DEVELOPMENT AND EVALUATION OF CULTURE-BASED MHEALTH USER INTERFACE GUIDELINES FOR ELDERLY ARAB USERS

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DEVELOPMENT AND EVALUATION OF CULTURE-BASED MHEALTH USER INTERFACE GUIDELINES FOR ELDERLY ARAB USERS

by

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LIST OF ABBREVIATIONS

App	Application
AT	Attitude
BI	Behavioral Intention
CITM	Centre for Instructional Technology and Multimedia
D	Desirable
EOU	Ease of Use
GUI	Graphical User Interface
HCI	Human Computer Interaction
ICT	Information Communication Technology
IT	Information Technology
M	Mandatory
MHealth	Mobile Health
O	Optional
PU	Perceived Usefulness
RAD	Rapid Application Development
SD	Standard Deviation
SPSS	Statistical Package for Social Science
TAM	Technology Acceptance Model
TPB	Theory of planned Behavior
UI	User Interface
UML	Unified Modeling Language
UTAUT	Unified Theory of Acceptance and Use of Technology
WUI	Web-based User Interface

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PEMBANGUNAN DAN PENILAIAN PANDUAN ANTARA MUKA PENGGUNA mHEALTH BERASASKAN BUDAYA BAGI PENGGUNA WARGA EMAS ARAB

ABSTRAK

Di sebalik lambakan aplikasi mobil dalam dunia Arab, hubungan antara budayanya, elemen antara muka pengguna (UI) serta warga emas Arab masih belum diterokai sepenuhnya. Juga, dunia Arab kekurangan garis panduan bagi menyokong reka bentuk UI aplikasi mobil yang berguna dan berkesan, yang telah menjejaskan penerimaan dan kepuasan pengguna. Kajian ini melibatkan pembangunan dan penilaian garis panduan UI dan aplikasi mobil berasaskan budaya bagi warga emas Arab. Satu penyiasatan awal melibatkan 40 warga emas Arab telah dilaksanakan bagi (i) mengenalpasti elemen-elemen bolehguna UI mobil dan masalah yang mereka hadapi apabila menggunakannya, dan (ii) menyiasat pendapat mereka berkaitan nilai budaya elemen-elemen tersebut. Berdasarkan penyiasatan ini, sebanyak 10 elemen UI serta enam masalah yang mereka hadapi telah dikenalpasti. Seterusnya, kesemua elemen UI dan enam masalah tersebut telah dipetakan, dan kesemua kemungkinan kombinasi komponen UI, aspek budaya serta komponen kebolehgunaan telah dianalisis bagi menghasilkan draf garis panduan UI. Garis panduan akhir telah dikumpulkan dalam lima kategori utama yang mengandungi 40 garis panduan UI serta 26 garis panduan masalah yang dihadapi pengguna warga emas Arab semasa menggunakan aplikasi mobil. Kemudian, Model Pembangunan Pantas beserta *Unified Modelling Language* telah digunakan bagi membangunkan aplikasi mHealth berdasarkan garis panduan tersebut. Seterusnya, kajian ini telah menyiasat faktor-faktor penting yang mempengaruhi penerimaan (aspek persepsi kebergunaan-PU,

persepsi mudah-guna-PEOU, sikap–ATT dan hasrat perlakuan-BI), kepuasan mereka (dari aspek terminologi dan maklumat aplikasi-TI, skrin-SC, pembelajaran-LE, keupayaan aplikasi-AC, serta aplikasi keseluruhan-OA) warga emas Arab setelah menggunakan aplikasi mHealth, serta hubungan antara konstruk penerimaan dan kepuasan. Satu soal selidik melibatkan pembolehubah penerimaan serta kepuasan penggunaan aplikasi mobil mHealth telah digunakan dalam kajian ini. Seramai 81 warga emas Arab (warga Jordan, Syria dan Palestin) yang menetap di Jordan serta berusia antara 60–79 tahun terlibat dalam kajian ini. Dapatan menunjukkan mereka mempunyai tahap penerimaan dan kepuasan yang tinggi terhadap mHealth. Juga, dalam konstruk penerimaan, wujud tiga korelasi yang kuat dan signifikan, iaitu antara BI dan ATT, BI dan PEU serta antara ATT dan PEU. Juga, bagi konstruk kepuasan pengguna, wujud lima korelasi yang kuat dan signifikan, iaitu antara LE dan OA, OA dan AC, LE dan AC, OA dan SC, serta antara SC dan AC. Tambahan pula, dapatan menunjukkan PEU dan ATT sebagai peramal penting bagi konstruk penerimaan, manakala LE dan SC sebagai peramal penting konstruk kepuasan mereka terhadap mHealth. Seterusnya, korelasi yang positif serta kuat juga dilihat antara penerimaan dan kepuasan. Berdasarkan temu bual separa struktur bersama 10 peserta kajian, didapati tahap penerimaan mereka adalah tinggi, mereka berpuashati serta menggemari aplikasi mHealth tersebut – dan dapatan ini adalah selari dengan dapatan kuantitatif kajian ini. Sebagai kesimpulannya, garis panduan yang dihasilkan dalam kajian ini boleh membantu para pembangun UI dalam mereka bentuk antara muka aplikasi mobil yang sesuai, khususnya untuk warga emas Arab.

