DEVELOPING AFFORDANCE MODEL OF SMARTPHONE USER INTERFACE FOR OLDER ADULTS

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By

WONG CHUI YIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATION

The Gift of Dhamma Excels All Gifts.

Sabbadãnam dhammadãnam jinãti

~ Dhammapada verse 354~

For my beloved late father, Wong Chan Kwong, who always blessed me spiritually.

For my beloved mother, Madam Ee Sok Kiew, who inspired me to embark on this PhD journey and will always be there for her love and endless support, especially during the tough time in my life.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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By

WONG CHUI YIN

November 2019

Chairman : Associate Professor Rahimah Ibrahim, PhD
Faculty : Malaysian Research Institute on Ageing

With a global increase in population ageing, Malaysia is expected to be an aged nation by 2035. Concurrent with the change in the demographic composition, smartphones have become ubiquitous mobile communication tools for a growing proportion of older adults in Malaysia. However, the older adults are generally perceived as *technophobic*. Smartphone user interface (UI) and some mobile apps are not designed to meet the needs and expectations of older adults. The gap in perception and intended use hinders older adults from fully utilizing the functions and services of a smartphone. Affordance is defined as '*perception and possibilities of actions for users (older adults) while interacting with an object (smartphone UI).*' This study refers to Norman's Execution/Evaluation Action Cycle (EEAC) model and Gaver's Technology Affordance.

This study aims to develop an affordance model on perception and action possibilities of smartphone UI for older adults. A conceptual framework and hypothetical model of the study were formulated. This research employs multiphase design mixed methods methodology. Phase 1 is a preliminary study using quantitative method (survey). This is followed by Phase 2 consisting of mobile-user interaction study using mixed methods which is 'concurrent embedded design' (questionnaire, observation, and interview). Results from Phase 1 indicate smartphone usage among the older adults and justification of

task design for Phase 2. The sample size for Phase 2 study was 80 'young-old' adults, from 60 to 74 years old.

To validate the affordance model, merged data analysis strategies were performed for quantitative and qualitative data. The empirical study indicates that 11 out of 16 hypotheses are supported. It is concluded that the affordance model is supported by the empirical findings. The major contribution of this study is the development of an affordance model, which is considered novel and adds value to the body of knowledge for Human-Computer Interaction and Gerontechnology. Based on the findings, it is crucial to incorporate older adults' needs and expectations to reduce affordance gap with the underlying affordance matrix.

Keywords: Affordance, smartphone, user interface, older adults, execution/evaluation action cycle.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN *AFFORDANCE* MODEL ANTARA MUKA PENGGUNA TELEFON PINTAR UNTUK WARGA EMAS

Oleh

WONG CHUI YIN

November 2019

Pengerusi : Profesor Madya Rahimah Ibrahim, PhD
Fakulti : Institut Penyelidikan Penuaan Malaysia

Dengan peningkatan penuaan penduduk di seluruh dunia, Malaysia dijangka menjadi negara berumur menjelang 2035. Seiring dengan perubahan komposisi demografi ini, telefon pintar telah menjadi alat komunikasi mudah alih yang semakin biasa digunakan oleh sebahagian warga emas di Malaysia. Walau bagaimanapun, warga emas umumnya dilihat mempunyai fobia terhadap teknologi. Antara muka telefon pintar dan beberapa aplikasi mudah alih tidak direka untuk memenuhi keperluan dan jangkaan warga emas. Jurang antara persepsi dan tujuan penggunaan menghalang warga emas daripada memanfaatkan sepenuhnya fungsi dan perkhidmatan pada telefon pintar. Kajian ini merujuk kepada Model Siklus Pelaksanaan / Evaluasi Norman (EEAC) dan Keterampilan Teknologi Gaver. *Affordance* ditakrifkan sebagai 'persepsi dan kemungkinan tindakan untuk pengguna (warga emas) semasa berinteraksi dengan objek (antara muka pengguna telefon pintar).

