experiences while talking about their positive life experiences. Furthermore, they emphasised how smartphones have changed their lives in a salutary way. That is the reason why I chose travelling with the support of a mobile phone as the main focus of this project.

4.1.2 Training

Before exploring the ways of improving the travel experience of people with visual impairments, it is critical to discuss the background information regarding how people with visual impairments are trained. The following themes can categorise the skills that they acquire:

- 'navigation training'
- 'clock position training'
- 'self-navigation skill'
- 'training to become independent'
- 'cognitive training'

The processes and the interviewees' views about the training section will be discussed in detail in the following section.

Orientation and Mobility Training is one of the most critical pieces of navigation training for visually impaired students in the blind school. Orientation and Mobility (O&M) training is a profession-specific method to train people with visual impairments about effective, efficient, and safe travel. "Orientation" means the capacity to perceive where you are and where you want to go, such as you are moving from one place to another or going to work. "Mobility" means the capacity to move effectively and safely from one location to another, such as being able to move without falling, and take public transportation.

The first process of navigation training involves memorisation. When students enter a new room, they have to memorise, for example, where the restroom is located by touching the objects in the room. As one participant pointed out, they could not memorise the location of the objects once, so they have to practise hard. *"We people with visual impairments have to put more efforts into memorising things than normal people."*

However, when they are outside their home, they also mentioned they cannot always memorise many steps between every two objects. *"Many people think we remember the route by counting our steps. However, I cannot memorise all the steps."*

Another aspect of navigation training is combining one's memories and senses. One subject expressed how he used his memory and his senses when he went out.

> *I usually will touch and count the telegraph poles or the pillars. I remember there is a bakery where I can smell the bread aroma so that I can recognise the location.*

Another interviewee used other senses to navigate.

I will also use different points to help me to navigate: if I feel cold air it means I am close to the entrance. There is a 7-11 convenience store near my home. There is a supermarket around the corner, and each time I smell the unique aroma of the supermarket, I know I am close to my apartment. After turning the corner, I can hear the sounds from 7-11, such as the sound of payments made by Octopus cards and the alert sound when customers go into the 7-11. I just try to find some points for navigation to assist me in memorising the routes. I will use pillars to locate myself.

The essential skill of Orientation and Mobility is clock positioning where the relative direction of an item is described using the analogy of a 12-hour clock. When showing the direction to people with visual impairments, people are recommended to refer to these clock positions (see *Figure 4.5*). "This way" or "that way", meanwhile, is very unclear and imprecise for some interviewees. The method of positioning employing clock position is a metaphor designed for the visually impaired to indicate directions. Based on the same interviewee, the principle is straightforward. One can imagine his/her visually impaired friend as the centre of a clock. Right in front of your friend is twelve o'clock and right after him/her is six o'clock. For example, there is a traffic light pole at your three o'clock direction. In this vein, visually impaired people can understand the directions more easily and precisely.

Similarly, people with no visual impairment can adopt this method to tell total blindness people the locations of objects. For example, we can indicate the location of food: the steak in three o'clock direction, the salad in six o'clock direction, a bowl of rice in nine o'clock direction, and drinks in twelve o'clock direction. This is how students with visual impairments are trained about clock direction at the blind school. At the beginning of teaching clock position, as most of the students cannot see, the teacher needs to refer to familiar objects, such as sticks to represent the hour hand and minute hand which they have never seen before. At the same time, teachers make tangible objects such as crafts in the craft room. The purpose of using tangible crafts is that people with visual impairments need to touch them to feel them. In this case, teachers make a paper clock as big as a pizza to let the students touch it. The reason for making the clock bigger is that it is easier to touch. One of the interviewees mentioned:

> *You can imagine that you are in the centre of a clock. Across from you is 12 o'clock, and your back is 6 o'clock. By analogy, you need to know how this method works.*
>
> […]
>
> *My teacher told us that there are two long sticks. The short one called the hour hand, the long one called the minute hand, and you touch it yourself. I have to touch to feel the clock. We have imitated the clock face of your normal clock. The clock face is as big as a pizza because we need to touch the clock face to sense how the clock hands are.*

Another interviewee described how his teacher was training his Orientation and Mobility skills:

> *I remember the positions of immobile things around me as reference points when I go out. They must be immobile things, not temporary things such as carts or trashcans, that will be moved soon. My teacher told me there are some bus stations next to me when I go out of the building. Moreover, there are handrails and trees to my left. I have to count the handrails before arriving at the fourth tree; then I must turn to my two o'clock position.*

Figure 4.5. Clock position training

One of the interviewees mentioned that they had to pass several tests according to the position of a clock training. He described the test as follows:

> *The teacher would throw a ball that produces special sounds, and I needed to tell the teacher the location of the ball regarding the position of a clock. Also, I was also asked to describe how many steps there are between me and the ball. Then, I need to find the ball. I can only pass the exam if I correctly find the ball in nine out of ten attempts.*

Indeed, people with visual impairment are encouraged to try doing things by themselves before asking for help. The principal at Ebenezer School stated the importance of being trained to be independent: *"We teach our students that you should try to do everything by yourself before you seek other people's help."*

Cognitive training for visually impaired students includes the use of their other senses, referring to the sense of smell, sense of touch, sense of hearing, memory, and imagination. Interviewees regarded sensory compensation as a basic coping strategy. Therefore, sensory compensation will be discussed in detail in the next section.

4.1.3 Sensory Compensation

There is no doubt that totally blind people who have lost their eye sight try to use their other senses to experience and sense the world around them. Thanks to the multisensory participant observation and interview, I was able to obtain detailed "sensory compensation" evidence from the interviewees. All participants highlighted the magnitude of sensory compensation such as adopting auditory, olfactory, taste and tactile experience for people with visual impairments.

In school, teachers will teach students cognition in sensory compensation. *"Teachers teach us basic cognitive training such as what we can eat and what we cannot eat by using our noses."*

There is the sensory park for training students' senses in the Ebenezer School (*Figure 4.6*).

Figure 4.6. Sensory park at the Ebenezer School

The teacher at the Ebenezer School shared how his students recognise their desks. Since the desks in the blind school can be fully opened (see *Figure 4.7*), students with visual impairments will open the desks to touch and feel the arrangement inside the desk.

Figure 4.7. Arrangement of objects in the drawer

Sensory compensation by people with visual impairments is evident in the following quotations: *"When my sight deteriorated, my mind tried to focus on other things such as what I heard rather than what I saw."*

Interviewees gave examples to demonstrate how they use their non-visual senses such as the sense of hearing, taste, touch and smell to assist themselves in perceiving the world. One interviewee gave an example:

> *As I approach a place slowly, I will always try to hear my footsteps. I can feel the change of the environment around me. If my skin becomes wet or cold, I know there is an entrance of a building since there is always an air conditioner near the entrance.*

Another participant touched on the same point:

> *I use my senses a lot. I can distinguish different sounds. On my way to the Blind Society, I hear the sound of construction work, and my shoes can feel the uneven wood boards. Above all, I know it is under construction now. Also, I will try to keep away from the construction zone.*
>
> [...]
>
> *As I cannot see, I must try hard to find a way to get to know the outside world. I cannot always rely on the sense of touch, so I need to use the sense of hearing to experience the outside world.*

The sense of hearing is quite significant: *"When I use a white cane, I will tap the white cane and use my senses to see whether there is a barrier on the road. I use my sense of hearing to recognise the different sounds, too."*

When they travel, they use their other senses to perceive unfamiliar environments: *"When I travel, I try to build a sense of space in my mind. In the hotel, I will walk around and try to get to know which place has what."*

I was impressed by how perceptive people with visual impairments can be to feel the world by using their other senses. This can be shown in their travel diary. As stated by one informant: *"In my travel diary, I describe the whole environment. I describe the whole atmosphere that I experience."*

She then shared her experience about how she used her other senses to feel the atmosphere when she travelled around Tibet.

> […] *We arrived very early. I could feel the golden sunlight from the sunrise. I can hear the sound of birds and the sound of the river. It is quiet there, with no cars. I can smell the aroma of the flowers and fresh air. All the sound and the atmosphere blend together.*

After she wrote her travel experience diary in Tibet, she showed the diary to her friends with sighted peers who also travelled to Tibet with her. Her friends were surprised by how she focused on the description of the sounds and smells that they usually do not notice.

This section demonstrates that people with visual impairments are being positive with their lives. The findings can be approached from the point of view of Maslow's Hierarchy of Needs and Self-Determination Theory. The results show that the participants want to achieve self-actualisation, such as challenging themselves and sharpening their skills once they have satisfied their physiological needs. Pearce (2005) stated that as a tourist, in an unfamiliar environment, can contribute to one's personal development. He also mentioned that travel can offer a chance to show one's capabilities, achieve a feeling of accomplishment and obtain a feeling of self-confidence. This finding resonates with Small et al. (2012, p. 946) who state that "for many sighted tourists, travel is an achievement, for those with vision impairment, this achievement can be profound". The findings also demonstrate that knowing one has overcome challenges in an unfamiliar environment can help one to cope with day-to-day challenges in familiar places and can prove that they can do it. This section also provides detailed information about how they are trained to use their other senses to engage with the world. By understanding their training, it enables me to understand their special skills which can be used for further design. The findings in this section are consistent with the existing literature from other countries that many visually impaired people can make use of their remaining vision supplemented by their other senses (especially sound and touch) and their kinaesthetic skills (the capacity to feel and sense things) (Richards et al., 2010). There are valuable results in the sensory compensation section, which can also be considered in app design functions, such as the usage of audio description, and how to utilise different senses to enable their travel experience.

4.2 General Needs of People with Visual Impairments

The interviewees were generally very positive about travel and socialising with other people. They also demonstrated a desire to play games on their iPhone. Therefore, I considered adding gamification elements to the app design to enhance engagement, motivation and enjoyment in the travel experience.

This decision was further strengthened by separating the 'general needs' section into three categories of 'interests', 'difficulties in everyday life', and 'accessibility' with a detailed analysis of each as in the following.

4.2.1 Interests

Under the theme 'interests': there are four sub-themes which are:

- 'usual relaxing activities'
- 'social activities'
- 'love travelling'
- 'internal needs'

People with visual impairments can join various activities just like sighted people. During the observation at Ebenezer School, I found that there are many activities, such as chess, which have been adapted specially for the students (*Figure 4.8*).

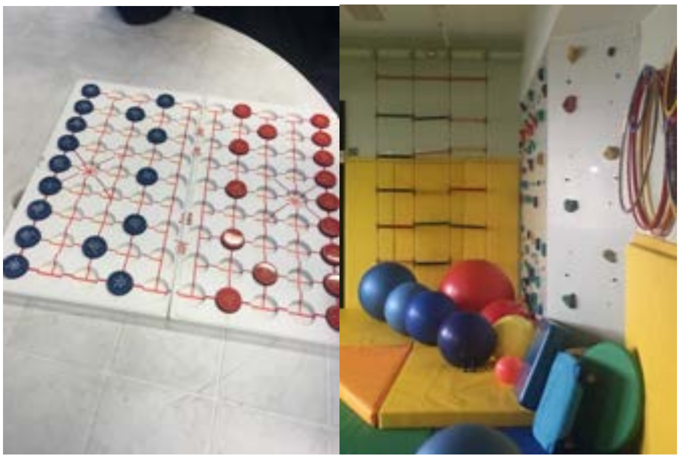


Figure 4.8. Activities adapted specifically for the students

Despite potential difficulties that people with visual impairments are generally perceived to face when venturing into the outside world, the study showed that, by contrast, they show great enthusiasm when given the opportunities to leave their home. During the interview, the majority of people mentioned they love going out to attend activities. One interviewee stated: *"We will go out to attend some activities just like normal people. We will yum cha and eat dim sum with friends."*

Some of them mentioned that they sometimes go running with staff from organisations which offer support to the visually handicapped such as Guangzhou Blind Union. Furthermore, even when not participating in other kinds of activities, they also feel satisfied even simply strolling along the streets. As one of the interviewees said: "I sometimes just dawdle outside, walking and then stopping. In the summer, I will also just go out for the cool air from shops in the street."

They also love sharing their lives with their peers: *"I love to share where I went and what I ate in the 'WeChat Moment' because I want to share my experience with my friends."* Another interviewee commented that:

> *One of my friends, who is totally blind, enjoys sharing photos on social media. She takes photos everywhere, such as when she is on the bus, sitting in a traffic jam, even though she cannot see anything. She posts several photos every day, sometimes they are a bit pointless.*

Since the study focuses on travelling experience, I will concentrate on the theme of travel in this section. The majority of respondents expressed a passion for travel, that they do not want to always stay in one place, so they like travelling. They can come into contact with the outside world by travelling both locally and overseas. They can also experience the lives of able-bodied persons. Although they cannot see, they can still do the same things as sighted people.

The interviewees also wanted to try new things and experiences. As stated by one participant:

I gain different experiences when I travel. I have been to South Korea in the winter, and it was my first time to experience snow. I also visited Taiwan to try different kinds of food. When I went to Shunde in mainland China, it was my first experience of a hot spring.

The most important thing is they can learn about different cultures in different places. Although they cannot see, they still want to use another way to experience the culture customs and surroundings of local people, which was supported by another of my subjects who commented:

As the old saying goes, 'It is better to travel ten thousand miles than to read ten thousand books.' I wished to travel around when I was young.

In addition to their love of learning new things, the interviewed people with visual impairments are eager to travel because they can experience a new culture. One subject stated what she felt and experienced with local people when she travels to different countries.

I experience locals' lives by meeting them. In Northern Europe, I took a walk near the hotel, and some local people greeted me, and I could sense that their life is peaceful and happy. In Vietnam, there were many motorcycles on the street. I could see their general outline, and I could hear the sound of motorcycles. I could also experience native people's music, food, and the games children play.

Regarding the local culture, trying the local food is an essential activity in experiencing the local culture while travelling. Those people with visual impairments emphasised that they loved trying the local food while travelling, and one of the interviewees stated that: *"I will use the food* *app to discover the local food."* Another interviewee shared his experience of using his senses when he travels to different places.

> *Compared to Guangzhou, it is dry in Beijing. I can smell the dry and cold air while the air in Guangzhou is wet and cold. When I visited the suburbs, such as the Baiyun Mountain, the fresh air made me feel relaxed and alive. I love to talk with the locals to get to know their customs.*

Although people with visual impairments cannot see the scenes, it does not necessarily mean that they cannot engage with the atmosphere, the customs, the food and the locals.

One of the most prominent benefits of travel is that it allows people with visual impairments, at least temporarily, to focus less on their disabilities and more on the experience of travelling itself such as experiencing local customs and habits. Travel will widen their outlook.

> *I know there are some visually impaired people who stay at home and complain about their disability. When I travel, it broadens my horizons, and I become more open-minded. I will not focus on the condition of my eyes too much. The world is big with beautiful scenes.*

However, most of the interviewees stated that when they travel, they realise that it is not necessary to focus all their attention on the issue of their eyes.

The study confirms that while people with visual impairments are travelling, they are in the flow experience, which shows a user's state between boredom and anxiety, that experience that focuses more on the travel experience and less on their eye issues (Csikszentmihalyi, 1990). The findings of the attitude to travelling in this section are consistent with much of the existing research depicted in Hong Kong (Packer et al., 2007).

4.2.2 Difficulties in Everyday Life

People with visual impairments encounter many difficulties in their lives. Under the theme 'difficulties in everyday life', there are three sub-themes which are:

- 'the need to be accompanied'
- 'inadequate audio description training'
- 'tactile guide paths obstructed'

Most of the interviewees stated that they needed sighted counterparts to go with them. This is because sighted counterparts can describe the scenes for them. One of the interviewees stated that he could not travel by himself because he cannot enjoy it at all. He still needed friends to describe the scenes for him.

Even though people with visual impairments have friends to go out with them, they still face challenges. Some interviewees complained about their travelling experience with sighted people. In view of the less audio description training, sighted people do not know how to describe the surroundings when accompanying people with visual impairments on outings. One of the participants expressed his dissatisfaction when his sighted peer accompanied him while travelling: *"My friend only told me that there is a lot of grass there, how beautiful the sun is today, and there is a lot of garbage on the beach."*

Even people with visual impairments do not how to describe the surroundings if they are not trained in audio description. One respondent with low vision shared her experience when she accompanied three people who are totally blind on their outings.

I have been diagnosed with low vision, so I can see a little bit. I once told them there are trees on both sides. However, they complained to me that 'you only tell us there are trees, can you describe them in more detail?' I then learned how to accompany the totally blind people gradually. When I accompanied them when we took a bus, I would tell them what shops appeared outside the windows. Alternatively, I would introduce where we were heading to next.

Therefore, audio description training with detailed descriptions in real time needs to be enhanced. Visually impaired people need sighted peers to describe their surroundings when travelling. However, visually impaired people currently have to accept the information passively, even though they wish to obtain and control the information by themselves. This is in accordance with the self-determination theory (Deci & Ryan, 2000) where the following three factors are identified as intrinsic motivators: autonomy, competence, relatedness.

There are some people who stand in or occupy the tactile guide paths which make it inaccessible. One interviewee said that "[…] *even though I said excuse me, they will ignore you."*

Understanding such obstacles enabled me to design a better experience for the target users.

4.2.3 Accessibility

Under the theme 'accessibility', there are five sub-themes which are:

- 'regional differences'
- 'government assistance'
- 'assistive technology'

- ‘asking people’
- ‘special design’

Accessibility varies from area to area in different regions as commented by one interviewee.

In Hong Kong, it is safe for visually impaired people to walk in the blind track by using a white cane. However, I do not think drivers will let you go first in China. The blind track is terrible in China. As such, I think the visually impaired in Hong Kong can walk independently.

Another interviewee compared the accessible pedestrian signals (APS) in Hunan, Beijing and Hong Kong.

Compared to Beijing, the accessible pedestrian signals (APS) in Hunan are not as loud as in Hong Kong. Not all the traffic lights support APS, so only the main routes have it. All the traffic lights in Hong Kong have APS. The sound in Hong Kong is loud enough to stand out from the traffic sound. When I cross the road, I usually use my sense of hearing to listen to the sound volume to make sure I am walking in a straight line.

Another interviewee shared his travelling experience of the regional accessibility differences. The traffic lights in Japan are worse than the traffic lights in Hong Kong due to the sound being low. However, the lifts in Japan are better than the lifts in Hong Kong, because the lifts produce a sound to indicate to the visually impaired the floor information, whether the lift is going up or down, and whether the door is opened or closed.

The Hong Kong government fully supports the community of people with visual impairments. As stated by one of the interviewees, there are mentor services for them to be familiar with the community when they move to a new area.

I lived on Hong Kong Island a few years ago. I only moved here in the past few years. For example, when I first came here, our neighbourhood committee found a mentor to assist me. First of all, he explored the community with me. Then the mentor taught me how to commute from my home to my office, such as how to take the subway, and how to get to Central Hong Kong by Ho Man Tin Station.

The Hong Kong government also trains volunteers with audio description skills that enable people with visual impairments to visit museums and watch films. However, there are not enough volunteers and it cannot provide services at all times.

The book for people with visual impairments is much thicker than the normal one (see *Figure 4.9*).

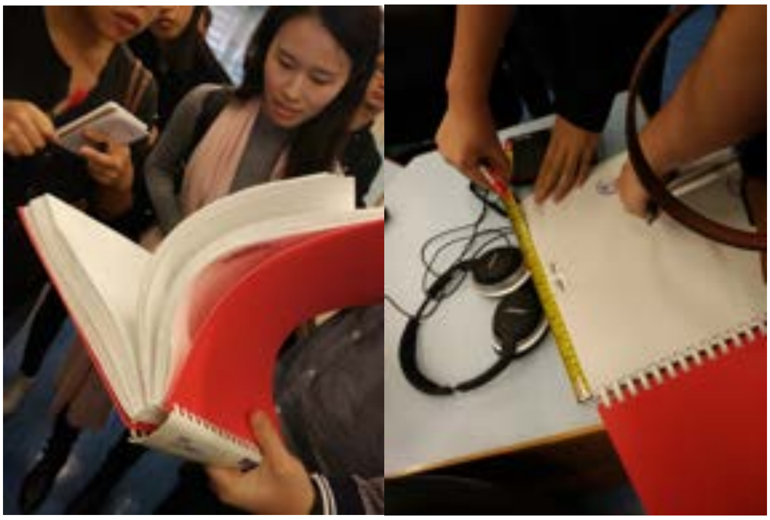


Figure 4.9. Textbooks for people with visual impairments

Many interviewees mentioned they would seek help from other citizens if they cannot solve something by themselves while they are on outings. The findings in this section draw our attention to the importance of considering gamification strategy for app design, which enables people with visual impairments to have a travelling experience that is more engaging, motivating, and enjoyable.

4.3 Implications for App Design

All the insights and findings presented in this chapter assisted me to design a better travel app for people with visual impairments. Nonetheless, during interviews, the participants also referred to existing app features and made recommendations for new features. These are discussed in the following.

4.3.1 Design Recommendations

All of the interviewees provided helpful suggestions for the app design. They all agreed that ensuring the accessibility features on the iPhone is the most fundamental issue. All of them recommended that knowledge and information could be fully provided in the app design. In this vein, the detailed description, as well as the audio description for the destination, are vital. For example, one completely blind person complained: *"When I travelled to the suburbs, my friend only told me there is a forest, waterfall, and river in front of me. I want more detail about it."* This was remarked by another interviewee:

When I travel to historical sites, I want to know more information about them. I would search for the places I would travel to on the internet in advance, but I cannot associate the information with the site.

They also suggested that travelling apps provide various recommendations that users can follow. There is another interesting point that when asking participants for suggestions about the app design, all of them would emphasise some key points, such as the detailed description needed while they are travelling. However, because the questions focus on design enhancement, interviewees were able only to provide some suggestions based on the existing applications they had tried. Also, the features of the existing applications were limited. Therefore, the users did not know what the application could be in the future, and they did not fully articulate the exact need. The emotional and psychological needs, which seem to be intangible elements, were hard to present. Therefore, the in-depth interviews about their past travel experience were useful, which can be added to the app design recommendation.