DEVELOPMENT AND EVALUATION OF CULTURE-BASED MHEALTH USER INTERFACE GUIDELINES FOR ELDERLY ARAB USERS

ABSTRACT

Despite the extensive availability of mobile applications in the Arab world, the relationship amongst its culture, mobile user interface (UI) elements and elderly Arab people has not been thoroughly explored. Moreover, the Arab world lacks usability guideline to support usable and effective mobile app UI design, which has resulted in low acceptance and satisfaction. This study involved the development and evaluation of culture-based UI guidelines and mobile applications for elderly Arab users. A preliminary study involving 40 elderly Arab users was carried out to (i) identify the usable elements of mobile UI and the current problems they encountered when using mobile apps, and to (ii) investigate their suggestions regarding the cultural values of these UI elements. From the preliminary work, ten UI elements and six problems encountered by them were identified. Then, these UI elements and problems were mapped, and all the possible combinations of UI components, cultural aspects and usability components were analysed in drafting a guideline. The final guideline was grouped into five distinct categories involving 40 UI design guidelines and 26 guidelines for the problems encountered by elderly Arab users when using mobile apps. Rapid Development Model together with the Unified Modelling Language was then applied to design and develop a mobile health (mHealth) app based on the guidelines. Next, this study investigated the critical factors that influence the users' acceptance (involving perceived usefulness-PU, perceived ease of use-PEOU, attitude-ATT and behavioural intention-BI, and their satisfaction (involving terminology and app information-TI, screen-SC, learning-LE, app

capabilities-AC, and overall application-OA) after using the mHealth app, as well as the relationship between the acceptance and satisfaction constructs. A questionnaire on the acceptance and satisfaction variables were used in this study. A total of 81 elderly Arab users from three different Arab countries (Jordan, Syria and Palestine) residing in Jordan and aged between 60 to 79 years old participated in this study. Findings showed that they have a high level of acceptance and satisfaction on the mHealth app. Also, three strong and positive correlations were observed between the acceptance construct: between BI and ATT, BI and PEU and between ATT and PEU. Next, for the user satisfaction construct, five strong and positive correlations were reported, involving LE and OA, OA and AC, LE and AC, OA and SC, as well as between SC and AC. In addition, PEU and ATT were found to be important predictors for user acceptance, while LE and SC are important predictors for satisfaction with the mHealth app. A positive and high correlation was also observed between user acceptance and satisfaction. Based on a semi-structured interview with 10 of the participants, it was found that they highly accepted,were satisfied and enjoyed the app; and these results are in line with that of the quantitative findings. In summary, the guidelines established in this study will help UI developers in designing a suitable mobile app interface especially for elderly Arab users.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Recently, the number of people in the world aged over 65 years old has increased rapidly and is predicted to reach approximately 1 billion by 2030 (Mamolo & Scherbov, 2009). The significant increase in the number of the elderly suggests the need to develop technologies for this group of users to comply with their demands (Welch et al., 2018). For example, the number of elderly aged 65 years or above in the United States is expected to increase from 40 million in 2010 to 72 million in 2030 (Vincent & Velkoff, 2013). According to 2012 statistics, the percentage of elderly American people who own a cell phone (56%) is higher than those who own a desktop (31%) or laptop (20%) (Zickuhr & Madden, 2012). These statistics show that mobile phones are an ideal technology to reach elderly people. This group of users has characteristics that differ from those of other groups (Nunes, 2014; Rosenberg et al., 2018). For example, part of this group has physical limitations (i.e. shaky hands and slow movement) and cognitive challenges (i.e. dementia and memory loss) (Loureiro & Rodrigues, 2011; Rosenberg et al., 2018). Some of them face difficulties and limitations in interacting through traditional input devices, such as the mouse and the keyboard (Boustani, 2010; Loureiro & Rodrigues, 2014).

Nowadays, end users mostly interact using technology in different ways depending on their cultural and personal differences, such as various languages,

religions, habits and customs (Hu, Hu, & Al-Gahtani, 2018; Khaddam & Vanderdonckt, 2014). Previous studies show that users feel comfortable when interacting with a user interface (UI) that is related to their own culture (Almakky, Sahandi, & Taylor, 2015). In other words, the interfaces should be convenient and acceptable to each cultural attribute (Van Biljon & Kotzé, 2008; Yaaqoubi & Reinecke, 2018). Therefore, designing a user-friendly mobile application interface is a critical factor for the success of such applications and products.