Kajian ini bertujuan untuk membangunkan model *affordance* tentang persepsi dan kemungkinan tindakan antara muka telefon pintar bagi warga emas. Satu rangka kerja konsep dan model hipotesis antara muka pengguna telefon pintar untuk warga emas telah dirangka. Kajian ini menggunakan reka bentuk berfasa dengan kaedah campuran. Fasa 1 adalah satu kajian awal menggunakan kaedah kuantitatif (kaji selidik). Ini diikuti dengan Fasa 2 yang melibatkan kajian

interaksi pengguna dengan telefon mudah alih menggunakan kaedah campuran, iaitu 'reka bentuk terbenam serentak' (soal selidik, pemerhatian dan temu bual). Hasil daripada fasa 1 menunjukkan penggunaan telefon pintar di kalangan warga emas dan justifikasi reka bentuk tugasan bagi Fasa 2. Saiz sampel kajian Fasa 2 adalah 80 orang warga emas berusia antara 60 hingga 74 tahun.

Untuk mengesahkan model *affordance*, strategi analisis gabungan data kuantitatif dan kualitatif telah dilakukan. Kajian empirikal menunjukkan bahawa 11 daripada 16 hipotesis disokong. Adalah disimpulkan bahawa model *affordance* disokong oleh penemuan empirikal. Sumbangan utama kajian ini ialah pembangunan model *affordance* sebagai penemuan baharu dan menambah nilai kepada bidang Interaksi Manusia-Komputer dan Geronteknologi. Berdasarkan keputusan kajian, adalah penting untuk menggabungkan keperluan dan jangkaan warga emas untuk mengurangkan jurang *affordance* melalui matriks *affordance*.

Kata kunci: *Affordance*, telefon pintar, antara muka pengguna, warga emas, kitaran tindakan pelaksanaan / penilaian

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I would like to sincerely thank my mum being tirelessly patient for my long-waited PhD completion. This thesis would not have been completed without my mum, as the source of inspiration that motivated me to delve into this topic to design better smartphone technology for an ageing population. The idea of embarking into the field of Gerontechnology and inclusive design derived from witnessing how my mum, who initially resisted adopting a smartphone and experienced frustration in using her phone, but has now become a frequent smartphone senior user.

I would also like to thank all my sponsors and research grants support for my PhD thesis, which are MyBrain 15, Ministry of Higher Education Malaysia (MOHE) FRGS grant (FRGS/1/2015/MMUE/150036), and UPM Putra Grant (UPM/700-2/1/GP-IPS/2013/9390400). I would also like to thank my earlier support with the industry collaborators, Telenor, and Canada SSHRC Research Partnership, who allowed me to explore and research further on the topic of ageing and mobile technology. Gratitude and appreciation extended to all the participants from the University of the Third Age (U3A) and also the other older adults from my previous projects who participated in this PhD thesis.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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This is to confirm that:

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LIST OF ABBREVIATIONS

AC	Adding Contact
ADL	Activities of Daily Living
Apps	Mobile applications
CCT	Cognitive Complexity Theory
DV	Dependent Variable
EADL	Enhanced Activities of Daily Living
EEAC	Execution/Evaluation Action Cycle
FCA	First Click Accuracy
GPS	Global Positioning Position
HAC	Hearing-Aid Compatibility
HCI	Human-Computer Interaction
IA	Icon Appearance
ICT	Information and Communication Technologies
ID	Interface Design
IF	Icon Function
IL	Icon Location
InA	Installing Apps
IV	Independent Variable
KiH	Knowledge in the Head
KiW	Knowledge in the World

MCMC	Malaysian Communications and Multimedia Commission
MLR	Multiple Linear Regression
MP	Making Phone call
OS	Operating System
SIRIM	Standards and Industrial Research Institute of Malaysia
SMS	Short Messaging Services
TAR	Task Accuracy Rate
TFR	Total Fertility Rate
U3A	University of the Third Age
UI-UX	User Interface-User Experience
UID	User Interface Design
UW	Using WhatsApp

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays, ageing is a worldwide phenomenon. Malaysia is expected to become an 'aged nation' by 2035 (Malaysia Healthy Ageing Society, 2012), where 15 percent or 5.6 million of the population will be 60 years old and above with an increase in life expectancy due to better healthcare and improved standards of living (Daim, 2016). The United Nations has denoted those aged 60 years old and above as old age (World Health Organisation, n.d.). It is inevitably that older adults, age 60 and above (World Health Organisation, 1989; United Nations (UNDESAP, 2013), are living in a digital era with ubiquitous technology where smartphones have become indispensable tools as everyday objects. However, these older adults aged 60 years old and above are not born as digital natives; instead, they are considered *digital immigrants* (Prensky, 2001), who adopted mobile technology such as smartphones in their later age.