4.3.2 App Design

The sub-themes in App design are:

- 'app advantages'
- 'iPhone's functions'
- 'limitation in apps'
- 'limitations in games'
- 'difficulty of use'

All interviewees emphasised that mobile apps assist them in different ways. Navigation and object recognition are the two main app categories that most interviewees mentioned they could gain benefits from in the existing applications. For the navigation function, they use *Google Map* a lot. When they go out, they also need to take transportation. Therefore, they need to use a bus app to gather information. With the bus and navigation app, they can go out more easily compared to before. For example, the *KMB* app, a bus information app, allows people with visual impairments go obtain bus information about when the bus will arrive in the station and also tell the users what the next station is, or how long it will be before they need to get off. When they travel, they prefer to use *Uber* or *DiDi* apps, an efficient mobility service, which can describe where they are and the driver can pick them up easily and drive them to their destination quickly. Another category is object recognition. Some of the interviewees mentioned they live alone, which holds various challenges. Therefore, object recognition apps help them a lot. They used an app called Scan and Translate to scan the text on paper, and the app will read the information aloud. They used an app called *Tap Tap See*, which utilises camera of the phone to recognise the colour, and objects around them. When they try to put on clothes, these kinds of apps help them to recognise colour and match styles. What makes the *Tap Tap See* stand out is that this app does not need users to take a photo, but only recognition by scanning the object. Although the recognition accuracy of these apps is not 100 percent accurate, the interviewees maintained that the object recognition helped them considerably, and they were positive about this technology. They had also mentioned that they also used apps such as *WhatsApp*, *WeChat*, and *Facebook*, which sighted people also use for social purposes. These apps have relatively satisfactory accessibility. Moreover, they 'read' news through the VoiceOver function in the apps such as *HK01* and *Mingpao*.

The interviewees complimented how the accessibility features in iPhone help the group of visually impaired users to enhance their lives a lot. The accessibility preferences can be found in (Settings > General > Accessibility) on the iPhone. As aforementioned, the 'VoiceOver' function integrated into the iPhone can turn all the text into speech to enable people with visual impairments to know what is happening on their iPhone. To support different types of vision challenges, such as colour blindness, the iOS system also allows users to invert colours, to reduce white points, to enable greyscale, or to choose from different colour filters. IOS has a built-in screen magnifier called Zoom that allows users to view the magnified area in an independent window while allowing the other part of the screen to remain at its original size. The interviewees were eager to show how the accessibility works on an iPhone. They can show different features to me by using the short cuts they set on the iPhone earlier quickly, as well as turn off and on the accessibility mode such as the VoiceOver function immediately. Users can significantly benefit from powerful accessibility features. However, enabling all the accessibility features, especially the VoiceOver function, would lead to much more power consumption. Therefore, there is another thoughtful design in the iPhone that allows users to turn on the 'Curtain' function that saves power by darkening the screen while retaining functionality. Apple has notably outstanding accessibility in the iPhone. However, the interviewees emphasised that all the accessibility features only fully work when developers ensure that the coding meets the requirements enabling the app to avail itself of all the accessibility features. During the investigation, the interviewees complained about the 'limitation in apps', and 'limitations in games' which will be presented in *Section 4.5*.

Thanks to mobile technology, people with visual impairments benefit greatly from the existing apps. The existing apps can meet their basic life requirements. However, the fact that the app can offer higher needs, such as psychological needs related to emotions, should be discussed. The accessibility features in iPhones are powerful and useful so that they should be fully used. In this way, when designers and developers create an app for visually impaired users should always consider the accessibility features in their minds and test the accessibility features of visually impaired users as early as possible. It is vital to follow the accessibility guidelines and regulations for app design.

4.4 Guidelines and Regulations for App Design

This section mainly describes the accessibility guidelines for designing and developing mobile applications internationally and more specifically in Hong Kong. *Section 4.4.2* will provide specific examples as evidence to support each principle in the guidelines.

4.4.1 International Guidelines

The World Wide Web Consortium (W3C), the leading global guidelines organisation for the World Wide Web, was founded by Tim Berners-Lee in the Massachusetts Institute of Technology (MIT) in 2014. Later, W3C promulgated the Web Accessibility Initiative (WAI) to promote the accessibility of the World Wide Web for people with disabilities in 1997. One of the most substantial accessibility guidelines in the WAI is the Content Accessibility Guidelines (WCAG), which covers a wide range of web accessibility guidelines. Following these guidelines will make digital content more accessible to a broader group of people with disabilities, including accommodations for speech disabilities, limited movement, deafness and hearing loss, blindness and low vision.

These guidelines demonstrate the accessibility of web content on laptops, mobile device tablets, and desktops. WCAG 2.0, the latest version, was provided in 2008 and became the International Organisation for Standardization (ISO) standard, ISO/IEC 40500:2012 in 2012. According to my research area, I only focus on how WCAG 2.0 and Other Web Accessibility Initiative (WAI) Guidelines are adopted in mobile applications and focus on blindness and low vision. Therefore, this section mainly concentrates on the guidelines, principles, and validated criteria of WCAG 2.0, which are used for mobile web content, hybrid apps, native apps, mobile web apps, and adopting web elements in apps (2015) for people with visual impairments. “Perceivable”, “Operable”, “Understandable”, and “Robust” are the four principles in WCAG 2.0. The following principles about mobile devices were selected from WCAG 2.0.

4.4.1.1 Principle 1: Perceivable

- Small screen size

One of the most typical traits of mobile devices is their small screen size. The small size of the screen limits the content that users can check at a time, particularly when people with low vision use the magnification function on mobile phones.

- Zoom/Magnification

A range of ways enables users to adjust information size on mobile devices with small screens. At the platform level, these techniques are available as accessibility functions to help visually impaired users. At the browser level, these techniques are usually available to serve a large number of users.

- Contrast

Compared to desktop devices, mobile devices are often used on various occasions, which include outdoors, where there is direct sunlight or other strong lighting sources which make it more challenging to read the screen. Therefore, people with low vision should access information with high contrast on mobile phones.

4.4.1.2 Principle 2: Operable

- Keyboard control for touchscreen devices

Although the majority of mobile devices have developed from built-in physical keyboards into devices that display an on-screen keyboard, keyboard accessibility is still as critical as ever, and mobile operating systems should allow external physical keyboards to be accessed.

- Touch target size and spacing

Various interactive components can be displayed together on a small screen because of the high definition of mobile phones. However, the interactive components should be big enough and have enough space from each other so that people can accurately select them by touching them with their fingers.

- Touchscreen gestures

Lots of mobile phones are developed to be operated through gestures on the touchscreen. The gestures could be simple, such as one tap with one finger, or complex, including drawn shapes, multiple taps, and multiple fingers.

- Providing device manipulation gestures

Besides touchscreen gestures, some mobile devices enable programmers with control options that are operated by physically controlling the mobile phone such as tilting and shaking it. When device manipulation gestures can allow designers to design creative user interfaces, this might become a challenge for people who cannot hold a mobile device. Many mobile operating systems offer workaround features that enable the user to simulate tilts and shakes of the device from an onscreen menu. That being so, even when device manipulation gestures are offered, designers should still offer keyboard operable alternative or touch control choices.

4.4.1.3 Principle 3: Understandable

- Changing screen orientation

Several mobile applications automatically adjust the screen to a specific screen orientation (portrait or landscape) and assume that users will respond by rotating their mobile devices. The user might give wrong navigation instructions if a screen reader user who cannot see is unaware of the shift of orientation. Therefore, app programmers should ensure the application can be detected by assistive technology such as screen readers when the mobile phones change in orientation.

- Ensuring consistent layout

Components should be presented in a consistent layout when they are repeated across multiple pages within one application.

- Placing essential page information before the page scroll

Many mobile devices with a small screen size limit the information that can be shown without scrolling. Placing essential page elements without scrolling can help users with cognitive impairments and users with low vision who have difficulty understanding information and processing it. Positioning essential information without scrolling the page ensures that those who utilise screen magnifiers can view the essential content without having to scroll.

- Grouping operable elements that execute the same action

Different elements that execute the same action should be positioned within the same actionable element. It helps users used keyboard and screen readers to increase the redundant focus targets.

- Providing clear indication that elements are actionable

Elements that can be triggered should be obviously distinguishable from non-actionable elements, such as content. The elements being actionable is relevant for native mobile applications, and web that has actionable elements such as links and buttons, should be provided with a clear indication. The actionable elements should use more than one distinguishing visual element. For visually impaired users, visual features serve as actionable elements including colour, style, shape, placing, traditional iconography, and a text label for action.

- Providing tutorials for custom device manipulation and touchscreen gestures

For lots of users, custom gestures can be difficult to detect and remember. Hence, instructions (such as tooltips, tutorials, and overlays) should be offered to interpret what gestures can be adopted to manage a given interface. From a practical perspective, the instructions should be offered anytime whenever the user needs them. Moreover, the tutorials should also be easily accessible and discoverable.

4.4.1.4 Principle 4: Robust

- Setting the virtual keyboard to the type of data entry required

The standard keyboard can be customised in the device settings. In addition, some mobile devices offer varied virtual keyboards depending on the type of data entry. For example, different keyboards will be shown automatically when users are typing information into that field. Setting the type of keyboard assists in preventing errors and ensures that information is correct.

- Providing easy methods for data entry

Users should input the information on mobile devices used different approaches, for instance, the Bluetooth keyboard, speech, touch, and on-screen keyboard. Text entry can be difficult and of low efficiency in specific situations. Providing radio buttons, select menus, checkboxes or by automatically entering known information (for example location and date) enable one to decrease the number of text entries needed.

- Supporting the characteristic properties of the platform

iPhones offer different functions to assist people with disabilities to access the content. The features include captions, larger fonts, and the zoom function. Different devices and operating systems provide unique functions and features.

4.4.2 Hong Kong

In 2018, the mobile phone penetration rate in Hong Kong reached 250% with 18 million mobile users, according to the Office of the Communications Authority in 2018. Mobile technologies have become widespread, targeting all parts of the community, which includes people with disabilities. Mobile devices and the internet provide great convenience to us. Indeed, an increasing number of people with disabilities use mobile devices with touch screen nowadays. Mobile applications and phones allow them to access the information and internet anytime and anywhere more effectively. Nevertheless, the society may have a wrong judgment that disabled users, notably visually impaired users, do not have the capacity to utilise mobile devices. Numerous mobile application programmers seldom consider the individual needs of those with disability. To aid mobile application developers and designers gain a full understanding of the accessibility needs from the disability groups of mobile applications, the Mobile Application Accessibility Handbook was enacted by the Hong Kong Government in May 2018. The handbook combined the feedback collected from the local disability groups and the WCAG 2.0 promoted by the W3C together. This section presents the typical mistakes that create barriers for people with visual impairments to use mobile applications. While developing a mobile application, developers could avoid such mistakes and implement proper coding methods. Following the Mobile Application Accessibility Handbook, the guidelines focus on the desires of people with visual impairments, which were divided into three main categories, namely, perceivable, operable, and understandable. In the following section, I will discuss the must-considered aspects by providing screenshot exemplifications.

4.4.2.1 Perceivable

The elements of the interfaces should be presented to users in ways that they can perceive.

- Providing text alternatives for non-text elements

People with visual impairments manipulate mobile phones using the text to voice function. Therefore, concise and meaningful text alternatives must be offered for non-text components such as icons, images, and buttons (except CAPTCHA and images designed for decoration). For example, designers should consider how to communicate the meaning of each button on a mobile application to visually impaired users who are using screen readers. Text alternatives should be short and no more than five words; therefore, they must have a concise and meaningful text description to read by screen readers. The text description allows users who cannot see know the visual information (see *Figure 4.10*).

Figure 4.10. Providing text alternatives for non-text elements

- Avoiding images of text

Designers should not use images to display textual information on the application. The text on the image cannot be read by screen readers; therefore, a text alternative should be offered for the picture (see *Figure 4.11*).

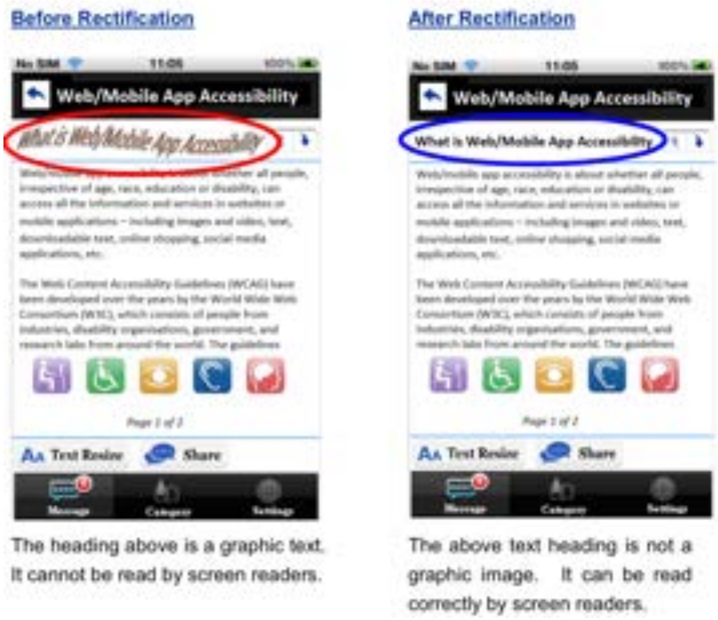


Figure 4.11. Avoiding images of text

- Ensuring that every function correctly when used with screen readers

Each navigation menu and button should work correctly when users use screen readers. Developers should test all the pages on mobile applications with screen readers to make sure the mobile application functions properly (see *Figure 4.12*).

Figure 4.12. Ensuring that everything functions correctly when used with screen readers

- Providing a resize function for font size and text

Some users still use cell phones with a small screen. Providing a scalable font size in mobile applications not only helps people who use small screen devices and elderly users but also facilitates disabled people to use mobile applications. It is necessary to enable users to enlarge the font size in their device. It should be possible for all text to be resized without missing information by offering zoom support or text resizing. Therefore, to be effective, with a text resize function enabled, people with visual impairments do not need to adopt assistive technologies such as screen magnifier but can view the information (see *Figure 4.13*).

Figure 4.13. Providing a resize function for font size and text

- Providing a meaningful content sequence

The layout of mobile applications should be designed in a logical order when the content needs to be read in a certain order. In the following figure, the headings and content will be read in the wrong order by a screen reader because the interface has been designed in a certain way. The reading order for screen readers should be from left to right and top to bottom if the screen page is correctly coded (see *Figure 4.14*).

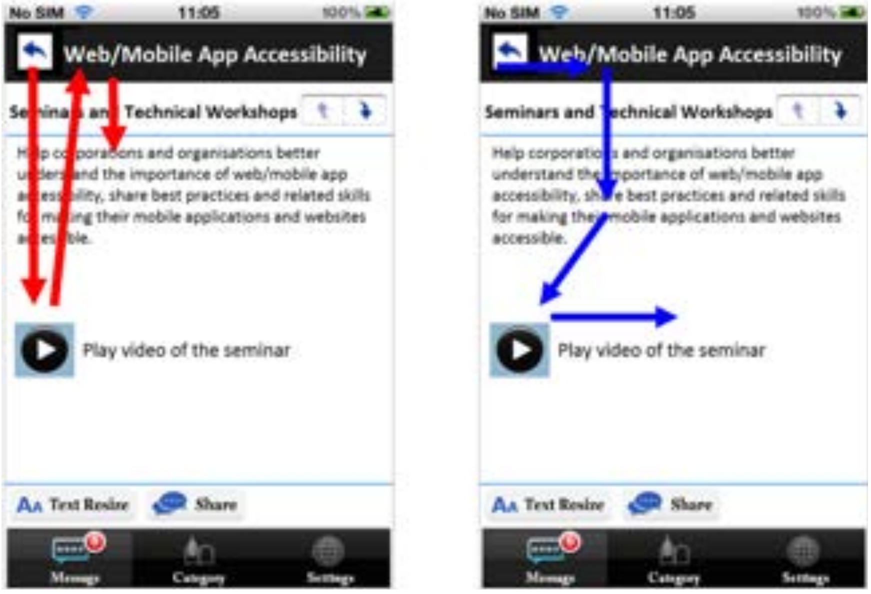


Figure 4.14. Providing a meaningful content sequence

Similarly, in the example below, the form has been designed so that the sequence goes from the Last Name, to Enquiry Content, then suddenly returns to First Name. With an appropriate logical sequence, screen readers would read the form in a logical order so that the sequence goes from the Last Name, to Enquiry Category, and finally to Enquiry Content (see *Figure 4.15*).

Figure 4.15. Providing a meaningful content sequence

- Do not simply rely on sensory characteristics for instructions

Do not only rely on one size, form, visual location, or sound to offer guides to the users. In the following instance, the next page button cannot be understood for people with visual impairments. The proper way is also to offer a text alternative to the button or label the button with clear instructions in a position noticeable for people (see *Figure 4.16*).

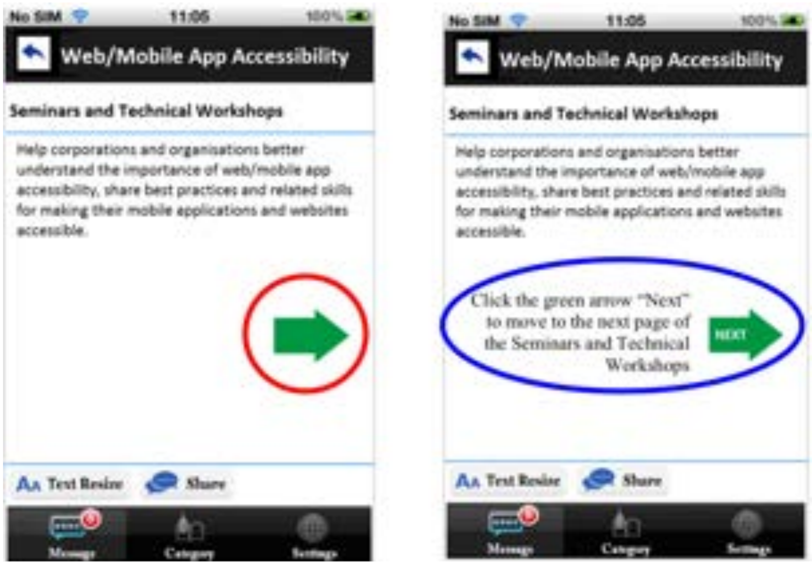


Figure 4.16. Do not solely rely on sensory characteristics for instructions

- Avoiding solely relying on colours to convey information

Do not only rely on colours to show information. Indeed, not all people can perceive colours in the same way (such as those who are colour blind or people with visual impairments), and information which seems evident to someone who might be omitted by another. In the following instance, titles in red refer to required fields. Yet, people who are colour blind or have visual impairments cannot detect the colour. By using an asterisk (*) after each label, colour blind people can still identify the mandatory fields (see *Figure 4.17*).

Figure 4.17. Avoid solely relying on colours to convey information

- Provide sufficient colour contrast

In order to make the text easy to read, designers should select proper background colours and text should have a contrast ratio of at least 4.5:1, called AA standard. In the following instance, the background colour of black and the heading text in purple colour has poor contrast, making the text difficult to identify. The higher the contrast ratio adopted, the easier the text can be read (see *Figure 4.18*).

Figure 4.18. Provide sufficient colour contrast

- Providing alternative means for notification

People with visual impairments and hearing impairments should receive more than one way of notification. The following instance merely offers a "Ringtone" choice for the warning of new messages, so that people with hearing impairments cannot perceive the notification. Both people with hearing or visual impairments can receive the alert when the application provides "Vibrate" and Ringtone choices for the alert of new messages (see *Figure 4.19*).

Figure 4.19. Provide alternative means for notification

- Providing a description for pre-recorded videos

People with visual impairments cannot see the visual elements but can only hear the audio when a video is playing in a mobile app. It should offer an extra description that interprets the content in the video for this group of people who cannot fully access all the content. From a higher-level accessibility perspective, the audio description of the video should be offered to interpret the scene changes, actors, actions, and the text on screen that is critical but is not spoken out or described in the soundtrack. The following example demonstrates a video to assist people with visual impairments in learning the ideas in the video. People with visual impairments can fully access the video information when the additional description is available, which interprets what is happening in the video (see *Figure 4.20*).

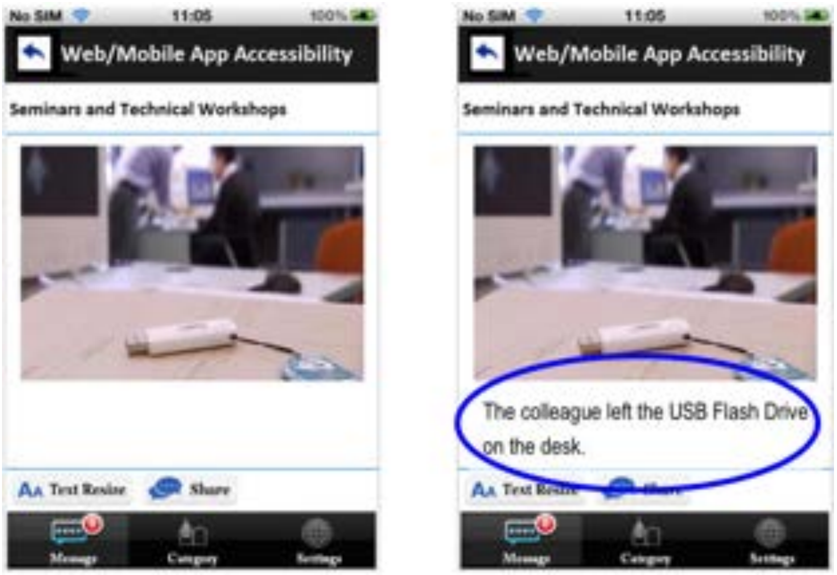


Figure 4.20. Provide a description for pre-recorded videos

4.4.2.2 Operable

The components and navigation of the app user interface must be operable.

- Ensuring navigation clearly and easily

A mobile application with poor navigation leads to difficult use for people with disabilities. An arrow button () associated with an appropriate text alternative enables the users to return to the previous page easily. In the following example on the left, there are no navigation buttons offered for users to return between the different pages. The back-arrow button enables users to jump to the previous screen page easily (see *Figure 4.21*).