The role of the designer is to ensure that the user can interact and learn how to use the product easily with free or minimal physical and mental efforts. Technologies that are not always usable leaves users unable to complete a simple task and causes them to feel depressed (Holthe, Halvorsrud, Karterud, Hoel, & Lund, 2018). User-centred design is a broad design process that addresses user needs and requirements to generate usable and accessible systems by focusing on application properties and human factors, such as usability, engineering, environment and other factors that surround the users. Therefore, considering the users' need and knowing how to engage them in the design process are crucial in designing an effective and efficient product, as well as in contributing to the acceptance and success of products (Abras, Maloney-Krichmar, & Preece, 2004).

Similarly, Arab cultures are (for the most part) traditional, with many practices and norms revolving around Islamic beliefs and customs. So, everyday words or phrases that may be completely acceptable in Western countries could be not acceptable to Arab audiences. According to the last statistics in 2017, the population of Arab countries is around 421 million which makes 5.6 % of the world population, in which more than 175 million of them are using internet (http//:www.internetworldstats.com/surfing.htm). In addition, the population of the

elderly in the Arab world has been rapidly increasing since the 1980s, and the percentage of the population aged 65 and older is expected to compose approximately 6.7% of the Arab world by 2030 (Kronfol, Sibai, & Rizk, 2013). The significant growth in the number of elderly Arabs introduces the need to develop technologies for this user group to comply with their demands.

Interest in the effect of culture on UI design has been developing rapidly. Several studies on cross-cultural UI design, especially in website design and desktop PCs, have been conducted (e.g., Akhter, 2016; Khurana & Mehra, 2015; Lin, 2015; Tolba, 2011) to investigate the effect of culture on UI design. The results of these studies confirm that addressing cultural differences of use in UIs could improve acceptance, usability and help users to interact with the interface. Furthermore, considering these differences in UI design may be important in designing a usable UI (Gu, Huang, Schultz, & Sheng, 2018).

Mobile phones are becoming an important part of our daily lives and are the most distributed and used devices in everyday life, in every situation and place (Parasuraman, Sam, Yee, Chuon, & Ren, 2017). Statistics show that the number of mobile phone users in the world is expected to reach over 6.2 billion by 2018 (Radicati, 2014) or approximately 84% of the world's population. This phenomenon requires mobile phone interfaces to be built intuitively and must be usable for users.

Recently, the use of mobile devices and their technologies in the health context, such as providing health services and accessing and collecting medical data, has rapidly increased, especially in developing countries (Collins, 2012; Latif et al., 2018). For example, mobile health (mHealth) technologies are being used around the world to determine diseases, improve access to health care information, reduce

medical service costs, help in information exchange and improve public and personalised medicine (Adepoju, Albersen, De Brouwere, van Roosmalen, & Zweekhorst, 2017; Henriquez-Camacho, Losa, Miranda, & Cheyne, 2014).

MHealth applications (mHealth apps) are used by the elderly for health purposes in various health programmes and fields, such as counting calories and measuring blood pressure and nutritional status, to control and improve their health. More than half of elderly users in the world use the Internet for health purposes (Henriquez-Camacho et al., 2014; Rasche et al., 2018). Elderly people aged 75 and above obtained high scores on Internet use for health purposes, and half of those with diseases showed that their understanding of their disease and its treatment properties and options improved due to Internet use (Baker, Wagner, Singer, & Bundorf, 2003; van Boekel, Peek, & Luijkx, 2017).

1.2 Background of the Study

Currently, rapid growth in the elderly is a global phenomenon. Approximately 10% of the world's population is aged 60 years and above, and the percentage is expected to rise dramatically by 2050. The aging population faces many challenges in different fields such as services, technology and how to improve it in order to enhance the health and quality of living for the elderly (Roupa et al., 2010). In this context, the UI of technology, for instance, systems and applications are viewed as having enormous potential. With age, several underlying physical changes occur, and the risk of chronic disease rises. By age 60, the problems of disability arise from age-related losses in hearing, vision and movement among others.

Elderly show a low adjustment to new technologies compared to younger generations either because of their present health limitations or they do not have enough technological experience (Kouroupetroglou & Mitsopoulos, 2000). This low adjustment to new technologies is related to the lack of innovation for elderly users such as a comprehensive and friendly UI design. Also, many technologies and services often are not suitable for the needs of the elderly. Moreover, in their effort to use new technology, they generally face many difficulties due to possible disabilities, education, and income, as well as difficulties related to the complexity of new technology (Roupa et al., 2010). In their effort to take greater responsibility for their physical limitations and individual health, elderly users seek easy to use technology (Roupa et al., 2010; Tacken, Marcellini, Mollenkopf, Ruoppila, & Szeman, 2005).

UI is critical when designing systems and applications because it links the users to the services and facilities their requirements (Faghih, Azadehfar, Reza, & Katebi, 2014). This means that services and facilities need to be presented for users in simple and easy ways through a friendly UI. Otherwise, the users risk an unsatisfactory experience using the system or application.