Due to ageing, many older adults experience changes and suffer the declination of cognitive, motor and physical abilities (Fisk, Rogers, Charness, Czaja, & Sharit, 2009; Pak & McLaughlin, 2011). Many of them experience difficulties using certain features when interacting with their mobile phones (Czaja & Lee, 2007; Khawaji, 2017; Leung, Findlater, McGrenere, Graf, & Yang, 2010). This scenario is exacerbated by an attitude of *'techno-phobia'* (Hogan, 2009), which poses a cognitive challenge of adopting the recent mobile technology shift from keypad-enabled mobile phones model to touch-screen smartphone user interface (UI) in the current mobile market in Malaysia. Consequently, older adults most likely will face difficulties that hinder them from using smartphones and their mobile application (app) services at the beginning. This research aims to examine the role of affordance in perception and action possibilities of smartphone UI for older adults. Affordance is related to how an older adult perceives a new smartphone UI when he or she is first exposed to it, has never seen it before, and has no clue as to what to do with it. Currently, there are limited research studies that address the applicability of affordances theory and its concept that influences the possibilities of action of smartphone UI for older adults in the Malaysian context.

1.2 Problem Statement

Malaysia is a fast-paced developing nation with a relatively slow computer-internet penetration, but a high mobile network growth (Wong, 2013). With the rise of an ageing population, and the prevalence of mobile ubiquitous technologies permeating into everybody's daily lives, we should not underestimate the capability of the so-called *'silver surfer'* group to stay connected and work as a mobility aid for communication. The birth of the iPhone in 2007 marked a 'smartphone' era, and almost nobody bought a feature phone 10 years later (Hern, 2017). As a result, the older adults also cannot escape from migrating into the 'silver smartphone users' cohort and join the 'grey market'. Having said this, the older adults are generally perceived as *'techno-phobic'* in taking up new technology (Essén & Östlund, 2011; Fisk et al., 2009; Haederi, 2011; Hogan, 2009).

The local market of smartphones and their services for senior citizens (or older adult population) remain widely unexplored and potentially lucrative. However, most of the current mobile operators and their related services focus on the young adult segments (age 18-45) (Digi, 2009; Marketing-Interactive.com, 2016; TheStar, 2014; U Mobile, 2014), and they are not designed for the needs and requirements of the older adults (60 years old and above). Some past research studies in the West found that older adults experienced challenges in using smartphones, especially in terms of usability issues of mobile UI (Kurniawan, 2008; Kurniawan, Mahmud, & Nugroho, 2006; Pak & McLaughlin, 2011). Due to prior product experience, learned knowledge, cultural exposure, older adults perceived smartphone UI differently as compared to the younger generation. A majority of older adults were more familiar with the feature phone, and not the smartphone UI. As such, many of them faced many challenges in adopting smartphones with their complex menu and navigation system, which were not familiar and intuitive to them.

Due to ageing, many older adults experience changes and suffer the declination of cognitive, motor and physical abilities (Fisk et al., 2009; Pak & McLaughlin, 2011; Wong, Khong, & Thwaites, 2010). Many of them experience difficulties using certain features when interacting with their smartphones. This scenario will be exacerbated by an attitude of '*techno-phobia*' (Fisk et al., 2009), which poses a cognitive challenge of adopting the recent mobile technology shift from keypad-enabled mobile phones model to touch-screen smartphone UIs in the current mobile market. This gives them a total new interaction experience, which is counter-intuitive to them. In return, the older adults group most likely

will face difficulties and some may be excluded from using smartphones and their services.

In the era of Industry 4.0 and Society 5.0 digital transformation, the aim is to tackle several challenges, by going far beyond the digitalization of economy towards the digitalization across all levels of the society itself, including the increasing ageing population (i-scoop, n.d.). This phenomenon of older adults having difficulties in adopting smartphones and interacting with their services yield marginalisation of this cohort from joining social-economy activities, which also hinder them from independent living and being financial independent during their old age.