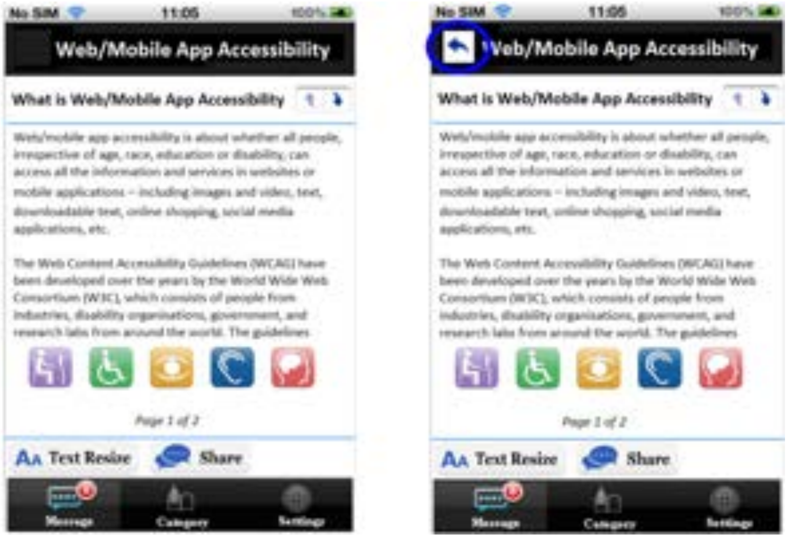


Figure 4.21. Ensuring clear and easy navigation

- Providing clear and simple headings

Providing a simple and clear heading and content in the app enables people with visual impairments to understand easily. On the left hand of the figure below (see *Figure 4.22*), the heading of the page is too long. Designers should offer clear and simple headings due to the limitation of screen size.

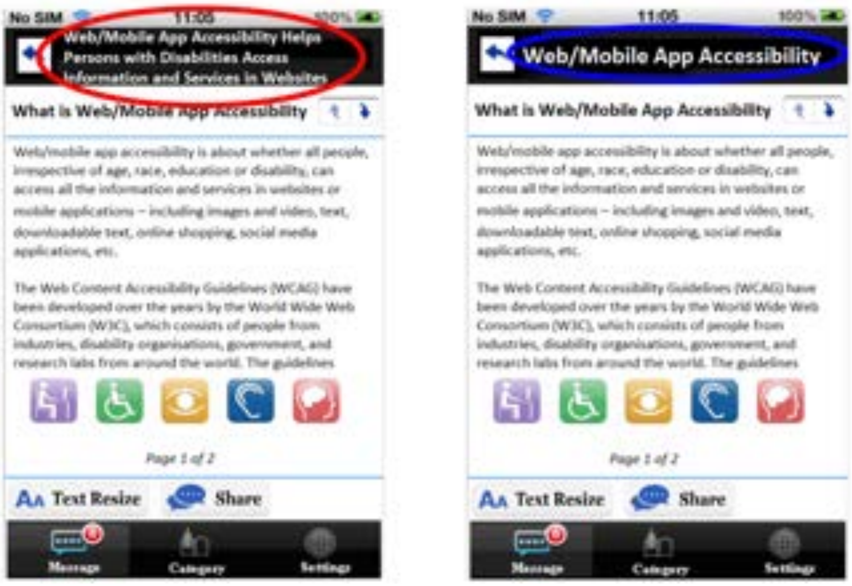


Figure 4.22. Providing clear and simple headings

- Providing clear and informative links

Providing depictive link text to make sure each link can be understood by the link text, or by the text alone and the context. In this example below (see *Figure 4.23*), the link "More" is confusing and does not demonstrate much meaning. As shown in the refined version below, the link labels should be more self-explanatory and descriptive.

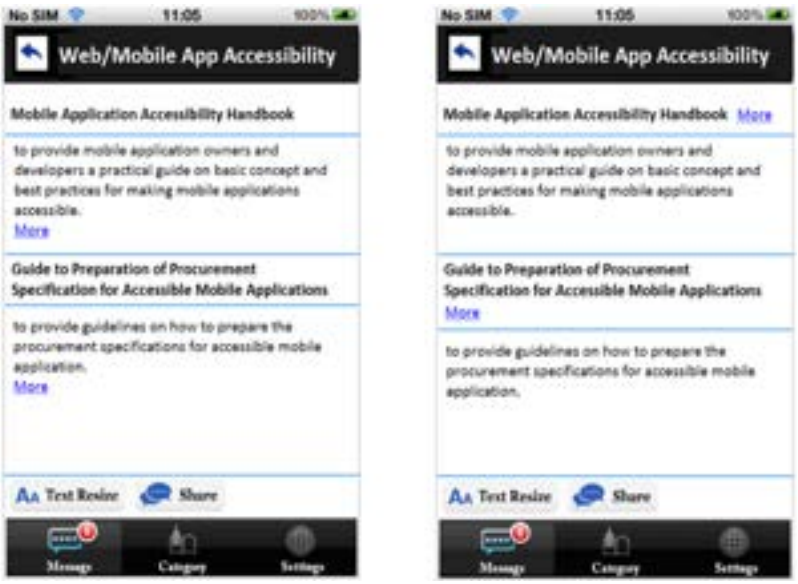


Figure 4.23. Provide clear and simple headings

- Providing focus visible

The focus should be moved into the "text field" when a text field is selected. Users' attention should be drawn to the vital elements and the related input field. On the left side of the figure, the users cannot determine which field should be focused on. The figure on the right side enables the focus to stand out. This allows people with visual impairments or low vision to perceive where they are on an input page (see *Figure 4.24*).

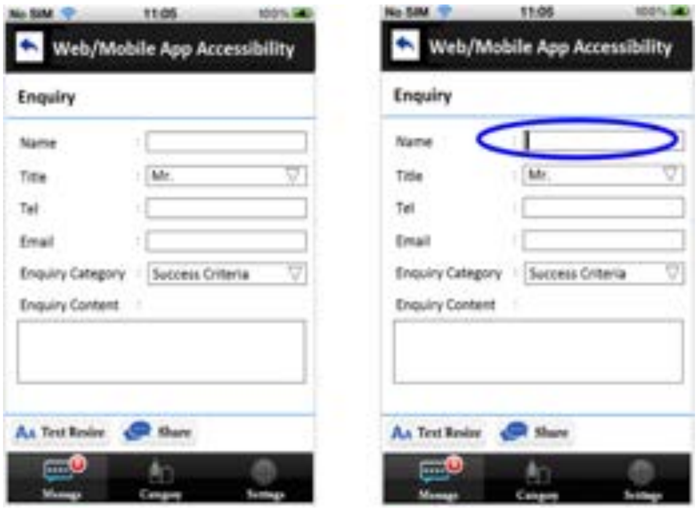


Figure 4.24. Provide focus visible

- Providing means to close popovers

All popovers should be turned off by buttons, which should work with the screen reader. On the left side of the figure, the users cannot close the popover. Designers should offer a close button for closing the popover as presented on the right of the figure (see *Figure 4.25*).

Figure 4.25. Providing means to close popovers

- Minimise user input

The elements, for instance, default values for the text input fields, pickers, election lists, and other controls should be used to minimise user input and avoid unnecessary input mistakes. Autodisplay of proper information for selection could assist user input by saving time. On the left side search form below, the users must input all fields. It is better to employ the selection list in the search form to avoid much typing, as seen on the right-hand side of the form (see *Figure 4.26*).

Figure 4.26. Minimise user input

- Making all clickable items large enough to be tapped

All clickable buttons and links should be big enough to be clicked by people with mobility issues. To offer an effective experience, the size of clickable items must be at least as big as the default icon size of the phone. Big-sized buttons enable the users to access the information on the mobile app efficiently (*Figure 4.27*).

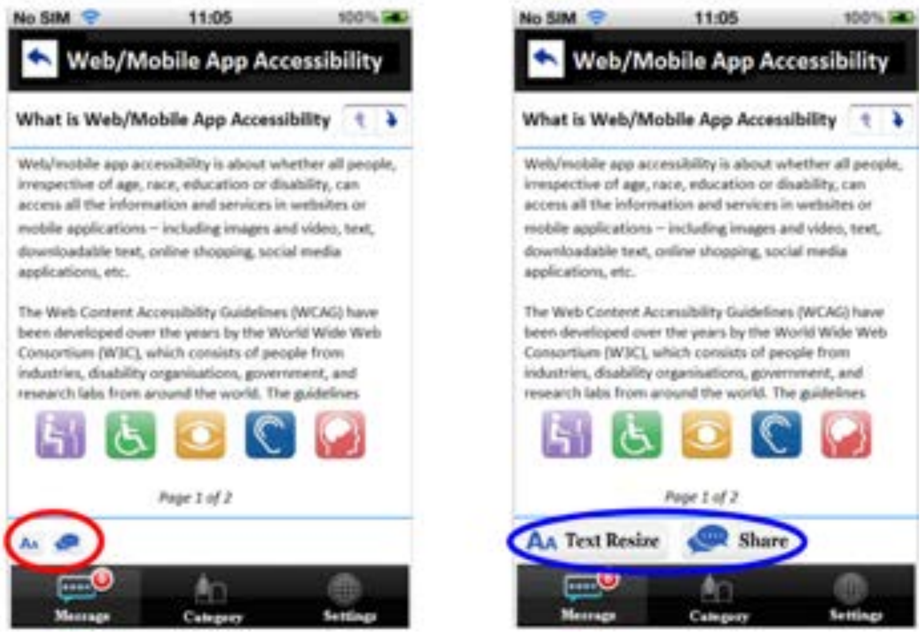


Figure 4.27. Minimise user input

4.4.2.3 Understandable

All the information and the operation of the app user interface should be understandable.

- Providing a consistent and simple user interface structure

On the left side of the figure, an inconsistent layout on different pages would cause confusion. After rectification, consistent screen interface design assists the user experience (see *Figure 4.28*).

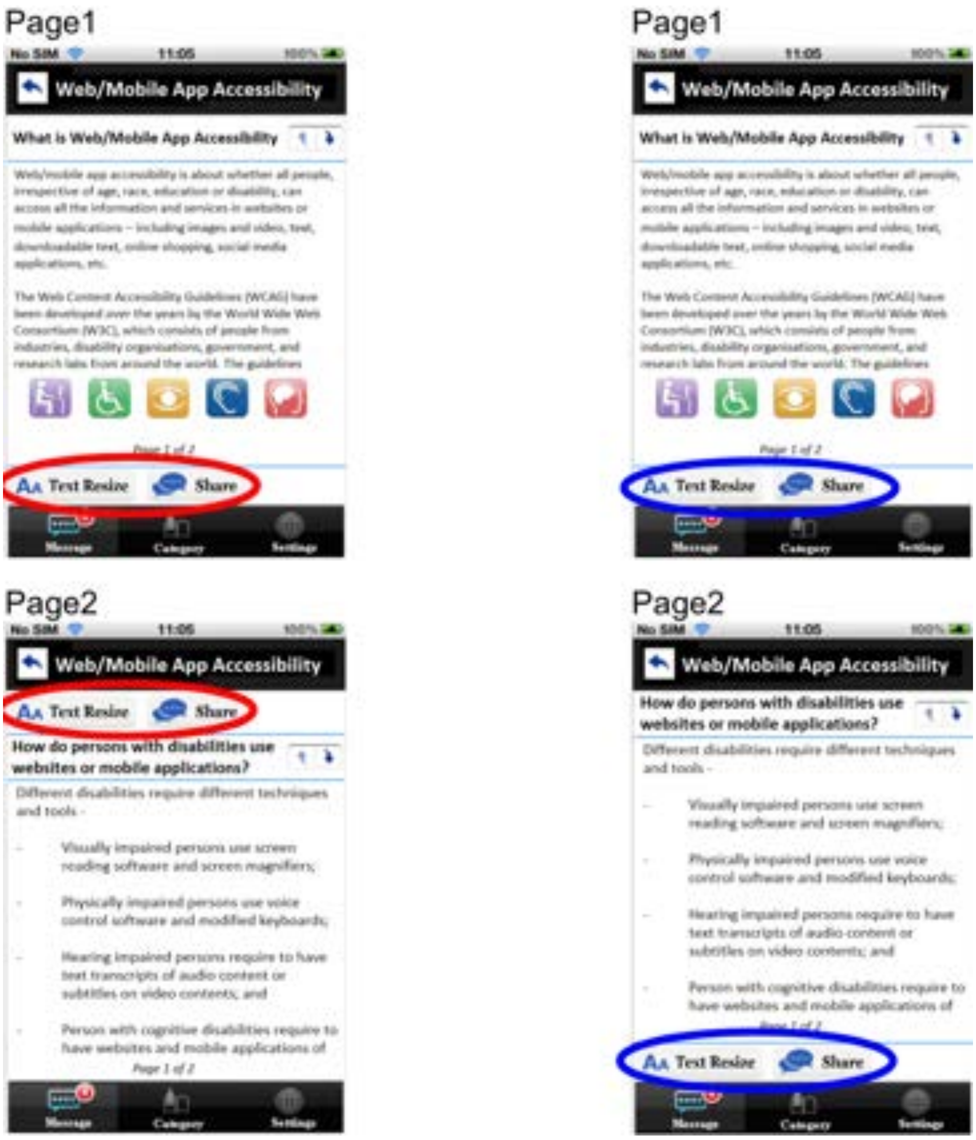


Figure 4.28. Provide a consistent and simple user interface structure

- Providing error identification

A hint that indicates where and what has been done wrong should be offered, when users make a mistake. In the example below, a reminder of an error has been given, but without a particular error hint offered. Users know exactly what is wrong when the specific error hint is provided (see *Figure 4.29*).

Figure 4.29. Providing a consistent and simple user interface structure

- Providing input assistance for user input

All input items, such as text fields, tabs, labels, and buttons, should provide a clear instruction or label so that screen readers can identify them. There is no input implication on the date format in the left example below. Users can understand the mobile application element and what should be input by offering input instructions or hint to the field (see *Figure 4.30*).

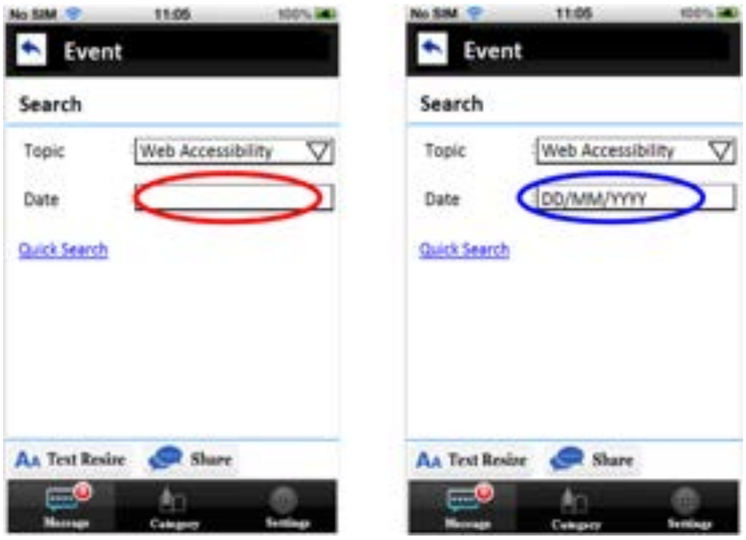


Figure 4.30. Provide a consistent and simple user interface structure

The handbook also provides a checklist for accessibility checking (Appendix 6). I will follow the checklist and conduct the accessibility test by enabling the screen reader function - VoiceOver in iPhone.

4.5 Lessons Learned from Previous App Design

The lessons learned from previous app design are two-fold. The first is the proper design from which I can learn; the other is the poor design I should prevent. Indeed, most of the apps with terrible reviews did not follow the guidelines from WCAG2.0 or the Hong Kong government guidelines. The best choice is using the checklist for accessibility checking. Several apps are full of small fonts in the interface which can be applied in bigger size and bold, such as app *OverThere* (see *Figure 4.31*).

Figure 4.31. OverThere app screenshot

Some interviewees also complained about the accessibility function not being fully accessible in some apps due to the fact that some buttons or texts did not have a detailed description of them. Those buttons will be read very clearly in this app, the problem of having a button will be much clearer, and there will be a lot of repeated actions. The app should be divided into subtitles and sub-buttons, so that the users can choose from a clear hierarchy.

Even if all buttons were given descriptions, and there are too many buttons on one page, it will also make it hard for people with visual impairments to handle it. This is because they have to go through all the buttons from the left top to right bottom to find the one they need.

Interviewee: *"No, it is all the title buttons you can read. It does not necessarily jump directly to the title, but there is a problem that you cannot read."*

Researcher: *"But if, for example, there are 50 buttons here, and you have to go to the 20th, how do you skip?"*

Interviewee: *"There is no skipping. Only the computer has a skip function. The problem is something I do not want to read, and that you cannot skip. This is also meaningless."*

For the feature enhancement of the current navigation app, one interviewee said that he seldom used navigation apps, and the reason was that it could only tell him the general direction. For example, the app told him the place he wanted to go is in his 2 o'clock position. However, he was still inside the building. The app should detect where he is, and the things that are around him. What he suggests is that when the users exit a building the app should be able to provide reference points, like outside the building there is a billboard in my 11 o'clock position. As the user goes towards the billboard, the app should start to tell me the next reference point. It is important to be more specific. Otherwise, the user needs to ask the people around him, so there was no point to use the app.

Interviewees also complained that some apps were useful at the beginning but were not updated to solve technical issues and add more contents. Therefore continued app enhancement for people with visual impairments is very important too.

4.6 Summary

Besides adopting the inductive method, the analysis was also followed by a deductive, top-down approach. The findings in this section match most of Reiss' 16 basic human desires (see *Figure 4.32*) such as: contact, curiosity, independence, social honour, power, idealism, eating, acceptance tranquillity, and saving the physical exercise. Whether we are sighted or have visual impairments, the desire for a quality travel experience is much the same. These motivations could assist me in designing a better-gamified application. Moreover, people with visual impairments need sighted peers to accompany them to travel who can describe the surroundings to them. However, people with visual impairments have to accept the information passively. They want to obtain and control the information themselves. The idea is to meet the self-determination theory (Deci & Ryan, 2000), which they determine the following three factors as intrinsic motivators: autonomy, competence, and relatedness.

Motive name	Motive	Animal behavior	Intrinsic feeling
Power	Desire to influence (including leadership; related to mastery)	Dominant animal eats more food	Efficacy
Curiosity	Desire for knowledge	Animal learns to find food more efficiently and learns to avoid prey	Wonder
Independence	Desire to be autonomous	Motivates animal to leave nest, searching for food over larger area	Freedom
Status	Desire for social standing (including desire for attention)	Attention in nest leads to better feedings	Self-importance
Social contact	Desire for peer companionship (desire to play)	Safety in numbers for animals in wild	Fun
Vengeance	Desire to get even (including desire to compete, to win)	Animal fights when threatened	Vindication
Honor	Desire to obey a traditional moral code	Animal runs back to herd when stared at by prey	Loyalty
Idealism	Desire to improve society (including altruism, justice)	Unclear: Do animals show true altruism?	Compassion
Physical exercise	Desire to exercise muscles	Strong animals eat more and are less vulnerable to prey	Vitality
Romance	Desire for sex (including courting)	Reproduction essential for species survival	Lust
Family	Desire to raise own children	Protection of young facilitates survival	Love
Order	Desire to organize (including desire for ritual)	Cleanliness rituals promote health	Stability
Eating	Desire to eat	Nutrition essential for survival	Satiation (avoidance of hunger)
Acceptance	Desire for approval	Unclear: animal self-concept?	Self-confidence
Tranquility	Desire to avoid anxiety, fear	Animal runs away from danger	Safe, relaxed
Saving	Desire to collect, value of frugality	Animal hoards food and other materials	Ownership

Figure 4.32. Reiss' 16 basic human motivators

CHAPTER 5: DESIGN VERIFICATION

This chapter introduces the detailed procedure of the app design development in this study. The first section covers the user journey maps design. *Section 5.2* includes the feature design of the app, including the participating design and user interface design. A detailed discussion of the app user testing is presented in *Section 5.3*. The next section demonstrates the findings of the app user testing. The last section concludes this app design study.

5.1 User Journey Maps

In order to build empathy internally to help understand people with visual impairments, I mapped out the entire travel process of such people and identified the touchpoints where users interact within each phase as well as users' actions, thoughts, feelings and pain points based on the data generated from the interviews. Alignment diagrams of user journey maps differ in structure. A chronological structure was adopted, which is the most common scheme that divides the travel experience into five phases of research and planning, booking, transportation, visiting and post-travel. Also, I used curves which are very suitable for describing the emotional state of the users in each situation (see *Figure 5.1*).

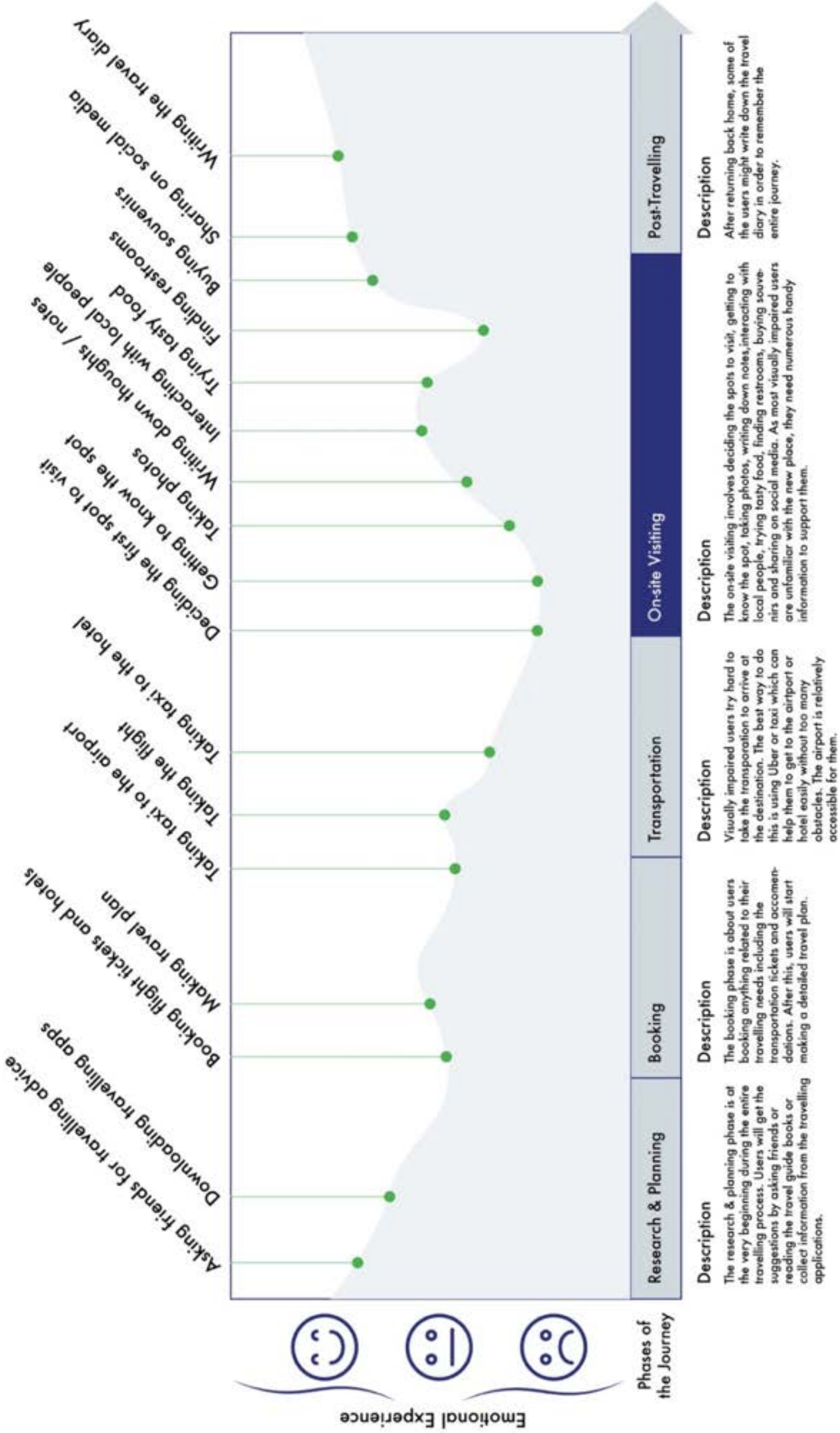


Figure 5.1. User journey map of people with visual impairments when they travel

The experience map helps researchers to identify problems and opportunities for re-design while concentrating on particular touchpoints which enables the experience to be broken down into different steps for further development (Stickdorn et al., 2011). From the experience map above, we can quickly identify areas such as the experience of the entire travel process for improvements to be made.