Culture is defined as the collective programming of the mind that differentiates a group of people from others (Hofstede & Hofstede, 1991) and implies that people with different cultures have various cognition, perceptions, thinking styles and values. Therefore, understanding different cultural behaviours is important to carefully design interfaces for international users (Abildgaard & Christensen, 2018). Several studies have been conducted on cross-cultural UI design. For example, Khushman, Todman, and Amin (2009) stated that the design interface for e-business websites, which involves high power distance, high collectivism, low masculinity and high uncertainty avoidance, is not optimally suited for Arab cultures.

Tolba (2011) indicated the importance of understanding the culture of users as part of the new human – computer interaction (HCI) field, in which users came from different cultures with various preferences for interface design and use different acceptance criteria. In addition, Kyriakoullis and Zaphiris (2016) stated that understanding cultural values is fundamental to the design of successful and broadly accepted UIs. Also, Ansari and Riasi (2016) found that investigating cultural influences on customers' perceptions is important because cultural aspects can have a remarkable impact on consumers' purchase behaviour.

Although Khushman et al. (2009) and Tolba (2011) reported on the cultural effect of the design of Arab websites based on various criteria, no studies have explored the design of mobile interface based on the Arab culture. Therefore, the interfaces should be convenient and acceptable to each cultural attribute and make the UI an important bridge between users and technology (Hsiao, Lee, Yang, & Chen, 2017; Van Biljon & Kotzé, 2008). Marcus and Hamoodi (2009) discussed issues on the influence of culture on Arabic websites on the basis of an analysis of three Arabic educational websites, namely, those from Jordan, Egypt and the United Arab Emirates. Results show that Arabic websites need to consider changes, such as adding multimedia components, representative pictures, links to websites and multilingual contents.

Reinecke (2010) stated that basic UI components could be mapped to cultural dimensions to develop a design that could meet the norms and trends of different cultures. Several researchers (e.g., Cyr, 2013; Cyr, Head & Larios, 2010; Salinas, 2002) have explored different cultural factors, such as icons, colours, language and symbols, that affect the UI design. In other words, these factors are important

elements that should be considered during UI design (Cyr, 2013; Kersten & Kersten, 2004).

Evers and Day (1997) examined the differences in interface acceptance for Indonesian and Chinese users on the basis of cultural differences in terms of system usage. The acceptance of the Indonesian participants is based on ease of use, whereas that of the Chinese participants is based on usefulness. This result shows that although the interface is difficult to use, the Chinese users still attempt to work with it, whereas Indonesian users prefer to use an interface that is easy to understand. This result is due to the higher culture dimension uncertainty avoidance of Indonesian culture than that of Chinese culture.

Goodall, Ward, and Newman (2010) claimed that a culturally different background was an additional barrier to elderly users' ability to use technology and access information. Furthermore, Young (2008) reported that the important challenge faced by the mobile learning (m-learning) technology is the lack of guidelines in acknowledging local culture in the design of m-learning applications.

Despite the increasing number of mHealth apps that can be used on smartphones, smartwatches and tablets, the proportion of sustained application use is low. Approximately 80% of mHealth app users stopped its use after two weeks (Baldwin, Singh, Sittig, & Giardina, 2017). Anderson, Burford, and Emmerton (2016) showed that the main reasons for discontinued mHealth app usage are as follows: (i) End users were more likely to continue the use of a health application if it fitted and involved them during use, (ii) usability and perceived usefulness improved according to how much information about the application is displayed based on the user's preferences, (iii) excluded users from application design resulted

in less persistent use of the application and (iv) the application is perceived as boring to use.

However, despite limited suggestions on explicit culture-based UI, researchers may need to examine these suggestions to obtain guidelines and formulate rules based on culture and help UI designers enhance UI usability to fulfil the cultural needs of end users.

1.3. Preliminary Study

This preliminary study was conducted among 40 elderly Arabs residing in Jordan from three Arab countries (Jordan, Palestine and Syria) to identify the challenges that they face when using mobile applications. It also attempted to investigate the Arab cultural aspects that affect UI design and the rules that should be applied when designing a UI for elderly Arabs. Semi-structured interviews that involve individual and focus group discussion and ranged from 30–40 minutes were conducted. The study was conducted in Penang, Malaysia. The sample included males and females who have at least one year of experience in using mobile applications and are aged 60 years and above. Table 1.1 shows the general demographic characteristics of the interviewees.