Industry and research are gradually recognizing the importance of older adults as a target group of smartphone users. However, there is still limited profound knowledge on how to design for this special user group, and which, the role of affordance may play to ensure usability of the smartphone UI for older adults. The term of 'Affordance' refers to '*the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used……*' (Norman, 1998a, p. 9). Affordance means the relationship of perception and possibilities of action upon an object or artefact UI. Use of mobile devices is possible if users can leverage their prior experience and knowledge (Norman, 1998a; O'Brien, 2010). Apart from prior experience, components of smartphone UI such as appearance, location, and function (operation) of a feature are the criteria that provide feedback for the users to determine the possible next action as well (Blackler, 2006; O'Brien, 2010).

Although a smartphone has become a ubiquitous communication tool for older adults in their daily lives, it is still not so easy and straight forward for them to learn a new interactive mode, and it takes time to adopt the overall smartphone UI. As such, affordance plays an important role for interaction and UI designers in terms of developing and designing intuitive smartphone UI. This implies that the concept of affordance is significant for user interface-user experience (UI-UX) designers and mobile app developers as it provides visual cues for users to understand the possible action when designing an artefact, device or system. It is crucial to learn that perceived affordance stresses both the action possibility and visual appearance for smartphone UI. For instance, the action possibility is conveyed or made visible to the users provided the UI components via icon design, menu system and navigation tabs are made visibly clear and make sense to the users. As a result, this study aims to investigate the role of affordance and propose an affordance model of how older adults interact with smartphone UI.

1.3 Research Questions

The research questions of the study are:

1. What are the older adults' profiles in terms of smartphone usage, preference of mobile application and prior product experience?
2. What is the model of measuring smartphone user interface for older adults?
3. To what extent and how does the model is validated of smartphone user interface for older adults?

1.4 Research Objectives

The **aim** of this research is to develop a model of affordance on perception and action possibilities of smartphone UI for older adults.

The **research objectives** of this study are:

1. To analyse older adults' smartphone usage, mobile application preference and prior product experience.
2. To propose an affordance model of smartphone UI for older adults.
3. To validate an affordance model of smartphone UI for older adults.

1.5 Conceptual and Operational Definitions of Terms

1.5.1 Affordance

(i) Conceptual Definition of Affordance

The term 'affordance' was conceived by Gibson (1979), a prominent perceptual psychologist in Ecology Psychology field, which refers to the actionable properties between the world (the environment) and an actor (the user). Gibson (1979, p. 127) also defines "*the affordances of the environment are what it offers animals, what it provides or furnishes, for good or ill.*"

An 'affordance' is a single attribute of an object, which allows the user to carry out an action. For example, a ball can be rolled, thrown, caught, and bounced; all these affordances are apparent and perceptible without the need for physical investigation. Therefore, the term 'affordance' acknowledges the human instinct to look upon their environment as the means of achieving their goals. For example, when a man saw a piece of flint, he appreciated the affordance of striking a fatal blow on the potential prey and when he saw the fur of his kill, he saw the affordance of warmth from the pelt of the animal.

In the 1980s, the term was later populated by Donald Norman, a design psychologist, among the human-computer interaction (HCI), interaction design and industry design communities. In his '*Design of Everyday Things*' book, Norman (1998a) defined affordance as *"…. the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used*." The concept is important for interaction designers as it provides visual cues for users to understand the possible action when designing an artefact, device or system. It is important to learn that perceived affordance stresses both the action possibility and the way (e.g. in this case smartphone UI) that the action possibility is conveyed or made visible to the users.

(ii) Operational Definition of Affordance

Affordance is about the relationship between a user and an object, and not the property of an object. It involves perception and possibilities of actions. As a result, the operational definition of affordance for this study is:

"Perception and possibilities of actions for users (older adults) while interacting with an object (smartphone UI)."

Affordance design of a smartphone UI refers to intuition, which is a type of cognitive processing that utilises knowledge gained through prior experience or knowledge (stored experiential knowledge). It is a process that is often fast and is non-conscious, or at least not recallable or verbalisable (Blackler, 2006). For instance, when a user sees a 'missed call' icon on a smartphone UI, he or she may perceive the icon differently. Hence, there are variations of actions to be taken by the user depending on individual interpretation, or prior knowledge.

Basically, affordance design is measured based on self-report metrics and observational metrics. Firstly, self-report metrics uses Expectation measure in an Affordance Questionnaire. Expectation measures the difference of 'Pre-Perception and Action' and 'Post-Perception and Action' in a 7-point semantic differential scale. Secondly, for observational metrics, UI elements (appearance, location and function) are measured on First Click Accuracy score and Task Accuracy rate (please refer to Section 4.3.1.).