5.2 Participatory Design

According to the data generated from the preliminary research, we attempted to propose the features in the travel app for visually impaired users. To better design the app, we conducted an in-depth interview and design workshop with three visually impaired people in the Hong Kong Blind Union in December 2017. These three visually impaired people all work as workers at the Hong Kong Blind Union with high education.

After fully understanding their other senses, visually impaired people can experience the sights, aromas, tactility, sounds, and ambience provided by destination regions. In app design, consideration of senses should be applied. Juul (2003) maintains that emotional attachment plays an important role between the player and the game itself. McGonigal (2011) urges that the vital traits of gaming are rules, goals, and feedback systems. Smartphones are widespread; therefore, gaming experiences become much more mobile. In particular, Geographical Positioning System (GPS) location-based supported mobile games, for example, Shadow Cities and Geocaching, offer players a more real and thrilling experience (Benford, 2012). Location-based mobile games enable players to gravitate from virtual worlds to a mixed world environment (Hinske et al., 2007; Gentes et al., 2010). Jacob (2011) surveyed the movement and the physical location of the players as being crucial in location-based mobile games. Mobile game application is expanding to become more context-oriented which relates players to physical locations and encourages users to complete local tasks, and to interact with and compete against other players (Klopfer & Squire, 2008). A cell phone's location-aware function enables users to check-in at locations, find other users nearby, and receive information related to particular sites (de Souza e Silva, 2013). Socialisation is becoming more and more critical for mobile players. Pertinently, Yovcheva et al. (2014) advocate that tourists need information distinct from other players. However, Fernandes et al. (2013) contend that tourists usually are unfamiliar with the location and have limited time while travelling. Hence, tasks need to be less challenging and less ambiguous when designing games. A sketch of the user journey flow was created as follows after discussions with the participants (see *Figure 5.2*).

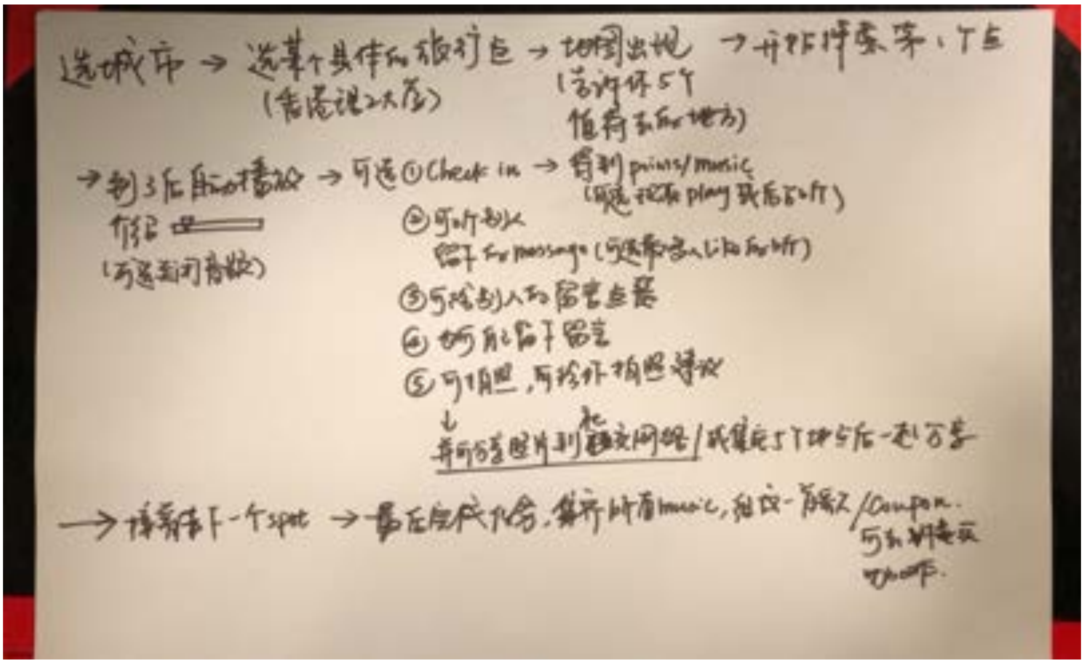


Figure 5.2. User journey flow of the app

5.3 User Interface

To apply gamification, I first list the elements extracted from game design, and then these elements should be integrated into my specific design. Nevertheless, the argument is that gamification researchers do not have agreement about what these elements are, and most researchers take the position that these elements cannot even be named.

The initial working title for the mobile application is “Gamified Travelling”. It is an audio-based application that utilises GPS on the user’s phone to allow greater independence when travelling. This app uses audio prompts to identify places as people pass by. Also, with the ability to tag route details and find nearby friends, the experience resembles having a local friend to guide you (see *Figure 5.3*). The interface design adopted a software called Sketch (Appendix 7).

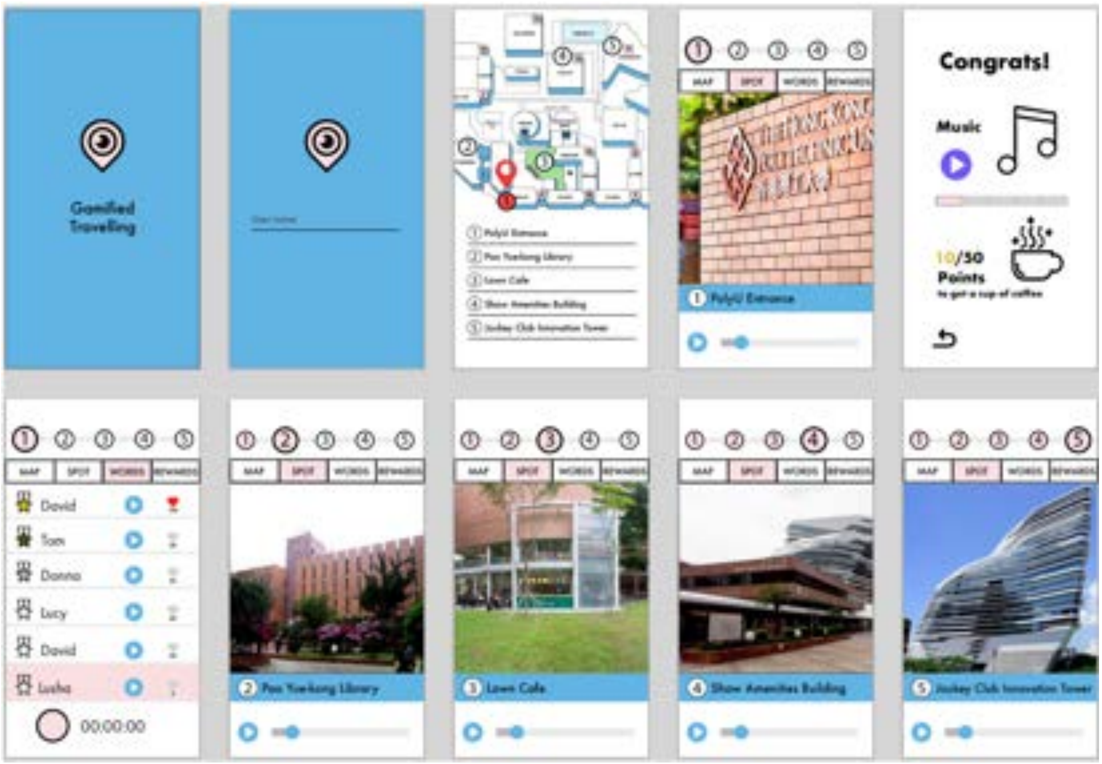


Figure 5.3. Early app interfaces

Section 5.4.1 Phase One of the App Testing shows in detail the early testing phase. Such as; The contrast of the app, the feature enhancements, the accessibility, and the VoiceOver. The final mature app interfaces were created after testing the previous versions (30 in total). The final working title for the mobile application is 'Lively Travelling', as the app will be available in Hong Kong, and 'Lively' can be read in Cantonese as '拉闊', which is famous for the meaning of live and 'on the spot' in Hong Kong. The name represents the traits of this app, which emphasises the travel experience specifically. The final version of the app interfaces are as follows (see *Figure 5.4*).

Figure 5.4. Final app interfaces

Regarding the category of people with visual impairments, only a small percentage of them are totally blind. Those who still can see to a certain degree still want to use their eyes to see the interface in the app. Blue was selected as the main colour in this app because it stands out. For those people who still can see the app interfaces to a limited extent, the accessibility of contrast colour and simulating different colour blindness should also be considered carefully in this app. The interface design still adopted the software Sketch (Appendix 8). By using the Sketch plugin called Stark, all the visual of images and text meet the international standard, i.e. the contrast ratio of at least 4.5:1 (AA level). Almost all the images and texts even met the highest level, AAA on the international standard that has a contrast ratio that should be kept above 7:1. This test ensured that the app provides great contrast, readability, and legibility.

To encourage travel, the app recommends noteworthy tourist attractions, sights, restaurants, bars, hotels and shops in the specific area. When users pass by a new spot within an attraction, this app will automatically play audio to describe what to see as well as stories, tips and advice from different senses.

After clicking the check button for a spot, users can receive a reward. The reward can be a part of a song or points for a coupon. In order to get the whole song or a coupon, the user should try to visit and check all the spots this app suggests in this area. Visually impaired people's other senses are often more sensitive, and they have subtle feelings when they get to know the world. To take advantage of this, visually impaired people can also leave a message before they leave such as a hint, or their feelings, or their experiences for other visually impaired people. The message can be liked by other app users with the top ten most-liked messages showing on the leaderboard of the app. Each attraction, for example the Hong Kong Polytechnic University, will have its own leaderboard, so users can discover the best experiences with helpful and meaningful tips from their peers whom they can trust. With a growing community, users can create detailed databases of localised information. The information grows with the community, creating a completely crowd-sourced travel map of the world.

In the long term, this app can be used for many attractions in Hong Kong. We piloted it in the Hong Kong Polytechnic University as an attraction to check how the app works with visually impaired people. We picked five essential spots for the visually impaired users: the entrance to the university, Pao Yue-Kong Library, campus grassland near the lawn café, Shaw Amenities Building, and Jockey Club Innovation Tower. This app can be considered as a mobile-based, location-aware collection game app.

This app can turn travel into an emotion-laden and commemorative experience. Building on the data generated from the preliminary research, the features were proposed in the travel app for visually impaired people. It includes the following features:

1. Users can choose from two experiences (see *Figure 5.5*):
   a. exploration version - they will receive several missions including finding local people for a photo sharing opportunity; or finding the hidden voices through a narrative; and discovering hidden virtual objects through a vibration pathway. Narrative, challenge, fellowship, discovery and submission in LeBlanc's 8 Kinds of Fun (2004). Social call to action builds on "surprise" and "unexpected delight" from the social engagement loop (Zichermann & Cunningham, 2011).
   b. chill version - the app will suggest the places to visit for meditation or relaxation. The feature provides "easy fun" from four kinds of fun concept (Lazzaro, 2004).

Figure 5.5. Two mode options

2. The app recommends nearby tourist attractions, sights, restaurants, and shops. This feature utilises a checklist and goal-setting to encourage users to visit new locations (see *Figure 5.6*). According to the participants, users with visual impairment are typically keen to visit new locations but lack the incentive and knowledge of what is available. This feature involves 'missions' from motivations for gamification design (Zichermann & Cunningham, 2011), and goals and strategy from hard fun in four kinds of fun concept (Lazzaro, 2004).

Figure 5.6. A goal-setting checklist

3. The app plays audio clips automatically to describe the stories and advice from different senses when users pass by a new spot within an attraction (see *Figure 5.7*). The feature draws on creating a sense of achievement from arriving at attractions ('unlocking' them) and triggering curiosity by feeding new knowledge without user prompting (Zichermann & Cunningham, 2011) as well as improvement of knowledge and competence from accomplishments (Seligman, 2011). The feature encourages the exploration of the space at the destination ('easy fun' in Lazzaro, 2004).

Figure 5.7. Automatic audio description

4. After visiting a spot, users can receive a reward automatically. The reward can be a part of a song or points for a coupon. In order to receive the whole song or a coupon, the user should try to visit and check all the spots that the app suggests in the area (see *Figure 5.8*). Collecting, surprise, gifting, reward system, and external coupons build on ideas presented by Zichermann and Cunningham (2011), and Lazzaro (2004), while the positive emotions of joy and gratitude are the related positive emotions (Seligman, 2011).

Figure 5.8. Reward system

5. Users can leave a message before they leave, such as a hint (for example, a tip or a secret message), or their feelings, or their experiences for other visually impaired people. The message can be liked by other app users, with the top ten most-liked messages shown on the leaderboard of the app. Users can discover the best experiences with helpful and meaningful tips from their peers whom they can trust in each attraction. Users can also post questions that everyone can answer (see *Figure 5.9*). Sharing, leaderboard, gaining status, fame, getting attention, competition, and "a social call" to action refer to recommendations made by Zichermann and Cunningham (2011), while Lazarro's (2004) ideas on communication and social aspects of fun serve to establish the basis of positive emotions.

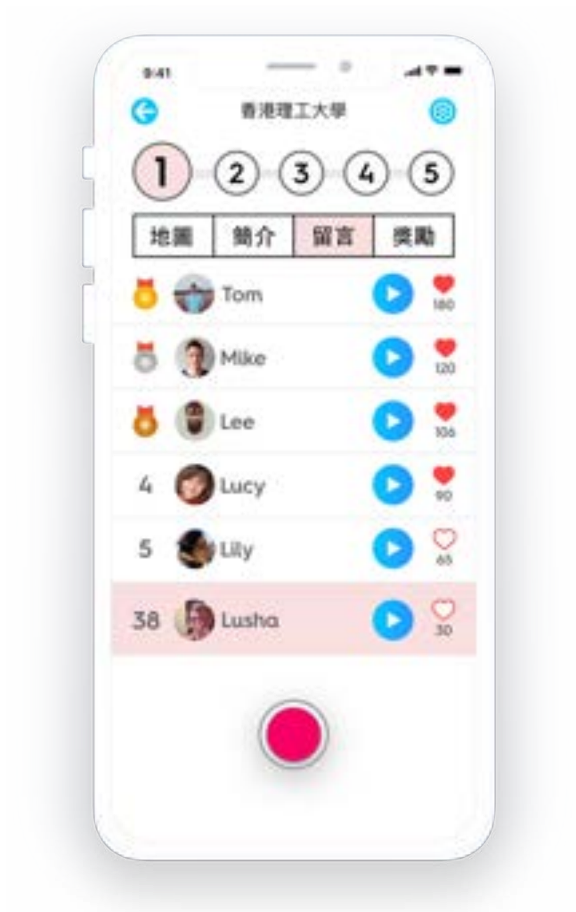


Figure 5.9. Message leaderboard

6. With a growing community, users can contribute towards detailed databases of localised information. The information grows with the community, creating an utterly crowd-sourced tourism map of the world. Increasing content, community, co-creativity, status in the community, collaboration, and feeling of "growing" are primarily inspired by Zichermann and Cunningham (2011).

5.4 App User Testing

As aforementioned, the app design process is in an iteration design way, a technique involving repeated cycles of design, development, evaluation, and analysis. The iterative development will be presented in this section.

In order to evaluate the app as early as possible, I conducted app user testing from a low-fidelity to high-fidelity prototype starting from 2017. Since the app should be embedded in the iPhone accessibility function, I did not know whether the app would work or not until I developed it. The challenge for the app user testing was I would have to test if the app would fully work with the VoiceOver function, the key and only accessibility function for people with visual impairment to use iPhone. However, the VoiceOver function entails a fully developed app with back-end programming. There are three types of iOS development, namely, Native, Hybrid, and Web. Native mobile app is designed to be "native" to one platform. The native system can be advantageous as it tends to optimise the user experience. As it was developed specifically for the platform, it is more intuitive and faster to operate. Hybrid mobile apps can be installed on any device just like native apps, but they only run through a web browser. All hybrid apps are developed through the HTML5 programming language. Technically, hybrid apps are websites set into a native app to look and function just like them. Though hybrid apps are not as fast or reliable as native apps, they have a higher capacity for streamlining the development process. It is ideal for apps that primarily deliver content. Web apps are written by the most popular programming languages, but they cannot be sold in the Apple store. After consulting with the iOS developer (see *Figure 5.10*), with the purpose to evaluate the app as early as possible, the hybrid development was selected to develop the app for phase one of app testing (Appendix 9).

Figure 5.10. The three app development methods written by the computer science expert on the whiteboard

The app development was conducted with Native app development in the second phase of app testing (Appendix 10). First, the future goal for app development is to upload it to the Apple store. Therefore, it is pointless to develop a web app since Apple will reject this development method. Second, it is much easier and cheaper to find the back-end developer who is an expert in HTML 5 to develop the app then skilled in the Native development in Hong Kong. Third, hybrid development is much faster and easier to develop, and most of the codes can also be used in the later Native app development.

As the researcher and designer, I outsourced application development to external programmers. Regarding the first phase of the app testing, the hybrid app development, I worked with a senior student from Computer Science in the school. As such, it was much more convenient to meet him for further discussion, which means solving errors would be straightforward. The hybrid app was written by Corona, an iOS application library that allows being built for the iOS Platform. The core of Cordova-based applications is those written in Web technologies: HTML, CSS and JavaScript. Regarding the second phase of the app testing, the Native app development, I worked with an experienced iOS developer, who entered the project with his extensive skills, background, and coding methods. I prepared the Product Requirement Document (PRD), including the flowchart and sitemap of the app for the developer (Appendix 12). The native development was written by Swift, a relatively modern programming language designed by Apple.

In this section, I will discuss two main rounds of app user testing based on high-fidelity applications. The first user testing was conducted with nine people with visual impairments and focuses on the errors and feature enhancements from March to August 2018, while the second-round user testing was conducted with 30 people with visual impairments that focused on the errors and user feedback in the gamification features in travelling setting in April 2019. All of them were familiar with the use of iPhone and VoiceOver.

5.4.1 Phase One of App Testing

The first user testing was conducted with nine people with visual impairments from April to August in 2018. Five out of the nine were totally blind, two had only light perception, and two were partially sighted. Before the test, I wrote down my assumptions and thoughts about the app test result. Firstly, I assumed that users over 45 years old would not be very interested in gaming features. Secondly, I was not sure that providing missions to them, such as the checkpoints and receiving a reward would entice and trigger the users. Thirdly, unlike sighted people, they cannot see visual elements, so they might not think “gamification” really assisted them in enhancing their experience. Fourthly, the gamification techniques for sighted people were validated by some frameworks, but it was not clear that the gamification techniques would also work for people with visual impairments effectively. Fifthly, it was not clear how people with visual impairments would feel about using the app, emotionally. Lastly, they might not be eager to pay for the app. Additionally, there are other issues related to the future business model.

Before the app testing, a visually impaired person, Ming, was invited to come to the Hong Kong Polytechnic University to take part in the pilot test, which helped to test the accessibility of this app. One vital thing he pointed out was, that the designer and developer missed was the registration process. When users tried to enter their information, especially when they needed to enter their email information, the keyboard should be adjusted based on the information that needs to be input. As presented in the following *Figure 5.11*, the left side of the screenshot was using the basic keyboard. However, the screen on the right side asked them to enter their email, to input it immediately; the keyboard should adjust into with “@” automatically. This is an example of how small interface changes significantly improve the usability of the app.

Figure 5.11. Keyboard adjustment screenshots

I went through the five locations on campus, and I found that the GPS around the library is quite weak since there are too many buildings accessing the GPS signal. It is a common problem for the weak internet connection outdoors in Hong Kong due to the high-rise buildings. After soliciting suggestions from an expert in Computer Science and discussing with the developer, we added three trigger points near the library and adjusted the trigger range from 30 to 40 metres (see *Figure 5.12*).

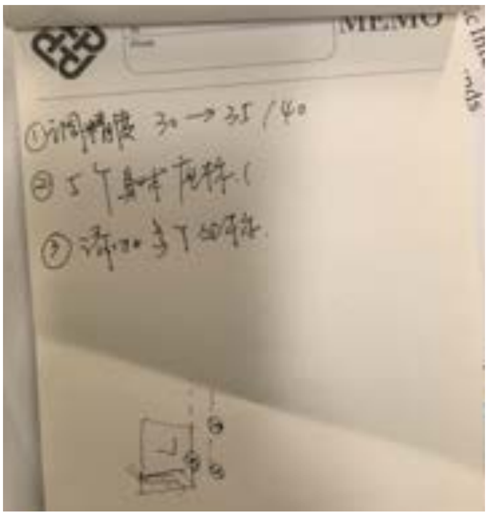


Figure 5.12. The note on adjusting the trigger

From March to August 2018, I invited ten participants to test the app at the Hong Kong Polytechnic University, which was the most accessible place to test this app (see *Figure 5.13*).