Table 1.1

Characteristics of the 40 interviewees

	Information	**No. of participants**	**Percentage of sample**
Age	60 – 64	33	82.5%
	65 – 69	6	15%
	70 – 74	1	2.5%
Participants' gender	Male	37	92.5%
	Female	3	7.5%

Country of origin	Jordan	6	15%
	Palestine	14	35%
	Syria	9	22.5%
	Yemen	11	27.5%
Participants' education level	School level	11	27.5%
	Diploma degree	9	25%
	Bachelor's degree	10	22.5%
	Master's degree	8	20%
	PhD degree	2	5%
Participants' experience level in using mobile apps	1 – 3 years	4	10%
	4 – 6 years	23	57.5%
	7 – 9 years	11	27.5%
	≥ 10 years	2	5%

The interviews were recorded and transcribed, and the data were subsequently collected, compared and analysed. The users were interviewed to answer the following questions:

1. What are the main barriers and challenges that elderly Arab users may face when using mobile UI?
2. How can the design elements be used to make you perceive mobile UI as culturally supported?
3. What rules should be applied when designing a mobile application interface for elderly Arab people?
4. On the basis of your experience, do the current mobile application interfaces for elderly Arab people reflect certain cultural values? How?
5. Do you think that the current design of mobile UI will benefit you in terms of cultural values?

6. How important to you is culture in the mobile UI design?

The result shows a relationship between cultural Arab aspects and all UI elements. In addition, its usability is attributed to the effective use of mobile

applications. For example, the use of standard Arabic language or standard English language to express the functionality of UI components, such as buttons, menus and icons, clarifies the functions of these components and makes them easy to understand. Furthermore, the use of simple and consistent information architecture in the UI design makes the system easy to learn and remember (memorability and learnability). Thus, cultural aspects and UI elements have a relationship. For example, the use of a suitable colour based on Arab culture, such as green, blue and black, may increase user acceptance, whilst the use of icons with meaningful symbols may increase their familiarity. This study also shows the problems that elderly users face when using mobile applications. Table 1.2 summarises the problems identified by the respondents during the preliminary study, while Table 1.3 highlights their suggestions in terms of cultural aspects regarding the UI of any proposed apps. Table 1.4 highlights some interviewees' quotations in terms of cultural aspects.

Table 1.2

Problems encountered by elderly Arab people when using mobile applications

No.	Problems	Explanation
1	Vision	Sometimes, the text size is small and not clear enough to read. Some text colours are not suitable to use as text or background colour, thereby resulting in poor vision.
2	Physical change (shivering in fingers or hand movements, slow movement)	Some elderly suffer from slow and shaky hands. Therefore, the small size of UI components, such as buttons and icons, makes the use of UI and control of finger movement difficult.
3	Stress	Sometimes, the elderly face unsuitable colours, inconsistent UI components and unclear language during mobile use. This situation hinders the elderly from using the application well and effectively, thereby causing them stress.
4	Boredom	Frequent instructions, commands and navigation from one screen to another to perform a certain action result in

		boredom.
5	Confusion	The use of many options in application design, non- Arabic language, complex UI design and different symbols and layouts from left to right confused the elderly in using the application.
6	Lack of trust	The users, especially the elderly, need to confirm each step or click that an action must be taken, especially when they use the application for the first time or the application involves payment. For example, many users do not trust products that differ in their exterior design and colours from what they use in their culture.

During the interview, 10 cultural aspects were identified, which were also stated by other researchers. Cyr (2010) Eiseman (2006) and Long (2015) investigated the role of colour in UI design for elderly people. In addition, Giese and Holmes (2003) and Ambrose and Harris (2011) identified the typeface in UI design, whilst Lawrence and Tavakol (2006) focused on the importance of UI layout in the design.

Table 1.3

UI and Arab cultural aspects

No.	**Cultural aspects**	**Participants' suggestions on values of cultural attributes**
1.	Languages	- Use standard words that have the same meaning in the Arab world. - Use Arabic language or provide good translation.
2.	Typeface	- Use 12 pt–14 pt/do not use italicised or underlined fonts - Use popular font types, such as Times New Roman - When using Arabic font, avoid the use of font types that are difficult to read, such as الثلث- الكوفي - الاندلسي
3.	Colour	- Use Arabic colours: green, blue and black
4.	Layout	- Use a right-to-left layout.
5.	Buttons	- Large size or space between buttons. - For buttons, use a colour that is different from that of the application background.

6.	Information architecture	- Use simple design (group the same functions)
7.	Symbols	- Use Islamic or related symbols.
8.	Icons	- Large/meaningful symbols.
9.	Label and messages	- Warning messages with or alarm symbols. - Use proper words to make the application UI-friendly.
10.	Images	- Use images of holy places and archaeological sites -Use pictures of Islamic and Arabic architecture for background and application icons. - Use images that involve holy places, culture and religion of users.

Table 1.3 lists the unique cultural guidelines designed based on the Arab culture, involving all cultural aspect components, to overcome the problems encountered by Arab users when using mobile applications. Some of these problems, such as poor vision and shaky hands, generally affect the elderly everywhere. Other problems affect only elderly Arab users because of the Arabs' cultural environment, such as lack of trust and confusion, which were identified by this preliminary study and do not necessarily exist in other cultures.