1.5.2 Smartphone User Interface (UI)

(i) Conceptual Definition of Smartphone UI

A smartphone is a mobile device with an advanced mobile operating system (OS) that provides a standardized UI and platform for applications. It has a larger display as compared to a standard mobile feature phone, and more powerful processors (PCmag.com, n.d.; Phonescoop.com, n.d.). A smartphone is defined as 'a mobile handset that is used as the person's primary phone device, which has capabilities to perform Internet-based services and functions like a computer, including having an operating system capable of downloading and running applications, also those created by third-party developers (Malaysian Communications and Multimedia Commission, 2017).

A smartphone UI is the graphical and touch-sensitive screen display on a mobile device, which allows users to interact with the mobile applications (apps), features, contents and its functions (Techtarget.com, n.d.). The User Interface Design (UID) requirements for a smartphone is different when compared to a desktop personal computing. The screen size display is smaller and it entirely relies on touch screen interaction for control.

On a smartphone UI, icons and symbols are used extensively, and some controls are automatically hidden unless accessed. The best practice for designing smartphone UI is the layout of the information, commands, and contents in an app that should echo with the mobile operating system in terms of placement, composition and colours. Consistency is the key to allow users to learn quickly how to use a UI with different types of mobile apps.

(ii) Operational Definition of Smartphone UI

A smartphone UI is the graphical and touch screen display on a mobile device that uses advanced mobile operating system (OS) for various mobile applications (apps), features, contents and its functions. The smartphone UID requirements depends on the *location, appearance* and *functions* of the icons and symbols to ensure the usability, readability and consistency of its operation.

1.5.3 Older Adults

(i) Conceptual Definition of Older Adults

Developed countries have accepted the chronological age of 65 years old as an 'elderly' or older person. However, the United Nation has agreed 60 years old is the cut-off age to refer to the older population (World Health Organisation, n.d.). In addition to chronological age, the age of a person can be defined in many ways, encompassing biological, psychological and socio-cultural processes (Cohen, 2002).

The concept of older adults also refers to the seniors or elderly at the last stage of adulthood, where one experiences ageing process in terms of physical, motor and cognitive ability. Ageing occurs in three dimensions, which are biological, psychological and physiological. Older adults are not a homogeneous group, and there are individual differences among them. There are two groups of older adults. The first group age ranging from 60 to 74 years old and is referred to as 'younger-old' or 'young-old' adults; the second group aged 75 years old and above is considered as 'older-old', or 'old-old' adults (Fisk et al., 2009). Naturally, older adults experience deterioration cognitively, physically and biologically that require a better design of technology that can assist them to live more independently.

(ii) Operational Definition of Older Adults

For this study, older adults refer to the elderly, who experience the decline of cognitive, physical and psychological change. For the context of potential uptake of smartphone adoption, the older adults here refer to the 'young-old' adult group, within the age range of 60 to 74 years old.

1.6 Justification of Research Methods

There are two (2) phases of this study. Phase 1 is a preliminary study, which consists of a small-scale survey entitled *'Smartphone Usage for Senior Citizens'* to explore the smartphone usage among older adults in the local context. The findings from the Phase 1 study lead to the subsequent Phase 2 of proposing an affordance model of smartphone UI for older adults using a mobile-user interaction study, which answer the research objectives 2 and 3.

This study employs mixed method methodology, which consists of qualitative and quantitative research strategies (Creswell, 2009). The mixed method research study uses multiphase design (Creswell & Clark, 2011), which covers two phases of the study. Phase 1 is a preliminary study, followed by Phase 2, which is a mobile-user interaction study using concurrent embedded design mixed methods. In Phase 1 preliminary study, the type of data collection is quantitative using survey. For Phase 2 mobile-user interaction study for a proposed affordance model for smartphone UI, qualitative data (interview) is collected concurrently and embedded within a major quantitative data (survey and observation).

The reason for using a multiphase design is to allow each phase of study to address a specific set of research questions that evolve to address a larger research objective, which is to study the role of affordance on perception and action possibilities of smartphone UI for older adults. It involves collecting multiple quantitative and qualitative data that build towards an overall research aim (Creswell & Clark, 2011). This study includes both sequential and concurrent forms of data collection in two different phases. In addition, the purpose of this study is also to support, compliment and further enhance the understanding of affordance on smartphone UI using mixed-methods in this study.