Figure 5.13. Phase one app testing

During the testing phase of the application, the participants were asked to use the app walking around campus for half an hour. A 40-minute discussion on the user experience with the participants was conducted afterwards. As mentioned in the previous chapter, the "Think Aloud" is a research method in which participants say out loud any words that come to mind as they complete a task. The task of this study was using the App that I created. This is familiar with people that have visual impairments because they have used and tested many Apps on their iPhones before. I did not teach them how to use the app since users could download and use the app on their own. All participants can enunciate their inner speech spontaneously, and they can always refer back the apps they have used before. The "Think Aloud" protocol was carried out during the testing phase to ask the participants to verbalise anything that they think, feel, do, or look at while processing the interface and app exercise. I have conducted this protocol both as a participant and as a researcher before. As a participant using the "Think Aloud" method, I found myself not using this matter as much. This is because I am able to see and use my sight to articulate what I feel and see instead of my speech. My other participants who are sighted people also found this to be true when they were testing the "Think Aloud" method. However, this method is a vital tool for this research, especially because through my observations people with visual impairments tend to be more conversational. This is because they are constantly talking about their emotions and describing what and how their feeling, touching, hearing and smelling compared to the sighted community. In this vein, most of the app enhancements in the reports I have written are based on the "Think Aloud" protocol. Also, the researchers must conduct this method with an open mind during the testing.

The following are the questions I asked the participants during the 40 minutes discussion on the user experience:

1. Have you been to the Hong Kong Polytechnic University before?
2. Are you satisfied with the usage of this app?
3. The following are the five main features in this app:

   Can you share your user experience with these five features?

   - the must-visit locations recommendation
   - automatic check-in
   - voice description about the site introduction
   - personal log on/record about surroundings when using the app
   - opportunity to gain rewards or music
4. Which function are you most satisfied with – and why?

5. Do you have any suggestions about what other feature(s) can be added to this app in order to enhance your travel experience?
6. Can you tell me what is the difference between this app and the travel apps you have used before (for example, the process/your feeling/anything sensory-related)?
7. Did you encounter any inconvenience when you used this app? If so, do you have any suggestions that could improve this app?
8. After trying this gamified travel app, would you recommend this app to other visually impaired people?

All of the participants were satisfied with the accessibility of this app, and they all agreed that it is an app that is easily manageable by people with visual impairments. The following are the suggestions about how this app could be enhanced:

1. Add vibration or sound to indicate that their recording is to begin or finish.
2. Add an "important amenities recommendation" regarding where users can find the restroom or water dispenser.
3. Add audio guidance to the braille information board in the app.

Regarding the description at each spot, one participant suggested that in addition, numbers could be used in the description such as "How many people can be seated?", "How many books can be accommodated or those can be less?" A participant also commented that it would be very useful to add more interesting information. She went on to state:

The app can introduce a certain kind of souvenirs we may purchase here, or talk about the interesting stories or ghost stories and so on. Ghost stories are just an example, but they can be scary, and the app can tell some interesting stories on each spot. As the attraction in *your app is the university, you can search "the five must to do things in the university" on google. The app could try to describe more interesting and different kinds of stories. Of course, various attractions have different stories and culture. If you could fully understand each attraction, you will be able to offer the information and stories of that attraction.*

Based on the advice from participants, I then added some interesting stories in the audio description for each spot. Additionally, the results show that the description in the destination can be enhanced by adding more description from different senses' perspective and more audio description to describe the visual elements. Especially for those who have been blind from birth, as they have been taught what different objects look like. Therefore, the audio description should use objects they are familiar with to describe the visual elements. If so, they can easily "visualise" these in their mind. After this, besides reading the literature reviews about audio description for people with visual impairments, I also held an expert interview with Dr Dawning Leung, the founder and CEO in the Hong Kong Audio Description Association in January 2019. Dr Leung just finished her PhD about audio description in the UK. She provided several essential techniques and helped me to revise the guidelines based on the outdoor activity context and in a Cantonese context. I found her to be an invaluable source that I would not have been able to find elsewhere. Also, little research has been published providing frameworks or guidelines about audio descriptions for outdoor travel. The following Audio Description Guidelines were written by Dr Leung for "Audio Description Training Course (Outdoor Activities)" (not published, internal data).

- From General to specific: describe the overview first and then go into details
- Describe colours: Be specific! Use more words to describe a colour, e.g. do not say "red" 紅色, but say "wine-red" 酒紅色, "blood-red" 血紅色 or "brick-red" 磚紅色
- Use similes: e.g. Do not say "tall", but say "it is as tall as a door" or you can describe an object from the audience's perspective: e.g. "Look up and you'll find..."
- Describe materials: materials and texture should be included in the AD
- Use sound, touch and smell: an audio-described tour should be multi-sensory. Use touch and smell as a complement.

After the interview, to better understand how to describe outdoor objects in a true context, I also participated in the Audio Description Services for Outdoor Activities, that Leung designed and executed on 9th March 2019. This activity was funded by the SIE, a catalyst for social innovation funding in Hong Kong (see *Figure 5.14*).

Figure 5.14. Participation in the audio description services for outdoor activities

Following Dr Leung's guidelines and recommendations, the contents of the audio description were amended and incorporated into this app. In response to the feedback of participants, I have acknowledged that It can be more engaging to the visually impaired by having a real voice versus using a robotic voice to describe the attractions. Therefore, a professional speaker was asked to provide the voice-over for this project.

After the first user testing, I found that only a small percentage of participants were totally blind. Those who still can see to a certain degree still wanted to use their eyes to see the interface in the app. Therefore, I revised the interface so that all the visuals of images and text meet the international standard. The accessibility of contrasting colours and simulating different colour blindness was also considered carefully in this app testing. By using Stark, the Sketch plugin, all the visuals of images and text have met the international standard, i.e. a contrast ratio of at least 4.5:1 (AA level). Almost all the images and text even met the level AAA on the international standard that has a contrast ratio that should be kept above 7:1. This test ensured that the app provides excellent contrast, readability, and legibility (Appendix 12 & Appendix 13). Several participants suggested that the app needed a return button on some pages because they were used to finding the return button in the upper right of the screen to return to other pages. According to their requirement, the return button was added in the app interface (see *Figure 5.15*). This is another example to show the importance of app testing. As a sighted user, I am used to swiping from left to right to go back on the screen. However, when the "VoiceOver" function was enabled, the "swipe from left to right" feature was locked.

Figure 5.15. Modified version of the interface

The "leave messages" function was added to every page, not just on the overview page (see *Figure 5.16*). It is more convenient to leave a message on the page related to each attraction, rather than just on a separate page. As some participants mentioned "I can share my feelings immediately in the same space after I listen to other messages."

Figure 5.16. Adding the "leave messages" button

The final app interfaces were revised after testing the previous versions. The final version of the app interfaces are as follows (see *Figure 5.17*).

Figure 5.17. Final app interfaces

5.4.2 Phase Two of App Testing

The participants for user testing were informed about (a) the goal of the investigation, (b) the expected workload and time duration, (c) the need to have at least a moderate level of knowledge of the iPhone, and (d) the HKD100 supermarket coupon compensation for completing the user testing. In March 2019, a message to recruit app testing participants was posted to different WhatsApp groups, mainly consisting of people with visual impairments (see *Figure 5.18*). The participants had to meet the following criteria: 1) be an iPhone user, 2) be aged 18 to 55. It was also required that the participants had the variety of different levels of visual impairment.

Figure 5.18. Phase two app testing

Before starting the second phase of app testing, I joined the iOS Developer Program to ensure the availability of the fully functional app for the end-users. The beta app was built and uploaded to the App Store Connect, a set of online tools for managing apps sold on the App Store. The second phase of app testing used the tool called TestFlight in the App Store Connect platform. TestFlight facilitates inviting users for installation and testing of iOS apps, which enables developers to collect feedback before releasing the app on the App Store.

Before conducting the app user testing and further interviews, two pilot interviews were conducted to develop further the skills of the interviewer. The two pilot tests were able to test the user testing guide including the interview questions and the procedure for the interview and app user testing. Several key aspects were found from these two pilot tests:

1. The app testing required users to perform the test in the actual location, that is, outdoors at the campus. As it is hot in Hong Kong in April, I had to remember to prepare a bottle of water

for the users after they finished the user testing and I invited them to have the interview indoors.

2. I needed to check the weather before confirming the time of user testing: it was the rainy season in Hong Kong, some people with visual impairments need their guide dogs to accompany them, and if it is raining, they might cancel the testing because it is inconvenient for them to take the guide dog in the rain.
3. The pilot test allowed me to enhance the user testing guide and interview guide better. The time was limited, so I should follow the clear guide step by step to finish the test and interview on time.
4. I needed to prepare a spare iPhone in case the phone of the participants could not be used.
5. Before the user testing, I needed to affirm to the participants that the user testing was only focused on the app per se, and not on the ability of the user, and that they should feel free to offer any feedback they believe may enhance the app.
6. I needed to send a message with detailed information to remind my participants the day before the test.

On top of this, I sent a thank you note to them after the test to inform them that they could text me to share any further thoughts. Also, I might have some questions and should enable them to respond after the test, which is efficient in helping to build a relationship with all the participants. The participants had diverse ages, jobs, genders and eye conditions. The age of participants ranged from 18 to 55 years old. Among the 30 participants, 11 were female, and 19 were male. The participants included 16 people with total blindness and 14 people with low vision (moderate and severe vision impairment). Of the totally blind people, 10 people were blind from birth, while the rest lost their vision afterwards. A summary of the details of the participants is shown in Table 5.1.

Table 5.1. Background details of the participants

Participant	Age	Gender	Vision Condition	Education	Job	Annual Revenue	iPhone Model
1	33	M	Totally blind from birth	High School	Tutor at Crossroad Foundation	85000	6s
2	43	M	Totally blind from birth	High School	Officer	90000	XS
3	31	F	Severely sight impairment	Undergraduate	Social Worker at HK Ebenezer School	15000	6s
4	33	F	Severely sight impairment	College	Social Worker at Hong Kong Blind Society	100000	6
5	45	M	Totally blind at age of 24	High School	Volunteer for Government	0	6
6	29	M	Totally blind at age of 19	High School	Work at Running Organization	60000	XR
7	30	M	Totally blind at age of 16	Middle School	No job	0	XS
8	21	F	Totally blind from birth	Undergraduate	No job	0	XE
9	26	F	Totally blind at age of 9	High School	Social Worker	60000	5s
10	55	F	Moderate visual impairment	High School	Volunteer at Hong Kong Blind Society	0	6plus
11	45	M	Severely sight impairment	Middle School	No job	0	6
12	52	M	Severely sight impairment	High School	Work for family	0	6
13	41	M	Severely sight impairment	High School	Sales at Apple Store	240000	XR
14	32	M	Totally blind from birth	High School	Volunteer at Hong Kong Blind Union	400000	6s
15	24	M	Totally blind from birth	Master	Social Worker at HK Ebenezer School"	200000	XS
16	25	M	Totally blind from birth	High School	Audio Decription Tutor	100000	6s
17	26	F	Totally blind from birth	College	Customer service	200000	SE
18	26	M	Severely sight impairment	Undergraduate	Social Worker at HK Ebenezer School	150000	SE
19	26	F	Moderate visual impairment	Undergraduate	Undergraduate Student	0	x
20	19	F	Severely sight impairment	College	Undergraduate Student	0	7plus
21	50	F	Severely sight impairment	High School	Housewife	0	5s
22	49	F	Severely sight impairment	Undergraduate	Housewife	0	6
23	38	M	Totally blind from birth	High School	Officer	120000	7
24	28	M	Totally blind from birth	High School	Massager	80000	SE
25	28	M	Totally blind at age of 14	College	Drummer	70000	7
26	43	M	Totally blind at age of 12	High School	Tutor at Social Enterprise	300000	8
27	53	F	Severely sight impairment	High School	Housewife	0	6
28	55	M	Severely sight impairment	High School	Retired	300000	7
29	27	M	Severely sight impairment	Undergraduate	Work at Social Enterprise	120000	6s
30	24	F	Totally blind from birth	Undergraduate	Sales at Apple Store	230000	XS MAX

During the recruitment process, I asked for their basic personal information (gender, education, and detailed vision condition) due to the fact that the participants were diverse. An interview has two formats:

individual and focus group interview. I arranged the participants with higher education degrees (including college, undergraduate) to attend an individual interview, because they have critical thinking and can provide intensive insights from their experience. At the same time, for those with lower education, I tried to form two or three participants into one group to encourage each other to share their thinking.

App user testing took around a half hour and further interviewing took around one hour and was all conducted in Cantonese. After they arrived in my office, I let them install the app and observed how they explored the app for their first time. I let them talk (Think Aloud) whenever they wanted to say anything; otherwise, they might forget some problems with the app. Then we started to use the app on the campus. I encouraged them to talk (Think Aloud) whenever they wanted to say anything; otherwise, they might forget some problems with the app.

All app user testing and further in-depth interviews were both video and audiotaped, and full transcriptions were created in Chinese. The questions for the in-depth interview are presented in the Appendix 14. Subsequently, the translation into English was produced by me. During the app testing and interview sessions, I took notes to document the participants' reactions, including non-verbal communication and their facial expressions comprising frowns and body language including scratching their heads or tilting their heads. At the same time, I recruited volunteers who were all master students from "HKE" group in *WeChat* in Hong Kong. The volunteers not only helped me to pick up the participants from the bus station or metro station but also took video to record the entire user testing process, which enabled me to better focus on observing my users' behaviours. Following Creswell's (2008) guideline, at the beginning of the user testing process, I clarified the goal of the research and every one of the participants was requested to endorse an informed consent form guaranteeing their anonymity and confidentiality.

Thanks to the Phase One app testing, as many as possible functions and feature enhancements had already been added and built into the app. The second app testing has two kinds of goals: error fixing and gamification testing. The first is fixing all the errors to ensure future problem-free availability on the Apple Store. Regarding the errors, several issues were amended after the user testing.

The initial interface and setting did not allow the iPhone model below iPhone 6 to use the confirm button when users tried to register for the app (see *Figure 5.19*), as the confirm button was covered by the keyboard. To solve this issue, I redesigned the interface to move the input box higher on the page.

Figure 5.19. Keyboard covering the confirm button

Another important issue was the error of the “VoiceOver” function. With enabling the “VoiceOver” function, when an item on the screen is selected, a black rectangle called the "VoiceOver Cursor" appears around it. However, the cursor was shown when users had not selected anything (see *Figure 5.20*). The error happens frequently when developing with the "Voiceover" function. Therefore, the developer fixed the error quickly.

Figure 5.20. System error with the "VoiceOver Cursor" on the interface

The same issue occurred with the "VoiceOver Cursor". I, as a designer, with an aesthetic purpose, tried to align the cursor with the item be selected. The left figure below is the current alignment, and the right figure in red is the ideal alignment for the item (see *Figure 5.21*). However, when I reported the design to the developer, the developer said there was no way to change the alignment of the "VoiceOver Cursor" since it was set by the iOS system.

Figure 5.21. The "VoiceOver cursor" alignment on the screen

The other purpose was testing the gamified features to see the difference between using this app and without it and receiving the feedback from the users, which will be presented in the *5.5 App Testing Findings* section. The second phase of app testing used the iterative development process that fixed the errors in each iteration. Regarding the function and errors, several reports were created and sent to the developer. The developer rapidly changed the code, re-built, and uploaded the app to the App Store Connect (Appendix 15).

5.5 App Test Findings

This section mainly focuses on the gamified features and the difference in the travelling experience between using this app and without it. Of the participants, 28 of 30 had visited the Hong Kong Polytechnic University before. Those two did not visit the campus, but they arrived at the entrance of the university. The reason they stopped at the entrance was they were unsure whether the university could be accessed by the public.

I adopted a quantitative approach to examine the satisfaction with the app by the participants first, and then I conducted a qualitative analysis to understand their feedback better. The following questions were asked in the interviews after the app testing, and were translated from Cantonese as follows:

1. How did the app enhance your travel experience compared with when you travelled without the app? (from -3 to 3, -3 means diminished experience, 3 means greatly enhanced experience)
   The mean value of their answers was 2.23, and standard deviation was 0.41.
2. How satisfied were you with this app's ease of use when you started using it? (from -3 to 3, -3 means not at all easy, 3 means extremely easily)
   The mean value of their answers was 2.67, and standard deviation was 0.5.
3. In terms of assisting you with accessibility, how satisfied are you with this app? (from -3 to 3, -3 means not at all satisfied 3 means extremely satisfied)
   The mean value of their answers was 2.25, and standard deviation was 0.41.
4. If you are of low vision, please rank the user interface design, colour, readability, and contrast? (from -3 to 3, -3 means not at all satisfied 3 means extremely satisfied)
   The mean value of their answers was 2.23, and standard deviation was 0.42.

5. Overall, how satisfactory was the app in meeting your travel requirements? (from -3 to 3, -3 means not at all satisfied 3 means extremely satisfied) The mean value of their answers is 2.43.

   There are six basic unique features of this app, please grade (-3 to 3) them based on your experience and emotions. See interview details in *Section 5.5.* Their preferences were as follows:

- The most popular feature was the rewards. After visiting a spot, users can receive a reward such as a clip of music and points automatically. The mean value of their answers is 2.68, and standard deviation was 0.46.
- Of equal popularity is the leaving message function. Users can leave a message before they leave, such as a hint, or their feelings, or their experiences for other visually impaired people.
  The mean value of their answers is 2.68, and standard deviation was 0.46.
- The second popular feature was the recommendation. The app recommends nearby tourist attractions, sights, restaurants, and shops. The mean value of their answers is 2.67, and standard deviation was 0.59.
- The third popular feature was the audio clips introduction. The app plays audio clips automatically to describe the stories and advice from different senses when users pass by a new spot within an attraction. The mean value of their answers is 2.61, and standard deviation was 0.47.
- The less popular function was the leaderboard. Users can like other users' audio comments and their comments are on the leaderboard.

The mean value of their answers is 2.59, and standard deviation was 0.7.

- The least popular function was the two versions alternative. Users can choose from two on-site experiences: Exploration version and Chill version

  The mean value of their answers is 2.52, and standard deviation was 0.62.

6. After trying this gamified travelling app, will you recommend this app to other visually impaired people? (from -3 to 3, --3 is will not at all, 3 is extremely will)

   The mean value of their answers is 2.6, and standard deviation was 0.48.

7. Will you use this app for your next travel? (from -3 to 3, --3 is will not at all, 3 is extremely will)

   The mean value of their answer is 2.8, , and standard deviation was 0.38.

All the above questions had an open-ended question for respondents to offer more information. Overall, the results are extremely positive. In order to understand their thoughts on the difference between using this app and without it and the gamified features, in-depth interviews were conducted after they graded each question. The app test data analysis followed both an inductive approach (findings to theory) and deductive approach (theory to findings) data analysis methods. I adopted the deductive approach because there are some frameworks I could use to validate the gamified experience; therefore, I combined the latest well-known gamification validation frameworks, such as GAMEX (Eppmann, Bekk, & Klein, 2018), the GAMEFULQUEST (Högberg, Hamari, &

Wästlund, 2019), and the self-determination theory (Deci & Ryan, 2000). The GAMEX (Eppmann et al., 2018, p. 104) has six elements: "enjoyment, creative-thinking, absorption, activation, dominance, and absence of negative affect." The dimensions of the GAMEFULQUEST (Högberg et al., 2019) are enjoyment, playfulness, immersion, affect, challenge, flow, competition, skill, sensory experience, presence, and social experience. There is little research specific to people with visual impairments, but I could utilise the inductive approach to seek the patterns for them. The analysis resulted in nine themes, namely uniqueness, playfulness, motivation, engagement, autonomy, competence, relation, accessibility and future suggestions which are presented below.

5.5.1 Uniqueness

All participants corroborated that they had never experienced any apps like this before. The concept of "Pokemon Go in a tourist app" attracted them. One participant mentioned that *"I feel happy and excited when I use this app because there is an app that can provide with such great function that will introduce detailed information on different spots. Therefore, I hope this app can be refined to be perfect in the future".* Another participant *"Before I came to join the app testing, I thought this was a navigation app. I realized that this was an app to help us understand that place better. Even some people accompanied me to travel, they might not know the information of each place. I can communicate and share with my friends and family after I listen to the information."* One participant who works at Apple maintained that the app is not only unique, but it can also assist people with visual impairments. *"I promise you will succeed, and if not, I will call my company."*

5.5.2 Playfulness

The second most popular theme was playfulness. In sum, the participants' four most used adjectives were "interesting", "enjoyable", "exciting" and "playful", which also aligned with the researcher's four most common interpretations of their facial expressions. The participants verified that there are numerous ways to learn about the destination, but playing game-like applications and knowing about the destination is more fun. Compared with other conventional ways of learning about a destination (such as books, the internet, travel agents), playing a game related to a destination is more playful. The playfulness component of exploratory play was emphasised by the interviewees. Exploratory play consists of a joyful component where users pursue amusement through the game; this again supports the idea that gaming is a new way to offer a joyful experience for tourists (Williams, 2006). Most of the participants associated this app with *Pokemon Go* and *City Hunt* games. Those games were popular but hard for them to play because those games are based on visual clues. This app provides another opportunity for them to play *Pokemon Go* and *City Hunts* which users were satisfied with. All participants mentioned they would discover more information about the sights and places of interest. Most of them used the word "exciting" to convey their feeling when they first heard the description of each attraction. *"No app has ever done this before, and I am very excited about this function."* When they arrived at the spot, they received a clip of music. This music signified "congratulations" of people's accomplishments. They also loved the music, because the music is in a game-like upbeat style. Most of the participants conveyed their feelings on the reward function that it is an interesting and special feature. One of the participants mentioned that *"I am very excited to participate in the app testing, and I really expect the app will be perfect in the future."*

5.5.3 Motivation

Participants were eager to check-in at all the spots, as recommended by the app. Indeed, 28 out of 30 participants had visited the Hong Kong Polytechnic University before. However, most of them did not know that there was a lawn on the campus. The app with clear goals and the rewarding system will motivate them to check-in at all the spots. Participants mentioned they had a strong sense of purpose when they use this app. "Before using this app, I came to PolyU with my friends and we were just wandering. With this app, we can now at least follow the target that the app provides to us." To equip with this app, people with visual impairment can learn much more details regarding the information of the on-site attraction as people would scarcely inform them. This will enhance their motivation to travel.