These components have two dimensions. The first dimension is cultural, indicating that the components have cultural values that can be applied in mobile application designs for user satisfaction and acceptance. The second dimension is usability, indicating that these components have an impact on the usability and acceptance of the mobile UI design that can help overcome the problems encountered by the elderly users. Table 1.4 shows the responses of the interviewees and the relevant statistics obtained from this preliminary study.

Table 1.4

Preliminary study responses and statistics

	Questions	Responses	(no. of respondents)
1.	What are the main barriers and challenges that may be encountered by elderly Arab users when using mobile UI?	'Frequent orders make me feel bored' (R3). 'Moving between screens to find information confuses and bores me' (R19). 'Using some colours that are not clear to vision causes eye pain' (R34). 'I feel stressed when I cannot use the application well or understand some words' (R11). 'Some of the symbols used in the applications ridicule public figures, national and religious symbols' (R35).	Vision: 34 Physical limitations: 29 Boredom: 27 Lack of trust: 23 Confusion: 25 Stress: 32
2.	How can the design elements be used to make you perceive mobile UI as culturally supported?	'Use Arabic colours' (R28). 'Use traditional fonts' (R6). 'Use Islamic images and symbols' (R13). 'Use simple design' (R4). 'Use Arabic language' (R11). 'Use Macca مكه image' (R15). 'Use big and clear buttons and font' (R27).	Arabic language: 40 Layout: 37 Arabic font: 39 Images:28 Buttons:36 Simple design: 35 Colours: 38 Label and messages:29 Icons: 31 Symbols: 34
3	On the basis of your experience, do the current mobile application interfaces reflect the certain cultural values of an elderly Arab? How?	'I face a problem when writing Arabic language from left to right' (R28). 'I feel strange when I use some applications' (R2). 'Some applications have poor design and are not attractive' (R31).	35: No 2: Yes 3: Do not know
4	What rules should be applied when designing a mobile application interface for elderly Arab people?	'Andalus font type is hard to read. Why is it used in design applications?' (R33). 'I prefer reading font types that I have studied in schoolbooks, such as font 'الرقعة' (R2). 'Use big fonts and labels' (R17).	Colour green: 40 Colour blue: 38 Colour black: 35 الرقعة typeface: 37 Large button size: 40
5	How important is culture to	'Using applications based on	Confidence: 33

	you in mobile UI design?	my customs increases my intention to use the applications' (R17). 'Applications according to my beliefs make me feel satisfied and confident' (R36).	Acceptance: 38 Ease of use: 40 Satisfaction: 32 Usefulness: 29
6	Do you think that the current mobile UI design can benefit you with cultural values?	'Most designers are non-Arab' (R37). 'Arab designers have poor knowledge of their culture' (R19).	37: No 2: Yes 1: Do not know

1.4 Problem Statement

The importance of providing best design solutions in promoting elderly users' interaction with the technology is to offer assistance for elderly users, improve their performance whilst using technology and satisfy the subjective feelings of the elderly users which reflect positively in their lives.

This research targets elderly Arab users of mobile application in which this group within the society is experiencing a decline in their mental and physical strengths (Al-Razgan & Al-Khalifa, 2017; Loureiro & Rodrigues, 2011). In addition, a preliminary study was conducted to understand current design problems among this group of people to gain more insights about current problems faced by elderly Arab users when using mobile applications (the discussion on the preliminary study can be found in the previous section). Through this preliminary investigation, an in-depth view about elderly users' interaction problems and their cultural preferences of design elements (i.e. colour, font, and buttons) were observed and recorded, thus allowing the researcher to propose a proper design guideline for this group of users.

Despite the rapid development in technologies and mobile devices in the world and due to their important roles in users' lives, especially for the elderly users,

there is still a lack of efforts to provide best-design experience to elderly people (Al-Razgan & Al-Khalifa, 2017; Kronfol, Sibai, & Rizk, 2014). The key issue associated with elderly users' use of mobile applications is that mobile phone systems are not well designed to accommodate elderly capabilities (Hwangbo, Yoon, Jin, Han, & Ji, 2013). That is, elderly users are not the main target of design technology and mobile applications (Rodríguez, Fuentes, Herskovic, & Pino, 2017). As well as they do not feel comfortable using new devices or learn new technology (Chen, Chan, & Tsang, 2013). This is due to elderly users have their own characteristics and necessities and basically totally different compared to younger users (Castilla et al., 2013). Thus, an initial investigation into users' perceptions is needed to provide feedback, assessment and enhance elderly mobile service usage.

There is limited research carried out toward the use of technology by elderly Arab (Al-Razgan & Al-Khalifa, 2017). Several factors contribute to rare research concerning elderly Arab users. These factors include (i) elderly have age-related decline ability, (ii) lack of funding, and (iii) insufficient training in aging (Sibai, Rizk, & Kronfol, 2014), which make UI designers shift their design focus away from elderly users. In addition, the limited usability guidelines for mobile applications due to the nature of mobile devices, and the isolation of mobile applications make usability evaluation for mobile devices difficult. These guidelines are either not explained suitably, thereby making understanding their intention difficult, or they are derived from web design guidelines and therefore do not show special regard to interactive issues (Blendinger, 2015). Cultural aspects and individual preferences make it difficult to aid or support the current design typology for elderly users (Browne, 2016). This phenomenon is due to the different ways in which users interact with technologies depending on their cultural and personal preferences

(Khaddam & Vanderdonckt, 2014). Nunes (2014) stated that designing an interface for elderly people is an ongoing challenge due to the limited understanding about design preferences for this group.