To be more specific, the Phase 1 is a preliminary study uses a survey to explore how older adults use smartphones and their usage in the Malaysian context. The findings of the Phase 1 inform the subsequent phase. The Phase 2 is to delve into a mobile-user interaction study of how older adults perceive affordance and interact with smartphone UI. This research study employs a concurrent embedded design mixed method methodology. This triangulation of methods consists of quantitative approach using a questionnaire, and qualitative approach using observation with verbal protocol analysis and interview during

the debriefing session. The outcome is an affordance model consists of affordance matrix framework of smartphone UI for older adults that identifies the affordance gap whether there is any variation of task accuracy, expectation and action taken. The diagram in Figure 1.1 depicts the overall research design of multiphase design mixed methods study.

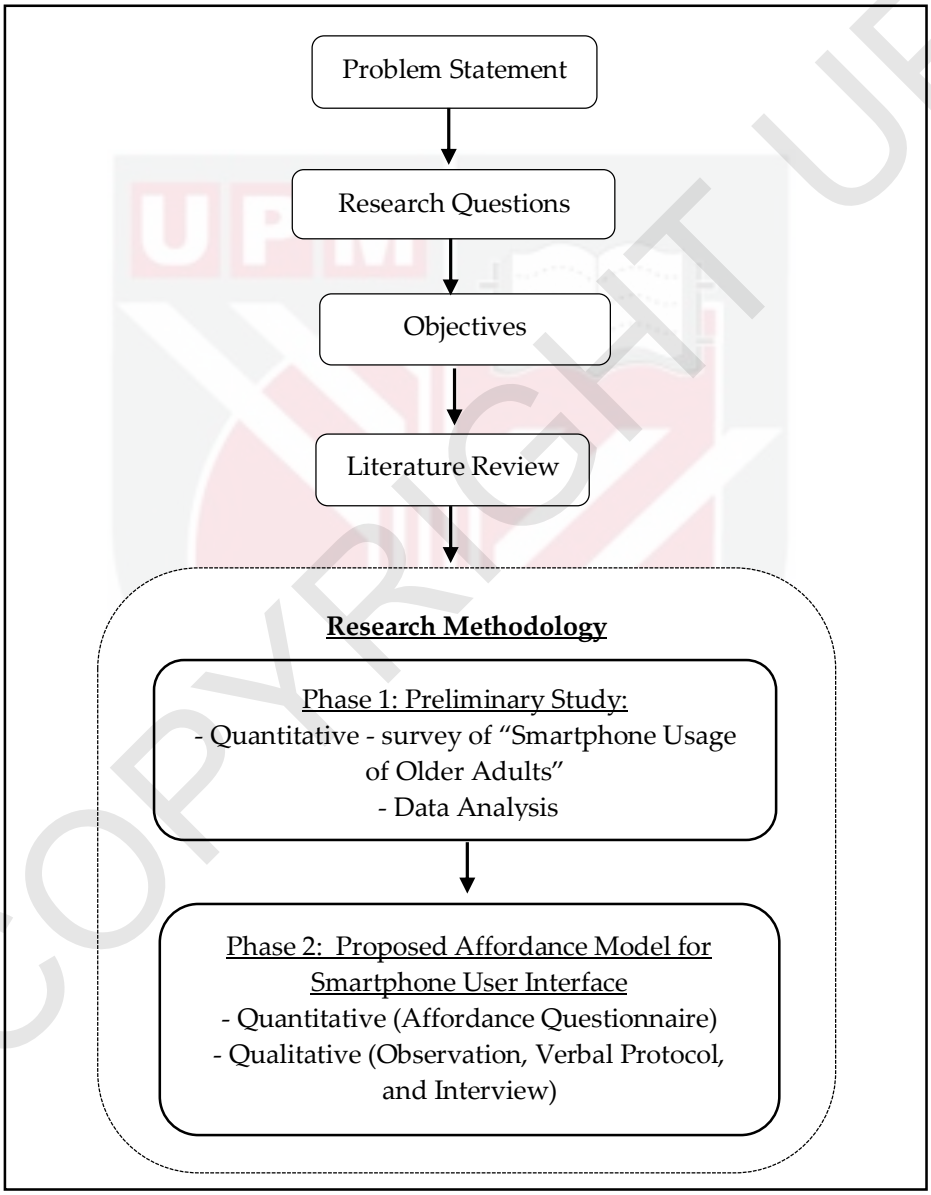

Figure 1.1 : Research Design for multiphase design mixed methods study

1.7 Scope of Research

This research is conducted based on developing an affordance model of measuring perception and possibilities of action on smartphone UI for older adults. The main theoretical framework use in this research is Norman Execution/Evaluation Action Cycle (EEAC) model (Norman, 1998a) because the concept of affordance is highlighted and populated among human-computer interaction (HCI) and interaction design community. The concept of affordance later has been evolved over the years. In addition, this study refers to Gaver's Technology Affordance (1991) due to its technological relevancy on smartphone UI. This study is situated at Gerontechnology and HCI domains. Gerontechnology is defined as the study of technology and ageing for ensuring good health, full social participation, and independent living throughout the entire lifespan (Harrington & Harrington, 2000).

The development of the model variables is based on the literature review and feedback from the experts. The model validation is established with the empirical data collected with senior citizen community from the University of the Third Age (U3A). There were two (2) phases of the study, which are Phase 1: preliminary study, and followed by Phase 2: a mobile-user interaction study using concurrent embedded design mixed methods to propose an affordance model of the study. Mobile-user interaction is a study of interaction between mobile devices (smartphone in this context) with users (Kjeldskov, 2014; Love, 2005). It is an aspect of HCI domain. The proposed model is then validated for its correctness through mixed methods using a series of statistical analysis methods for quantitative data and thematic analysis for qualitative data.

1.8 Significance of the Study

The research findings bring significant contributions to the following parties:

(a) Literature and Body of Knowledge:

Firstly, the findings of this research study bring contributions to the body of knowledge in the fields of Gerontechnology, HCI and Mobile UI Design. In particular, the findings propose an integrated conceptual framework that examines affordance gaps of smartphone interface design for the older adult population. It also depicts how to measure the affordance gap that yields the affordance matrix.