5.5.4 Engagement/Flow

Commenting on the engagement with this app, one of the interviewees said:

> *With this app, you can know more details concerning the background, history and building characteristics of the Hong Kong Polytechnic University. For example, I failed to learn that the bricks in the school were red. No one told me specifically the design, but now I envisage that the original bricks were shipped from the United Kingdom, and I do not*

know that they were so huge. The Innovation Tower is so large that it can accommodate 1500 people to work and study simultaneously. I really feel amazed and excited. My previous knowledge is that one building can only accommodate around hundreds of people. As you know, Hong Kong is small. In this connection, too many people cannot stay at the buildings in Hong Kong at the same time. Right? Nevertheless, the Innovation Tower building is spacious.

The participants mentioned that they fully engaged with the app, the key features such as clear goals, immediate feedback and challenge and skill balance, which were shown by the app. The clear goal setting and balanced challenges, which were between the easy and difficult levels, allow users to enter a flow situation. The features matched the Flow theory (Csikszentmihalyi, 1990) that need to be considered when designing an experience that aims to generate a state of flow.

5.5.5 Autonomy (dominance, feel they are in charge)

The majority of people mentioned "autonomy" in that this app allows them to obtain the information themselves, and not just wait passively for other sighted people to "feed" the information to them. One participant mentioned that he had visited the Hong Kong Polytechnic University before with a sighted friend. However, they still did not know where to go. He emphasised that this app allows users to follow the recommended spots like setting some clear goals for them to complete. Also, the app provides two travel modes (exploration mode or chill mode), which enable users to travel more autonomously.

5.5.6 Competence (Accomplishment)

They were all satisfied that this app provided them with some clear goals and missions for them to accomplish. In particular, they could automatically receive feedback by listening to the music to check if they have completed the mission or reached the target.

5.5.7 Relation (Social experience)

More than 80% of the participants took delight in recording their feelings when they arrived at each spot. One of the participants mentioned that *"finally there is a function that lets us interact with other users."* One participant stated: *"I can communicate with my friends who also visited the same place by listening to their audio messages. Alternatively, if the lawn café is wonderful, we can go there together. This feature provides another opportunity to enhance our friendship and connect with each other.*" Also, several participants mentioned that this app is similar to the mobile games they played, and they usually will make friends with other players in the game. They talked in the games, then added each other's social accounts, and finally they might hang out. In this app, users can make friends with any users on the leaderboard by leaving a message for them. This feature offers them an opportunity to make a new friend and to expand their circle of friends. Another valuable point mentioned by one participant was that the recording also could provide some safety tips. He recalled his undesirable travel experience when he visited a mountain; he heard the sound of the river and smelled the aroma from the air. Suddenly, he bumped his head on an overhanging rock. He commented that if someone had left a message to warn other users in the app, that would be great.

5.5.8 Accessibility

From an accessibility perspective, overall, all the participants were impressed by all the buttons and pictures in the app, which had added labels that allow the VoiceOver function to read them. They mentioned some previous negative experiences using other apps with VoiceOver enabled. Some buttons in the app seldom have any "text to speech" function, which means they were not labelled. These people with low vision were satisfied with the contrast of the app interfaces. There was only one person with low vision who turned on the invert colours feature in order to use the app (*Figure 5.22*).

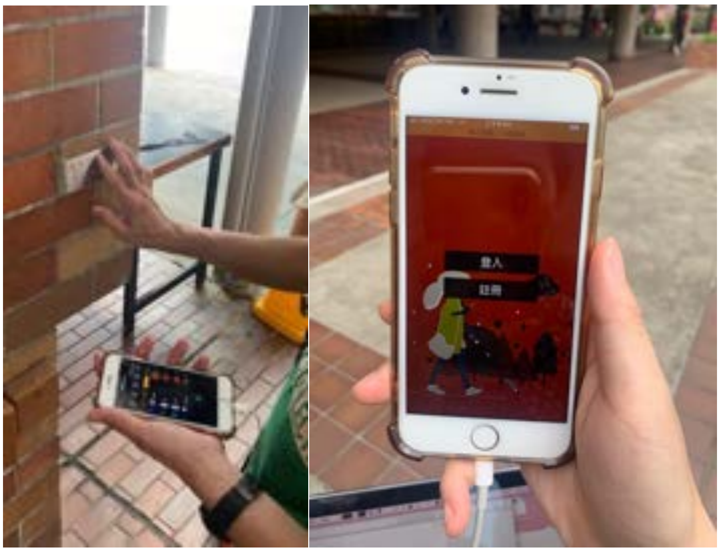


Figure 5.22. Captured moments of using the inverted colour mode

5.5.9 Future Recommendations

The potential features and functions suggested by the participants were concluded as two main categories: 1. General features 2. Business suggestions as follows:

- General features

1. Some people mentioned they would find out more information about the spots/attraction; 28 out of 30 participants also mentioned a valuable point that at least you should provide more information that allows users to choose whether to listen to the basic information or detailed information. For those who have limited time, they can skip it.
2. Not only using the audio to play the description for each spot but also being able to add text that allows users to use the "VoiceOver" function to listen, the text enables users to adjust the speed of play which saves users' time.
3. Different apps have different expertise and focus if the app can shift to other apps such as *Openrice*, *Facebook* or *Google Map*. Alternatively, this app can link to Wikipedia, when users want to know more information about the place, which will enhance the power of this app, too.
4. The reward could be diversity, not just coffee, but can provide some souvenirs related to the attraction per se.

- Business suggestions

1. Besides using points, they suggested that the app can collaborate with different shops then provide stamps when users complete missions that lead to obtaining a coupon or use *WeChat* or *Alipay* to buy things. Alternatively, the stamps will offer different themes for different holidays. One of the participants mentioned holiday themes, such as at Christmas, users can collect stamps with Christmas themes for a small Christmas present or at Chinese New Year, a certain amount of

the stamps will amount to a red pocket for the users. Although people with visual impairments cannot see, they still can sense the festive atmosphere by adding a description of the content of the stamp.

2. Some participants mentioned that the audio descriptions could be sponsored by some companies where the sponsor buys the right to name the audio description that describes each spot.
3. Regarding the points towards a reward, one participant provided us with his insight that the app can use theme-based stickers as the collection counting towards the final reward in different special places. Currently, the point system that the app adopts is just the plain number. "You can cooperate with those people in each place. For instance, during Christmas, the users can get some rewards when they collect certain Christmas decoration stickers. With different themes, you can design different stickers, such as Christmas ornaments or Christmas decorations at Christmas as well as red envelope stickers at New Year and so on"

5.6 Summary

In sum, all participants mentioned that they would definitely recommend the app to their peers and would play next time. On the whole, the participants reaffirmed the significant potential in gamification as a direction for engaging with tourist destinations and recommended that if the gamified applications are designed appropriately with consideration of users' motivations and needs, they can definitely enhance their tourism experience throughout their travel.

Consistent with the literature, the app test findings in this chapter support gamification as a means to encourage motivation, engagement, and enjoyment (Zichermann & Cunningham, 2011; Seaborn & Fels, 2015). According to the app test findings and the studies discussed in the previous chapters, a gamified framework of designing a travel application for people with visual impairments could be developed (*Figure 5.23*).

Figure 5.23. Gamified framework for designing a travel experience for people with visual impairments

Accessibility is in the middle of the entire framework, surrounded by the motivation, emotion, meaning, knowledge, playfulness, competence, autonomy, and relatedness. The most vital consideration is that full accessibility is enabled. Apple devoted notable effort to improving the access of the various functions in the iPhone. Hence, those, such as researchers, designers, and developers, wish to create applications for people with visual impairments or even for the general public who need to follow the relevant international and local accessibility guides and fully understand all the accessibility features on iPhones. There are detailed guidelines for developing an accessibility application which is available online. A gamified system for people with visual impairments cannot succeed without full access to all the functions on the mobile phone. As was pointed out in *Section 2.1.3*, the user is at the root of gamification, and the user's motivation eventually propels the outcome. Hence, understanding users' motivation is vital to creating a successfully gamified system. As mentioned in *Section 2.1.4*, the emotions, especially positive emotions such as happiness and excitement, are a vital part of the memorable tourism experience. People's motivation and emotions can be accessed by conducting in-depth interviews and observations. Meaning is another consideration. As mentioned in the literature review section, tourism is about gaining information. The gamification features should meet their requirements for acquiring information. Without considering the meaning and providing knowledge for people with visual impairments, the gamification technique can only be regarded as a fancy term. With meaningful and knowledge feeding, the core of gamification is playfulness. Autonomy, competence, and relatedness, the three critical elements in intrinsic motivators, should also be assessed. The gamification features are various. Designers should choose the proper features based on the experience content and related to the visual impairment need. For example, in the travel experience content, knowledge and curiosity should be essential elements. Therefore, the challenges of gamification should be less considered. Besides that, there are many apps on the market, but the reason why not many people with visual impairment use them is that the amount of information is not large enough, and maintaining an app requires a lot of human and material resources. While the concept is impressive, whether the app developer can maintain it is another issue.

CHAPTER 6: CONCLUSIONS

This concluding chapter opens with an overview summarising the dissertation. This is followed by a review of the main findings based on the research questions and how they present the goals of this research. Building on this, the significant contributions of the research to theory and practice are highlighted. Finally, the limitations of the research are discussed, as well as the future work that falls outside this research.

6.1. Overview of the dissertation

This doctoral dissertation was an attempt to investigate how mobile application design can address the psychological needs of people with visual impairments in Hong Kong. Accordingly, this goal was achieved through a systematic process of investigation which has been presented in the five chapters of the dissertation.

Chapter 1 introduced the general background information, including personal motivation, research questions, the scope of the dissertation, the objective of the research, and contribution of the study. *Chapter 2* set out to establish the current research gap and links to this research with existing research and design practice by reviewing the existing studies and exploring the concepts associated with visual impairments. *Chapter 3* was devoted to developing a holistic understanding of the subject matter as well as to deriving the needs of the target group. The research included two ethnographic studies of people with visual impairment in Hong Kong, and in-depth analysis of the psychological demands of people with visual impairments. Most importantly, the project includes a "research through design" methodology, which goes beyond focusing only on the theory development but also involves adopting design practice to validate the assumptions with target users. *Chapter 4* provided a detailed data analysis of the qualitative material obtained from interviews and observations. The findings in this chapter led to a specific design which is introduced in *Chapter 5*. This chapter presented in detail how to apply gamification elements into the tourism experience. The interactive app development process with several app testing sessions was introduced in this section as well. This chapter provided evidence that employing gamification can be used to enhance the tourism experiences of people with visual impairments.

The main research question of this project was **"How can the travel experience of people with visual impairments be enhanced through a mobile application?"** The answer can be provided by the answers to the following sub-research questions.

1. **What is the current situation of people with visual impairments using assistive products in general and travel apps in particular in Hong Kong?**

   To address this research question, *Chapter 1* and *Chapter 2* reviewed the background information and relevant literature. The Hong Kong government offers to fully support the basic needs of a range of different communities of persons with disability groups, including people with visual impairments. Various assistive products have been developed in Hong Kong. However, these assistive products, specifically in digital form, aimed at people with visual impairments meet only their basic needs, such as navigation and object recognition (such as *SESAMI*, 2013 and *Tap My Dish*, 2017). In order to address the scant research available, this research looked beyond the basic needs of people with visual impairments to ameliorate their quality of life through expanding their dimensions of experiences. The conducted studies suggested participants' dissatisfaction with how many available apps for people with visual impairment lack careful consideration of accessibility. Additionally, there are dozens of apps that do not fully consider target users' needs, eventually leading to those apps' failure. Therefore, the key to serving people with visual impairments should be to understand the range and depth of their needs comprehensively. The ways to understand their actual needs are crucial, which leads to my second research question.

2. **How can researchers better understand the needs of people with visual impairments?**

   For any user-centred design, understanding the needs and capabilities of users is crucial. This research provided empirical notes and comprehensive descriptions on the procedure that implemented empathic design and the methods from sensory ethnography to gain an understanding of the needs of people with visual impairments (see *Chapter 3*). Empathic experience exercises assisted me to put myself in the same situation as people with visual impairments which furthered my understanding of the importance of accessibility in applications. Therefore, I put accessibility as the first consideration of this project. This project adopted a qualitative research approach, which focuses on the "deep data" instead of "big data". Experience design consists of user stories and assumes different phases of user stories being the key towards better design. Only in-depth interviews with more interpretative data could evoke the users' actual stories and needs, which cannot be conveyed merely by numbers or simple questionnaires. Therefore, empathic design research was chosen to help gain a full understanding of the actual desires and limitations of people with special needs.

3. **How do people with visual impairments use their non-visual senses to engage with the world, particularly when travelling?**

   Despite the difficulties that people with visual impairments may face, they can still lead positive lives in general. Multisensory participant observation and in-depth interviews show how people with visual impairments use their non-visual senses to engage with the world. The findings from the two main ethnographic studies provided various types of data regarding how people with visual impairments use their non-visual senses to engage with the world, particularly when travelling. All participants highlighted the importance of sensory compensation, meaning that adopting auditory, olfactory, taste, and tactile experiences were vital for people with visual impairments. The detailed findings can be viewed in *Section 4.1.3*. The key findings in the sensory compensation section fed into app design, such as a feature to provide audio descriptions of different senses that enable people with visual impairments to better understand the destination. The results show that the participants want to achieve self-actualisation, such as to challenge themselves and to sharpen their skills once they have satisfied their physiological needs. Travelling as a tourist, away from the familiar places, can promote personal development. Travel can offer a chance to learn about one's capabilities, to gain a sense of self-confidence, and to gain a sense of accomplishment (Pearce, 2005).

4. **What is the best way to design mobile-assisted apps in order to enhance the travel experience of people with visual impairments?**
The findings from the background studies, study 1 and study 2, indicated that participants are interested in challenging themselves to fully benefit from sensory compensation and to gain deep descriptions of their environments which were among the key insights. In this vein, applying gamification to mobile applications was considered an effective strategy for enhancing the engagement, enjoyment, and motivation of people with visual impairments. The results from the final app testing show that such an approach allows a departure from the functional services conventionally provided to people with visual impairments. Gamification strategy could increase tourists' interests in the destination and offer new knowledge together with engaging experiences. Building a connection between the player and locals and the player and other players can enhance the travel experience and influence how people interact with destinations. A gamified framework of how to develop a travel application for people with visual impairments could be developed (see *Figure 6.1*).

Figure 6.1. Gamified framework for designing a travel experience for people with visual impairments

Accessibility is in the middle of the entire framework, and is surrounded by motivation, emotion, meaning, knowledge, playfulness, competence, autonomy, and relatedness. The most vital consideration is that full accessibility is enabled. Apple devoted a notable effort to improving iPhone accessibility (see *Section 1.3*). Therefore, stakeholders, such as researchers, designers, and developers who wish to create applications for people with visual impairments or even for the general public need to follow the relevant international and local accessibility guides and fully understand all the accessibility features on iPhones and iOS (see *Section 4.4*). A gamified system for people with visual impairments cannot succeed without full access to all functions on the mobile phone. As was pointed out in *Section 2.1.3*, the user is at the root of gamification, and the user's motivation eventually propels the outcome. Therefore, understanding users' motivation is vital to creating a successful gamified system. As mentioned in *Section 2.1.4*, emotions, especially positive emotions such as happiness and excitement, are a vital part of the memorable tourism experience. People's motivation and emotions can be assessed by conducting in-depth interviews and observations. Meaning and information are other significant considerations. Without considering the meaning and providing knowledge for people with visual impairments, the gamification technique can only be regarded as a fancy term. In terms of meaning, gamification in the travelling setting regards users' personal value realisation and self-actualisation, not just merely in completing tasks or obtaining rewards but focusing on deeply fulfilling users' actual demands and enabling them to understand how powerful achievements can be made. As mentioned in the Chapter 2, tourism is about gaining information. Information feeding could be provided through a well-designed audio description (see *Section 2.1.7*). As this dissertation considered the two main types of blindness: congenital (blind from birth) and adventitious (lost their vision afterwards), the audio description should cover these two types of blindness. The main difference between congenital and adventitious blindness is that people who are congenitally blind do not have "visual memories". Therefore, an audio description that introduces travel information should be considered when using familiar objects to describe visual elements. In the final app testing, both people who were blind at birth or who lost their vision afterwards, were satisfied with the information offering. They all agreed that the audio description of the visual elements and the background information can truly assist them in deeply understanding the destination and fully engaging with the destination. The gamification features, such as check points and reward points also lead them to acquire more information and form a positive interest to learn new things. With meaning and knowledge feeding, the core of gamification is playfulness. Autonomy, competence, and relatedness, the three critical elements in intrinsic motivations, should also be assessed.

The framework was created by involving several studies and stages with different participants; throughout the process, the data are triangulated from different groups of participants to reflect the consistent qualitative findings. The theoretical foundations in this study supported features as design possibilities. All findings that have mentioned have been consistent with previous research. This design research that contains a large number of theoretical grounds along with the framework in this study was developed with the purpose to enhance the travel experience for people with visual impairments.

With emphasise on the “accessibility” focus, this framework could be adjusted based on the context. Designers should choose the proper features based on the domain area of the experience (such as travelling, shopping, navigation) and related to the visual impairments addressed. For example, in the travel experience setting, knowledge and curiosity should be essential elements. Therefore, the challenges of gamification should be less considered. Indeed, for people with visual impairments, travelling is already a challenge to them. The app makes “challenge (s)” more meaningful and interesting, especially for assisting people with visual impairments. These two are the main ideas why games are so addictive to players. For those who like travelling but are hesitant this app gives them the support and motivation to feel more comfortable. In this light, the notion of challenge, one of the standard gamification concepts, was shifted in the context of this specific audience. The concept of receiving immediate feedback in gamification is the key for these audiences to gain benefit while travelling. In general, a thorough understanding of people's needs is crucial when conducting empathic design research and methods from sensory ethnography that can evoke subjects' memory and encourage them to share their everyday life experiences with researchers.

Building on the answers to each research question, the significant contributions of the research to theory and practice are highlighted as follows. The main contributions of this investigation are emphasised and addressed in the following six ways. Firstly, as its foremost contribution to knowledge, this research advances the understanding of the general needs of people with visual impairments, particularly, from the mobile device perspective, from which contributions to knowledge and literature are discussed. Secondly, this project offered empirical notes on and comprehensive descriptions of the procedure so that researchers can implement empathic design and sensory ethnography methods to gain an understanding of the needs of people with visual impairment. Thirdly, the project offers a comprehensive gamified framework for interaction and also game designers, which is drawn mainly from the available literature and first-hand research into enhancing the travel experience for people with visual impairments. The "research through design" methodology was adopted in this thesis, along with a detailed documentation of the process from the beginning to finally publishing a mobile app in the Apple store. It offers a new approach for transferring knowledge produced in the HCI research to the HCI practice. Also, there are some digital tools for testing the accessibility functions on mobile phones for designers, which were highlighted in this study. Fourthly, apart from the research's contribution to designing an app for people with visual impairments, the study also benefits the iOS development. The findings contribute to practice in the industry by highlighting the significance of game and iOS developers and their role in realising the actual travel experience product. Most importantly, the actual outcome of this research is a fully working application, not just a prototype, and can be downloaded from the Apple store. Apple's review process assures that an app follows the relevant guidelines published in the Apple store. Fifthly, the empirical findings in this project provide a new, more inclusive, understanding of travel experiences. It also shows how application design is an affordable option for dedicated assistive technologies. Lastly, the research provides insights into the travelling experience of people with visual impairments and introduces a framework for government entities, social enterprises, and organisations serving people with visual impairments. In brief, the research fills the gap of a lack of studies which focus on the psychological needs of people with visual impairments.

6.2. Limitations

There are limitations to this research that restrict the generalisation of its results. As the first limitation, the research was conducted in Hong Kong, a well-developed urban area, where the assistive equipment already meets the basic life requirements of people with visual impairments. Therefore, the findings may not necessarily apply to other developing areas or cities. Another limitation is the small sample size. As Chmiel and Mazur (2012, p. 61) stated, "In fact, one of the major hurdles in reception research including blind and partially sighted participants is getting access to them". I made an effort to contact all the organisations which serve people with visual impairments in Hong Kong, Guangzhou, and New York, and to participate in events for blind people in order to recruit intended participants who meet the requirements for this research. The current research focused mainly on no more than 100 participants in Hong Kong. Although diverse visually impaired subjects participated in this research, more participants could ideally have been involved. As a downside, this study included most of the participants from a low-income background only, and they were all mainly linked to two organisations. Potential target users with a higher income who have more possibilities to travel outside their home city/country may require a more nuanced and customised approach regarding safety and cultural factors, among others. Besides, this research only explored the gamified testing based on the university environment, but tourism has different categories, such as urban and rural settings, theme parks, cultural heritage sites, and so on. Different types of settings might apply to different gamification concepts.

Some studies suggest that the results of gamification might not be long-term (Hamari, 2013; Farzan, DiMicco, Millen, Brownholtz, Geyer, & Dugan, 2008a, 2008b), but instead could be viewed in the light of a novelty effect. Morschheuser et al. (2017, p. 1304) emphasise that "gamification projects should not be considered as typical deterministic software projects. A successful gamification project should never end because it will become part of how the organisation works”. This idea leads to the next section: the future plan.

6.3. Future plan

The app developed for and during this PhD project is available on the Apple store from where it can be downloaded (see *Figure 6.2*).

Figure 6.2. Screenshot of the Lively Tour App in the Apple Store

After submitting it successfully to the Apple store, useful suggestions and feedback will be received from the end users. The app could still follow the iterative app development process to fix the errors and add more features. It would be interesting to discover potential problems by applying the theoretical framework in gamification in the other fields of tourism such as urban and rural environments, cultural heritage sites, theme parks, landscapes, and so on. I will disseminate the app among the research participants first, then ask them to promote it through their networks. The app in the Apple store has only one destination to explore. It is vital to enable its scale and contents to attract more users. One primary recommendation arising from this research is that collaboration with a relevant organisation or applying for funds such as the Social Innovation and Entrepreneurship Development Fund (SIE Fund), a fund for creating social impact through innovative solutions, enables research to grow in scale. Another feasible direction for sustaining the direction of this project could be collaboration with companies which care about their social impact. The contents of the app will be augmented by the different tourist attractions in Hong Kong. If possible, the app will expand the content to other main tourist cities, such as Beijing, Paris and Tokyo. With a growing community, users can create comprehensive databases of localised information. The information grows with the community, forming a fully crowd-sourced travel map of the world.