Designing an interface without considering the preferences of the main users would eventually influence their experience, thus satisfaction with the technology (Foreman et al., 2012; Hanson, 2011; Olson, O'Brien, Rogers, & Charness, 2011). That is why previous studies argued that the design of mobile UI need to be engaging, meaningful, usable, easy to use and motivating (Kascak, Rébola, Braunstein, & Sanford, 2013), particularly for elderly users (Chadwick-Dias, McNulty, & Tullis, 2003; Franklin & Myneni, 2018).

One aspect for consideration is embedding cultural values into the design of UI has proven to play a significant role in promoting the usage behaviour of the user (Browne, 2016). Prior studies suggested that customisation in mobile apps UI can improve UI and user experience (Mora, González, Arnedo-Moreno, & Álvarez, 2016). Therefore, designing a culture-based mobile app UI will satisfy users (Almakky, Sahandi, & Taylor, 2015). This is supported by Goodall, Ward, and Newman (2010) who claimed that a culturally different background was an additional barrier to elderly users' ability to use technology and access information. In addition, culture theory studies, such as those by Hall (1976) and Hofstede (1980; 1991), revealed that Arab countries have greatly different cultural values from other countries.

Studies on the relationship amongst UI components usability and Arabic culture are still in their early stages (Benaida, 2014). This study has attempted to show how usability is influenced by Arab culture and UI components and how

usability guidelines can be devised to help elderly Arab users use the interactive mHealth app UI efficiently. The principal aim of this research is to develop usability guidelines for an Arab-based mobile app UI for elderly Arab users and develop an mHealth app UI based on this guideline.

Therefore, it can be assumed that designing a culture-based mobile app UI will probably satisfy elderly users. In order to gain further insights about the specific design issues faced by elderly Arab users when using mobile UI, a preliminary study was conducted and explained in the next section.

1.5 Research Objectives

This study mainly aims (i) to design UI guidelines for elderly Arabs based on Arab cultural values for mobile applications and (ii) to create useful and effective UIs that can be utilised by all potential users with Arab cultural background. Therefore, this study intends to achieve the following objectives:

1. to identify cultural design elements and guidelines to be used for the mobile interface.
2. to develop an appropriate interface according to the proposed guidelines.
3. to investigate the effects of cultural aspects and UI components on user acceptance using the Technology Acceptance Model (TAM).
4. to investigate the effects of the designed UI on users' satisfaction.
5. to investigate the relationships between satisfaction and acceptance factors.

1.6 Research Questions

After setting the goals and objectives for this study, the researcher constructed the following questions to meet the proposed research objectives:

1. What are the main cultural mobile UI elements mostly preferred by elderly Arab users?

2. How can we provide a suitable mobile UI design for elderly Arab users?

3. To what extent is the culture-based mobile app UI accepted by elderly Arab users?

4. To what extent does the culture-based mobile app UI satisfy elderly Arab users?

5. Are there any relationships between acceptance and UI satisfaction factors amongst the users of the mobile app?

1.7 Theoretical Framework

The theoretical framework for this study is constructed based on theories and models from the literature, and some of these models are as follows:

1.7.1 Technology Acceptance Model (TAM)

Given that computers have become a common part of our society, many models and theories related to technology readiness and acceptance have been constructed, selected and rebuilt. In 1989, Davis developed the TAM, which is the most well-known model on how users accept and use technology. According to Davis (1989), two main factors indicate how people accept a technology:

- Perceive usefulness: The degree to which a person believes that the use of a particular system would enhance his or her job performance (Davis, 1989, p. 230).

- Perceived ease of use: How people use the system without much effort.

Figure 1.1 indicates the TAM model as proposed by Davis (1989). The details of this model will be explained in Chapter Two.