(b) Practice & Industry:

Secondly, this research study also benefits the telecommunication and mobile industries in Malaysia by providing insights into how local adults as 'silver surfers' perceive smartphone UI, their needs and requirements for current and future mobile technology. In addition, the findings of this research study also helps contribute to the Smartphone UI Design guidelines, design process and recommendations: in particular, how they perceive the meaning of an Android phone UI and some app services. As older adults are the growing mobile user groups worldwide, these insights can help to inform design decisions, in particular to Human Factors/User Experience practitioners, the telecommunication industry, the mobile UI designers, the mobile apps developers and the interaction design community.

(c) Policy-making:

The design process and recommendations derived from the research findings will also contribute to the Malaysian policy-makers, such as SIRIM (Standards and Industrial Research Institute of Malaysia), and MCMC (Malaysian Communications and Multimedia Commission). This research study is also in line with the 11th Malaysian Plan with the aim of creating a Digital Inclusive Society by closing the digital divide gap of the nation by 2020. The findings of the study also provide insights by empowering the older adults towards independent living as stated in the National Policy and Action Plan of Older Persons (DPTWEN, 2011-2020) (Ministry of Women, Family and Community Development, n.d.) and align with United Nation's Sustainable Development Goals 11 of developing an aged-friendly city for Sustainable Cities and Communities.

1.9 Thesis Organisation

This thesis is organised into five (5) main chapters.

Chapter 1 discusses about the background of the study, problem statement, research questions and research objectives, conceptual and operational definitions of affordance, smartphone UI and older adults. It also discusses about the justification of research methods for the two phases in the entire research study, followed by scope of research and significance of study.

Chapter 2 details out the literature review on ageing population, mobile technology and smartphone studies, affordance and its related work. This chapter ends with a theoretical framework of the study based on the literature review.

Chapter 3 describes the Phase 1: preliminary study, the research method and processes used for Phase 1 study, and it also includes the result and discussion of Phase 1 study.

Chapter 4 presents the Phase 2: proposed affordance model of smartphone UI for older adults, the research methodology for Phase 2, and the model development. This chapter also details out the measures, the interview questions, conceptual framework, hypotheses development of the study. It discusses the result for model validation based on hypotheses testing and mixed-methods analysis.

Chapter 5 concludes the research study as well as discusses the contribution of the study in terms of theoretical, mixed-method methodology, and industrial practice, limitation of the study and recommendation for future research.

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