In addition to the app development perspective, from the research standpoint, this research has shown that the infrastructure in Hong Kong is highly accessible and the awareness and knowledge of Hong Kong residents about accessibility to this infrastructure for people with visual impairments are relatively positive. This is because the Hong Kong government focuses on creating and enhancing an inclusive society so that all individuals can enjoy equality and respect in different areas of life. Thanks to this inclusive society, there are more opportunities to create meaningful research beyond the basic needs of people with special needs. The present research lays the groundwork for future investigations into studying the psychological needs of people with visual impairments in Hong Kong. Using this research as a substantial starting point, there is a vast scope to conduct further empirical studies in Hong Kong and explore various other aspects of future research for people with visual impairment in Hong Kong. The procedure for implementing the methodology in this research, such as empathic experience exercises and techniques from sensory ethnography, that have been proved effective here, can be further developed to investigate the requirements of people with other special needs. Although this gamified framework was specifically developed based on the travelling setting, it can also be implemented in other situations, such as education and healthcare. The major change when developing a gamified application should be the selection of different proportions of the various gamification features based on users' needs. In addition, the thorough consideration of ethical issues (see *Section 3.3.1.5*) raised in this project can also be used for further investigation. In the future, there will be increasing digital inclusion and increased focus on experience enhancement for people with special needs in Hong Kong. On the whole, tremendous efforts are certainly required for researchers to discover the actual needs of people with visual impairments by adopting empathic research methods and developing ongoing assistive digital products while the technology evolves.

7. APPENDICES

Appendix 1: A detailed list of the applications designed for people with visual impairments

Name	Launch Year	Country	Company	Type	Description	Offical Website	Other Links
TalkBack	2009	USA	Google	App in Android	TalkBack is the most typical accessibility application in Android platform. It helps visually impaired users interact with their devices. TalkBack adds spoken, audible, and vibration feedback to your device. TalkBack comes pre-installed on most Android devices.	https://play.google.com/store/apps/details?id=com.google.android.marvin.talkback	
iYomube			[illegible] (Amedia) [illegible]		App for optical character recognition for printed	http://www.amedia.co.jp/chinese/product/iyo	https://itunes.apple.com/us/app/
Sight							
Be My Eyes	2013	Denmark		Android+IOS	Be My Eyes is an app that connects blind and	http://www.bemyeyes.org/	http://www.bemyeyes.org/faq/
Aipoly Vision	March, 2016	SF USA	Aipoly	Android+IOS	Aipoly helps the blind and visually impaired see the	http://aipoly.com	http://www.socialtech.org.uk/pro
[illegible] BlindSquare	2012	Helsinki, Finland		IOS	look up information about your surroundings on Foursquare and Open Street Map Text To Speech/ [illegible] Acapela Voices	http://blindsquare.com/	
Seeing AI	2017				Seeing AI is a free app that narrates the world	https://www.microsoft.com/en-us/seeing-ai/	https://itunes.apple.com/us/app/
Navigation							
KMB					KMB that not only announces each stop, it will also alert user two stops in advance before their final stop.		
[illegible] VoiceMa	2016		Lands Departme	IOS	VoiceMapHK is a digital inclusion mobile map app, with the vision to bridge the digital gap and enable everyone enjoy the benefits of the technology advancements. ""VoiceMapHK"" provides users with a one-stop access to geospatial information in Hong Kong, including detailed digital maps and building information maintained by the Lands Department, and integrated geospatial information about public facilities provided by various government departments."	http://www.brailleinstitute.org/digital/mobile-applications.html	
[illegible] E-Guide						http://www.landsd.gov.hk/mapping/tc/Voice	
BackMap	2017	USA		Prototype?	backpack that vibrates to let you know when to turn right and when to turn left, without taking their phones out of their pocket. Each strap contains a vibration motor that vibrates the respective side when the user needs to turn left or right. Both straps vibrate if the user receives a push notification.	https://techcrunch.com/2017/05/14/backmap-helps-people-who-are-visually-impaired-navigate-cities-and-indoor-areas/	
iMove		Milan, Italy	EveryWare Lab		iMove supports independent mobility of visually impai	https://itunes.apple.com/us/app/imove/id[illegible]	
iWalkStraight		Milan, Italy	EveryWare Lab		iWalkStraight helps you walk straight in absence of		
Seeing Eye GPS		New York	Sendero Group LLC		The Seeing Eye, the pioneer in guide dogs, and	https://itunes.apple.com/us/app/seeing-eye-	
Microsoft Soundscap	2018	USA			Microsoft Soundscape uses 3D audio technology to enhance your awareness of what is around you, and	https://itunes.apple.com/us/app/microsoft-soundscape/id[illegible]	
VisionSim					[illegible]		
Ariadne gGPS							
Game							
Outlast					where a key mechanic is using battery to use nightvision mode on your camera so you can see in the dark. If you run out of battery you can't use the nightvision so can only be in the dark		
Perception					It's about playing as a blind girl. There's videos of it but it is not released yet		
A Blind Legend	2014				an app game with no interface or graphics. Only a black screen. Bulb Boy is a point and click adventure in a dark house and you can use your own head as a light. I'll keep thinking for more examples		http://www.ablindlegend.com/en/home-2/
Amnesia The Dark Descent					in a dark castle with only a lamp and you need to find oil for the lamp.		
Alan Wake					ery famous one where you use a light as a weapon		
Hotel Blind			Serellan				
The Invisible Puzzle		Milan, Italy	EveryWare Lab		In "The Invisible Puzzle" you must recognise drawings relying only on sound!	https://itunes.apple.com/us/app/the-invisible-puzzle/id[illegible]	
Ear Monsters: A 3D					Your Mission: Kill as many monsters as you can, as	https://itunes.apple.com/us/app/ear-	
[illegible]							
[illegible]							
[illegible]							
Blind Gladiator	2016	Italy			http://www.audiogame.store/en/home-en/	https://itunes.apple.com/hk/app/blind-gladiator/id[illegible]	
TypeInBraille		Milan, Italy	EveryWare Lab		TypeInBraille allows you to write in Braille on your	https://itunes.apple.com/us/app/typeinbraille	
the Eclipse Soundscapes Project					"rumble map" app that will allow users to visualize	http://eclipsesoundscapes.org/	

Appendix 2: Interview questions for study 1

The following are the interview questions for study 1:

1. What places do you routinely go to everyday?
2. When you go out, what aids do you use? What kind of technology do you use? Why?
3. What apps do you use for helping you go out? Can you show me? Could you tell me their advantages and disadvantages?
4. What leisure activities do you usually do?
5. Have you ever visited any of the well-known tourist attractions in Hong Kong? What were they?
6. Have you ever tried to explore an unfamiliar place alone? Do you prefer to explore alone or with someone/ like family/ friends take you there?
7. What's the biggest challenge for you when you go outside alone?
8. When you explore the unfamiliar places, how do you use your senses to assist you?
9. Do you think the other senses of people with visual impairments are stronger than those of non-people with visual impairments?
10. How do you cultivate and train your senses?
11. When did you first to use an iPhone?
12. Can you describe the difference between before and after you had an iPhone?
13. What is your favourite app? Do you play any games on your phone?

Appendix 3: Application for ethical review

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

To	Wirman Hanna Elina (School of Design)
From	Koskinen Ilpo Kalevi, Chair, Departmental Research Committee
Email	ilpo.koskinen@ Date 20-Oct-2016

Application for Ethical Review for Teaching/Research Involving Human Subjects

I write to inform you that approval has been given to your application for human subjects ethics review of the following project for a period from 04-Jul-2016 to 04-Jul-2019:

Project Title:	Enhancing the Digital Products Experience for Vision-Impaired People using Empathic Design
Department:	School of Design
Principal Investigator:	Wirman Hanna Elina
Project Start Date:	04-Jul-2016
Reference Number:	HSEARS20161006001

You will be held responsible for the ethical approval granted for the project and the ethical conduct of the personnel involved in the project. In the case of the Co-PI, if any, has also obtained ethical approval for the project, the Co-PI will also assume the responsibility in respect of the ethical approval (in relation to the areas of expertise of respective Co-PI in accordance with the stipulations given by the approving authority).

You are responsible for informing the Human Subjects Ethics Sub-committee in advance of any changes in the proposal or procedures which may affect the validity of this ethical approval.

Koskinen Ilpo Kalevi

Chair

Departmental Research Committee

Appendix 4: Information sheet

The Hong Kong Polytechnic University
香港理工大學

Annex V

INFORMATION SHEET

Enhancing the Digital Product Experience through Gamification for the Visually Impaired Using Empathic Design and Sensory Ethnography

You are invited to participate in a study conducted by Huang Lusha, who is a post-graduate student of the School of Design in The Hong Kong Polytechnic University. The project has been approved by the Human Subjects Ethics Sub-committee (HSESC) (or its Delegate) of The Hong Kong Polytechnic University (HSESC Reference Number: HSEARS20161006001).

The aim of this study is to assess and to explain the needs of visually-impaired people in order to propose innovative solutions to enhance their experience in the digital world. The study will involve completing an interview, which will take you about half hour or less. It is hoped that this information will help to understand the digital product used by visually-impaired people in order to develop better solutions.

The testing should not result in any undue discomfort, the interview session will be video recorded and photographs will be taken. All information related to you will remain confidential and will be identifiable by codes only known to the researcher. You have every right to withdraw from the study before or during the measurement without penalty of any kind.

If you would like to obtain more information about this study, please contact my chief supervisor Dr Hanna Wirman on tel. no.: +852 2774 ; mailing address: V902d, 9/F, Jockey Club Innovation Tower (Block V), The Hong Kong Polytechnic University, Hung Hom, Kowloon,Hong Kong; email: hanna.wirman@ .

If you have any complaints about the conduct of this research study, please do not hesitate to contact Miss Cherrie Mok, Secretary of the Human Subjects Ethics Sub-Committee of The Hong Kong Polytechnic University in writing (c/o Research Office of the University) stating clearly the responsible person and department of this study as well as the HSESC Reference Number.

Thank you for your interest in participating in this study.

Huang Lusha
Principal Investigator

Hung Hom Kowloon Hong Kong
Tel (852) 2766 5111 Fax (852) 2764 3374
Email polyu@polyu.edu.hk
Website www.polyu.edu.hk

Appendix 5: Consent to participate in research

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

CONSENT TO PARTICIPATE IN RESEARCH

Enhancing the Digital Product Experience through Gamification for the Visually Impaired Using Empathic Design and Sensory Ethnography

I _______ hereby consent to participate in the captioned research conducted by Huang Lusha.

I understand that information obtained from this research may be used in future research and published. However, my right to privacy will be retained, i.e. my personal details will not be revealed.

The procedure as set out in the attached information sheet has been fully explained. I understand the benefit and risks involved. My participation in the project is voluntary.

I acknowledge that I have the right to question any part of the procedure and can withdraw at any time without penalty of any kind.

Name of participant ____________________

Signature of participant ____________________

Name of Parent or Guardian (if applicable) ____________________

Signature of Parent or Guardian (if applicable) ____________________

Name of researcher ____________________

Signature of researcher

____

Date ____________________

Hung Hom Kowloon Hong Kong
Tel (852) 2766 5111 Fax (852) 2764 3374
Email polyu@polyu.edu.hk
Website www.polyu.edu.hk

Appendix 6: Mobile application accessibility checklists

(A) Best Practice Checklist ***Advanced level***

Best Practice		N/A	Visual Review	Screen Readers
1	**Perceivable**			
Text related				
1.1	Provide text alternatives for non-text contents	☐	Skip	☐
1.2	Avoid images of text	☐	☐	Skip
1.3	Provide text resize function to scale up text size or zoom support function (or work well with device's zoom feature) without loss of content	☐	☐	Skip
1.4	Provide meaningful content sequence	☐	Skip	☐
Sensory				
1.5	Do not solely rely on sensory characteristics for instructions	☐	☐	☐
1.6	Avoid solely rely on colours to convey information	☐	☐	Skip
1.7	Provide sufficient colour contrast	☐	☐	Skip
1.8	Provide alternative means for notification	☐	☐	Skip
Multi-media related				
1.9	Provide description for prerecorded videos	☐	☐	☐
1.10	Provide captions for videos	☐	☐	☐
1.11	Provide sign language for prerecorded videos	☐	☐	Skip
1.12	Provide alternatives for audio-only information	☐	☐	☐
1.13	Easy to turn off background sound or set as user-initiated only	☐	☐	☐
2	**Operable**			
Navigation related				
2.1	Provide navigation for going backward	☐	☐	☐
2.2	Provide multiple ways	☐	☐	Skip
2.3	Provide clear and simple headings	☐	☐	Skip
2.4	Provide clear and informative links	☐	☐	☐
2.5	Provide focus visible	☐	☐	Skip
Control related				
2.6	Provide means to close popovers	☐	☐	☐
2.7	Minimize user input	☐	☐	☐

Best Practice		N/A	Visual Review	Screen Readers
2.8	Make all clickable objects large enough to be tapped	☐	☐	☐
2.9	Provide simple gesture	☐	☐	☐
2.10	Provide sufficient time for users to read the content and operate a function	☐	☐	☐
2.11	Lists with user-initiated auto-updating	☐	☐	☐
2.12	Provide three flashes or below threshold	☐	☐	Skip
3	**Understandable**			
User interface related				
3.1	Provide consistent and simple user interface structure	☐	☐	☐
3.2	Avoid sudden change of context	☐	☐	☐
3.3	Provide consistent identification	☐	☐	☐
Input related				
3.4	Provide error identification	☐	☐	☐
3.5	Provide input assistance such as proper labels or instructions for user input	☐	☐	☐
3.6	Provide error suggestion	☐	☐	☐
3.7	Provide means for error prevention (legal, financial, data)	☐	☐	☐
4	**Other Best Practice**			
4.1	Provide contact points or email feedback as well as an accessibility statement	☐	☐	☐

(B) Best Practice Checklist *Baseline level*

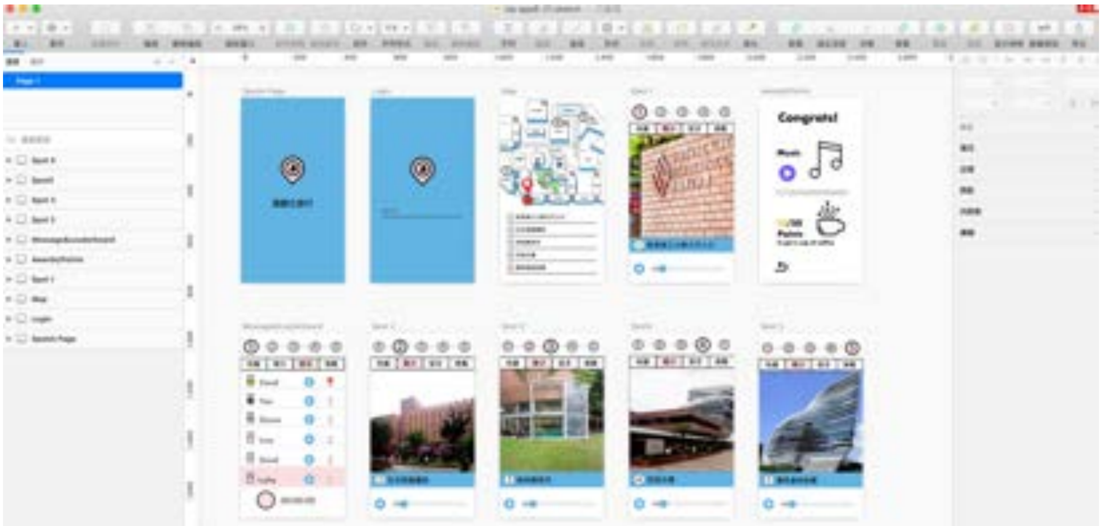
Best Practice		N/A	Visual Review	Screen Readers
1	**Perceivable**			
Text related				
1.1	Provide text alternatives for non-text contents	☐	Skip	☐
1.3	Provide text resize function to scale up text size or zoom support function (or work well with device's zoom feature) without loss of content	☐	☐	Skip
1.4	Provide meaningful content sequence	☐	Skip	☐
Sensory				
1.7	Provide sufficient colour contrast	☐	☐	Skip
1.8	Provide alternative means for notification	☐	☐	Skip
Multi-media related				
1.9*	Provide description for prerecorded videos	☐	☐	☐
1.10*	Provide captions for videos	☐	☐	☐
1.11*	Provide sign language for prerecorded videos	☐	☐	Skip
1.13	Easy to turn off background sound or set as user-initiated only	☐	☐	☐
2	**Operable**			
Navigation related				
2.1	Provide navigation for going backward	☐	☐	☐
2.3	Provide clear and simple headings	☐	☐	Skip
2.4	Provide clear and informative links	☐	☐	☐
Control related				
2.6	Provide means to close popovers	☐	☐	☐
2.8	Make all clickable objects large enough to be tapped	☐	☐	☐
2.10	Provide sufficient time for users to read the content and operate a function	☐	☐	☐
3	**Understandable**			
User interface related				
3.1	Provide consistent and simple user interface structure	☐	☐	☐

Best Practice		N/A	Visual Review	Screen Readers
3.3	Provide consistent identification	☐	☐	☐
Input related				
3.4	Provide error identification	☐	☐	☐
3.5	Provide input assistance such as proper labels or instructions for user input	☐	☐	☐
3.6	Provide error suggestion	☐	☐	☐
3.7	Provide means for error prevention (legal, financial, data)	☐	☐	☐
4	**Other Best Practice**			
4.1	Provide contact points or email feedback as well as an accessibility statement	☐	☐	☐

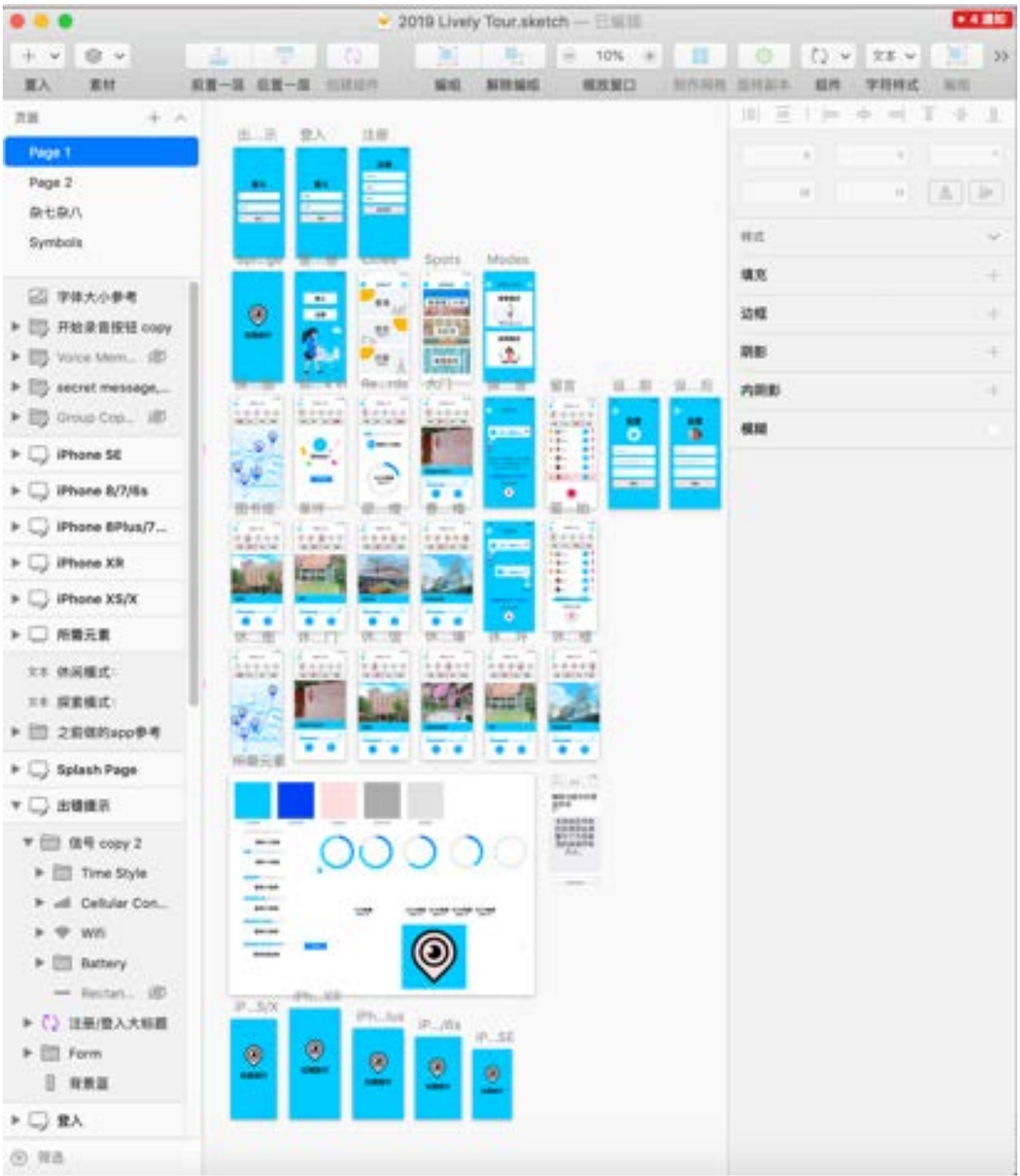
Notes:

* To attain the Baseline level, mobile applications are required to adopt all the best practices in the above table while adopting any of the best practices 1.9, 1.10 and 1.11.

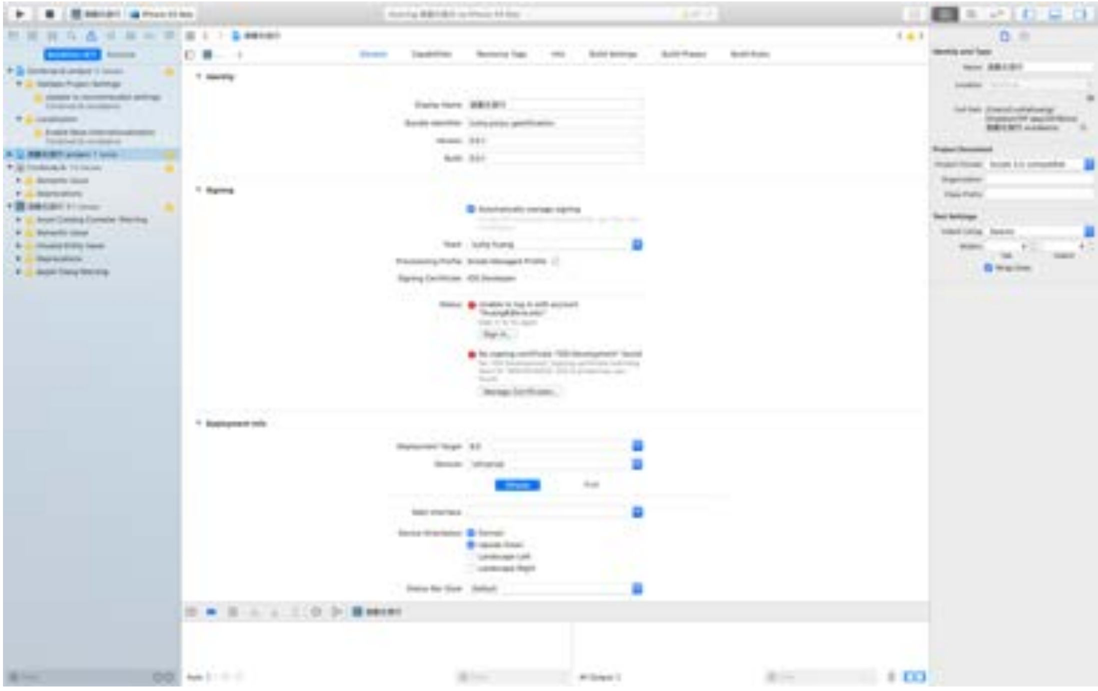
Appendix 7: Phase one of app testing using *Sketch*



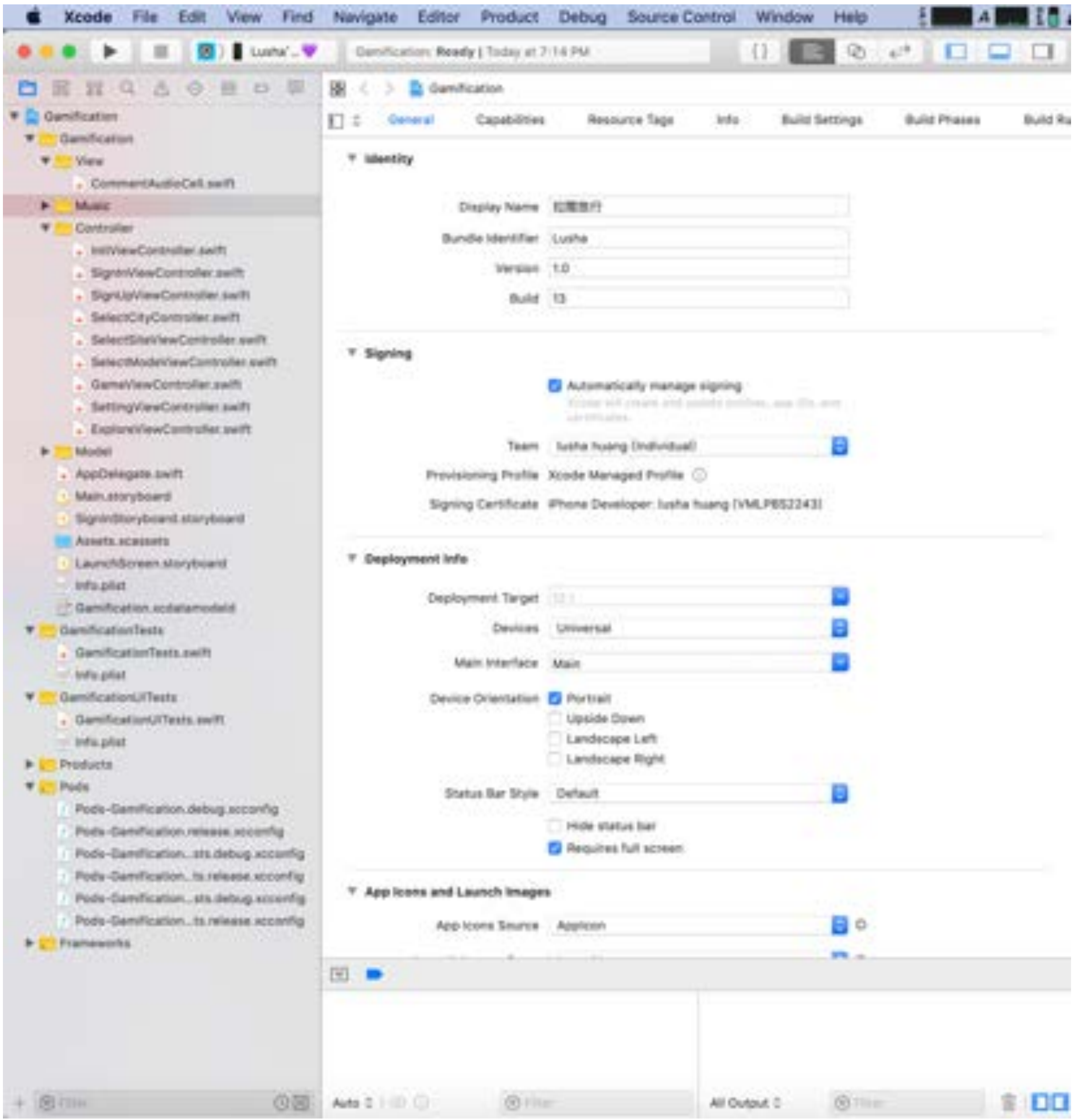
Appendix 8: Phase two of app testing using *Sketch*



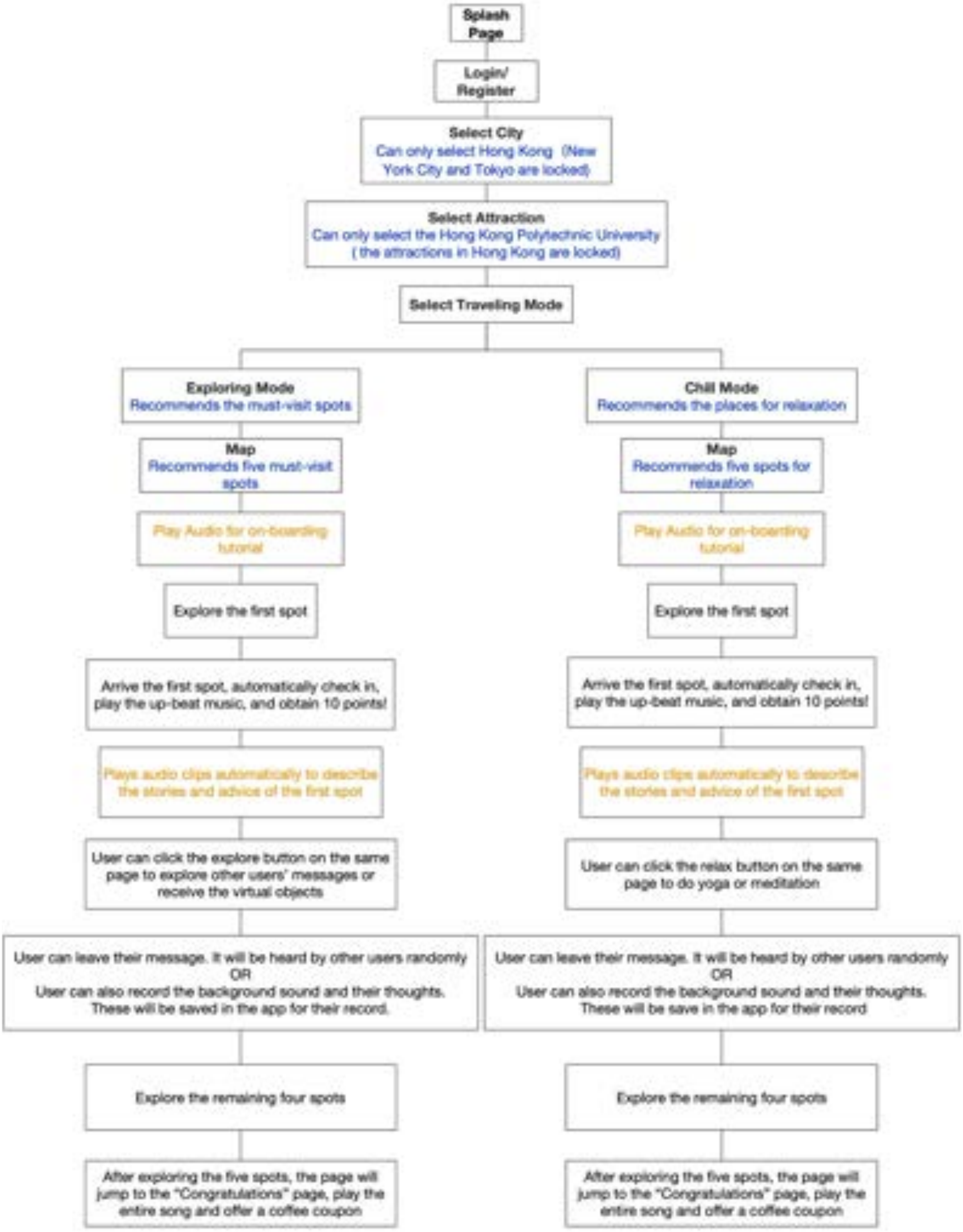
Appendix 9: Developing the app by writing Cordova in Xcode

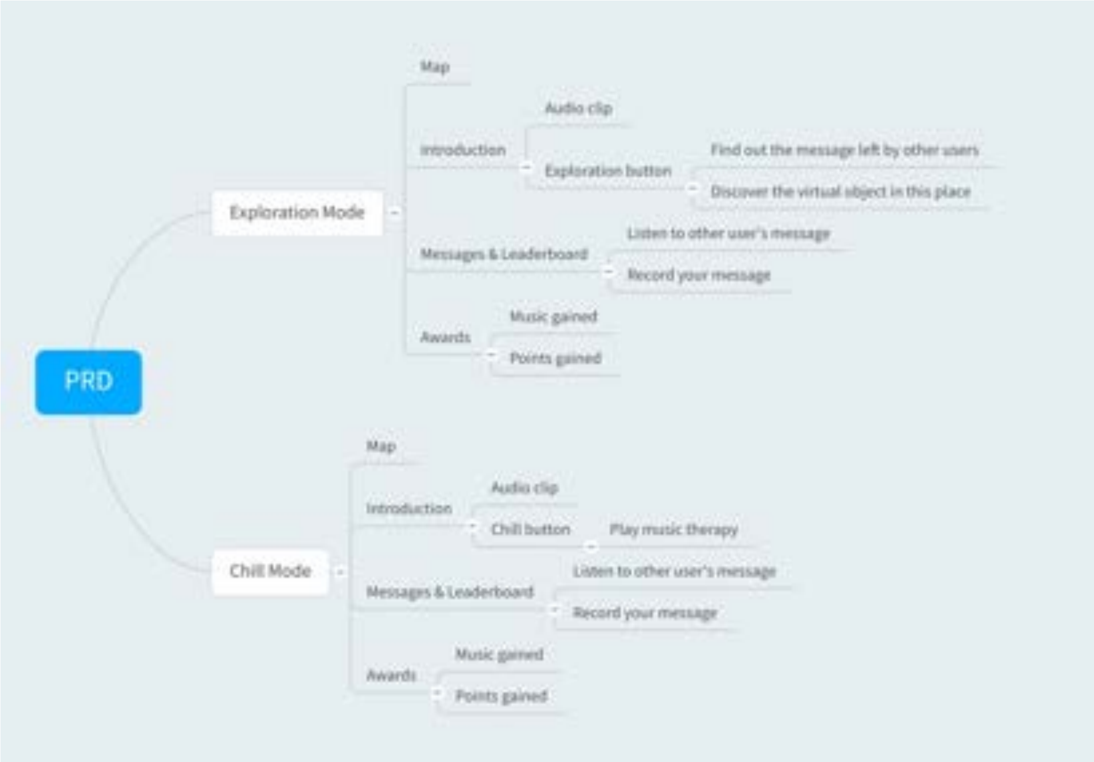


Appendix 10: Screenshot of developing the app by writing Swift in Xcode



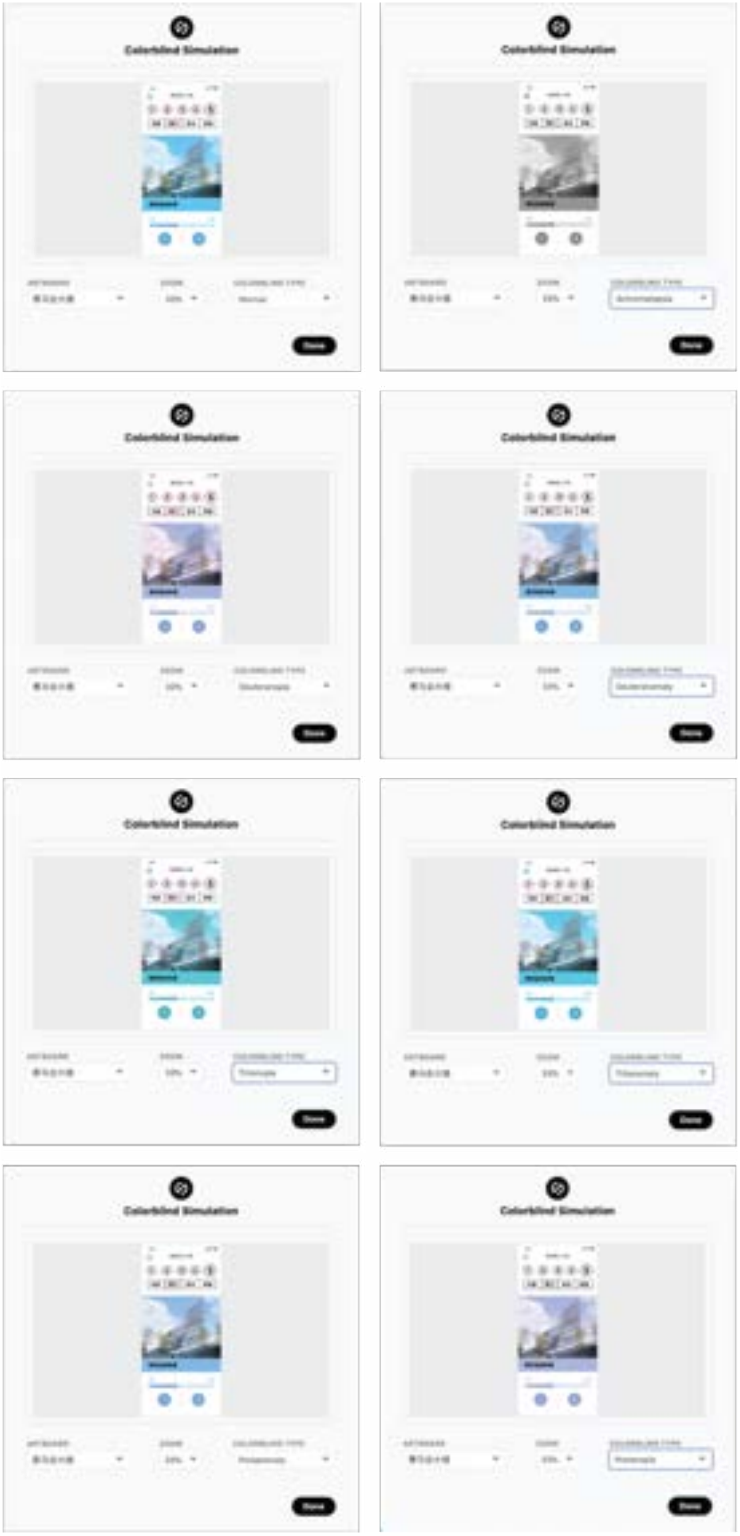
Appendix 11: The product requirement document prepared for the developer




PRD
Exploration Mode
Map
Introduction
Audio clip
Exploration button
Find out the message left by other users
Discover the virtual object in this place
Messages & Leaderboard
Listen to other user's message
Record your message
Awards
Music gained
Points gained
Chill Mode
Map
Introduction
Audio clip
Chill button
Play music therapy
Messages & Leaderboard
Listen to other user's message
Record your message
Awards
Music gained
Points gained

Appendix 12: Contrast checker

Appendix 13: Screenshots of colour-blind simulation



Appendix 14: Interview questions for final user testing

The following are the interview questions for final user testing:

1. Have you been to the Hong Kong Polytechnic University? If so, what is the difference between using this app and without it? How did the app enhance your travel experience compared with when you travelled without the app? (from -3 to 3, -3 means diminished experience, 3 means greatly enhanced experience)
2. How satisfied were you with this app's ease of use when you started using it?
   a) (from -3 to 3, -3 means not at all easy, 3 means extremely easily)
3. In terms of assisting you with accessibility, how satisfied are you with this app? (from -3 to 3, -3 means not at all satisfied 3 means extremely satisfied)
4. If you are of low vision, please rank the user interface design, colour, readability, and contrast? (from -3 to 3, -3 means not at all satisfied 3 means extremely satisfied)
5. Overall, how satisfactory was the app in meeting your travel requirements? (from -3 to 3, -3 means not at all satisfied 3 means extremely satisfied)
6. Overall, how does the app enhance or reduce the quality of your travelling experience? (from -3 to 3, -3 means not at all well, 3 means extremely well)
7. What do you find confusing about using this app? Please describe the problem you encountered in more detail

8. Which of the issues below was the biggest problem during your experience with the app?

- the app was missing features I needed
- the app was confusing to use
- the app was not accessible enough
- I experienced bugs
- other

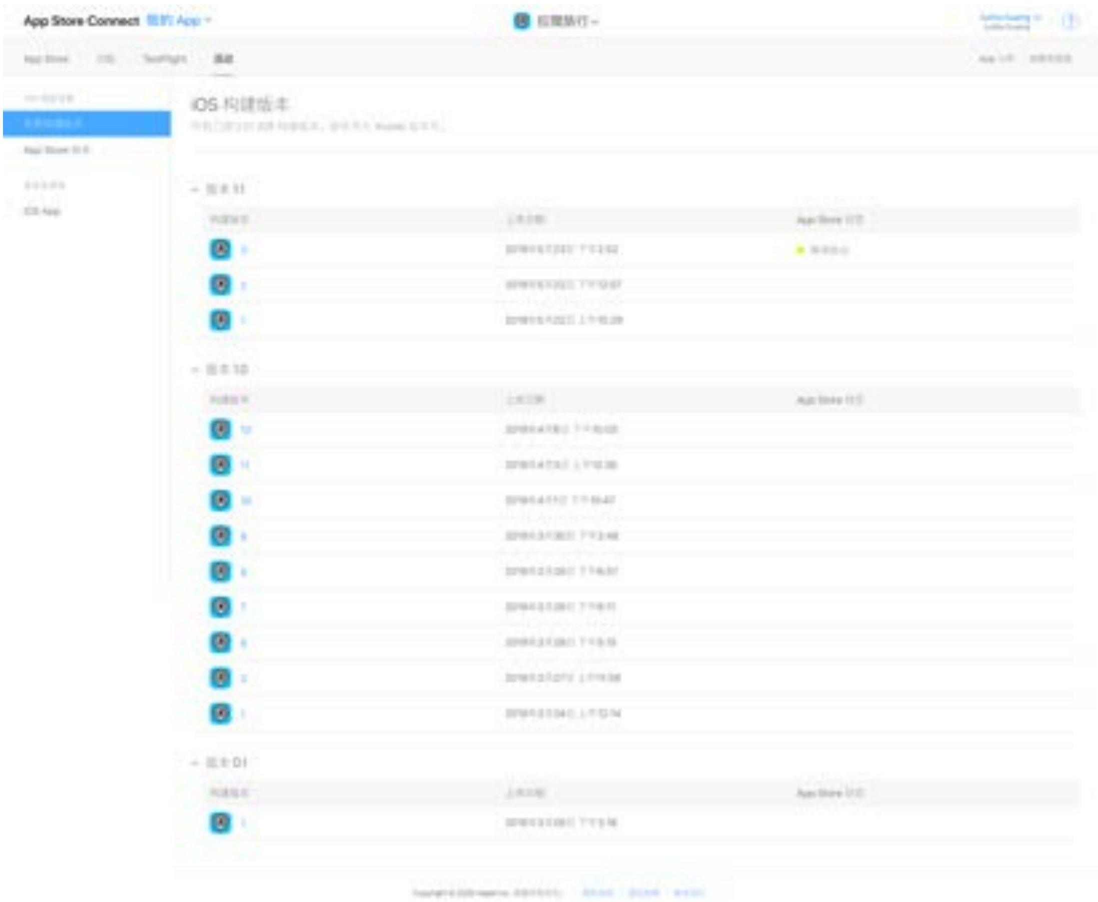
9. There are six basic unique features on this app, please grade (-3 to 3) them based on your experience and emotion:

- Users can choose from two on-site experiences: Exploration version and Chill version
- The app recommends nearby tourist attractions, sights, restaurants, and shops.
- After visiting a spot, users can receive a reward such as a clip of music and points automatically.
- The app plays audio clips automatically to describe the stories and advice from different senses when users pass by a new spot within an attraction.
- Users can leave a message before they leave, such as a hint, or their feelings, or their experiences for other visually impaired people.
- Users can like other users' voices and their voices are on the leaderboard.

10. Please use adjectives to describe these six features when you used the app
11. Do you have any suggestions or ideas for features that you'd like to see added into this app in order to enhance your travelling experience?

12. Can you tell me what's the difference between this app and the travelling apps you have used before? the process your feeling, and sensory related?
13. Can you imagine using this app when you visit other tourist attractions?
14. After trying this gamified travelling app, will you recommend this app to other visually impaired people? (from -3 to 3, --3 is will not at all, 3 is extremely will)
15. Will you use this app for your next travel? (from -3 to 3, --3 is will not at all, 3 is extremely will)
16. Have you paid to any app before? And how much for each?
17. If this app is 'paid to use', how much will you be willing to pay? Would you prefer the app free to use but with ads (In-App Advertising)?
18. Do you have any other suggestions or remarks about how this app be enhanced?

Appendix 15: The screenshot for re-uploaded the app to the App Store Connect



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