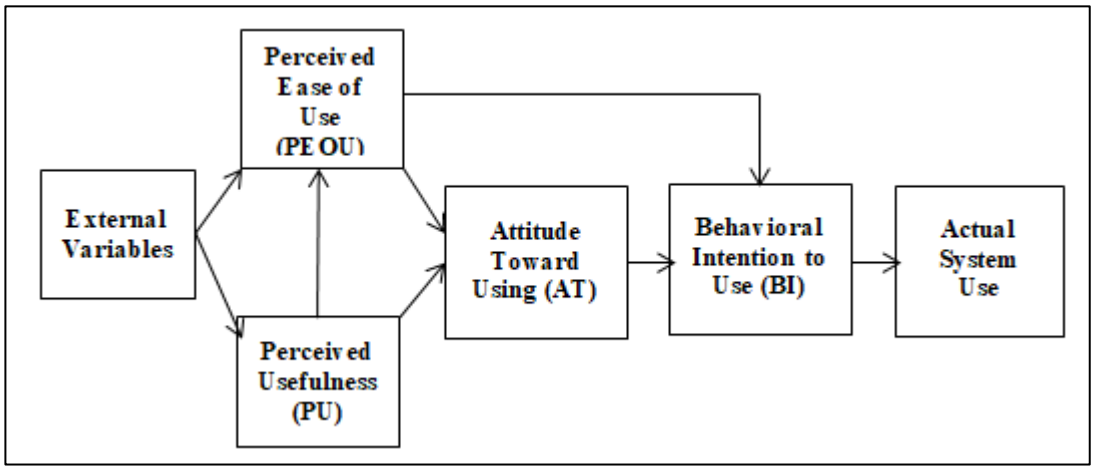

Figure 1.1. Technology Acceptance Model (Davis, 1989)

1.7.2 Activity Theory

Activity theory focuses on understanding the human activity, work practice and the principles and components of an activity (Uden, 2006). This theory has been used as an analytical tool for many different subjects, such as human-computer interaction (HCI) (Kuutti, 1996a), information systems (Bødker, 1987), interface design (Bødker, 1990), communities of practice (Engeström, 1999) and education (Engeström, 2001). Figure 1.2 shows the elements of activity theory.

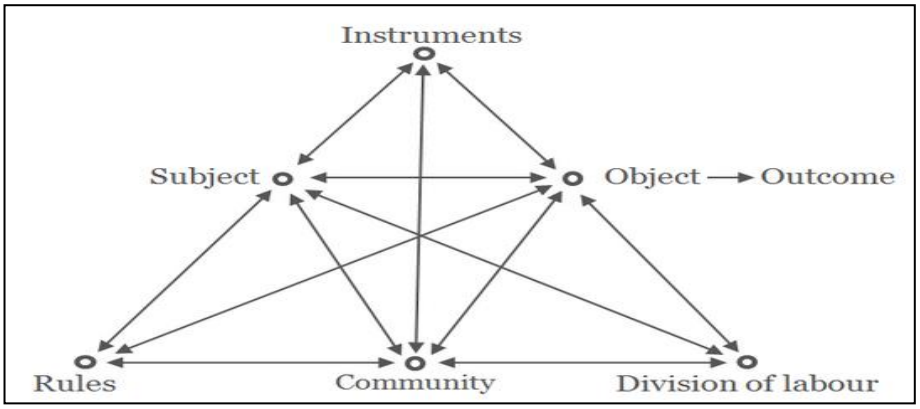

Figure 1.2. Activity system diagram of communication and learning (Engeström, 1987).

According to Engestrom (1987), five elements indicate activity theory.

i. Subject (User): Who are the people involved in the activity system?
ii. Instruments: What instruments are used in this activity?
iii. Object: What is the expected outcome of the activity?
iv. Rules: What are the formal and informal rules that guide the activities learners are engaged in?
v. Division of labour: Who have traditionally taken on the different roles? How does that affect work group activities or breakdowns?

The details of this theory will be further explained in Chapter Two.

1.8 Research Significance

This study aims to design the mobile principle guidelines for elderly Arab users. These guidelines will help designers and developers design a suitable UI that meets elderly users' acceptance and satisfaction, which in turn improves their lives and increase the number of users by opening up many new avenues through applications.

Moreover, cultural aspects have a crucial role in UI design. Only a few software is designed for elderly people (for example, blood pressure monitoring and

luminosity) because most currently available software is designed to support young people or is based on the experience of young developers. These developers encounter difficulties in understanding the demands of elderly people (Keates, 2000). Therefore, a guideline for elderly Arab users will help designers and developers design UIs that are convenient and compatible with their needs. The findings will add to dearth of knowledge in the area of message design within the context of Arab culture.

The number of people who are over 65 years has increased rapidly throughout the world, indicating that the average age of workers is increasing. Some Arab countries have raised the retirement age from 60 to 65 years old. If the software is designed only for maximum usage of the younger generations, then the workforce that can operate software may decrease. For this reason, UI components should be considered to ensure that elderly users are satisfied with the application that is designed for young users. This research attempts to offer a design guideline that can help solve this problem.

In addition, designing mobile applications based on culture and meeting the acceptance and satisfaction of users can increase the number of users and the number of sold apps, which will reflect positively on the economy by increasing the profits of technology companies.

1.9 Operational Definitions

1- Culture: Culture can be defined as a collective property that includes ideas, beliefs, laws, customs, knowledge, morals and art to distinguish the members of one group of people from another (Hofstede, 2001; Taylor & Harper, 2001).

Although many different cultures throughout the world, the current study focuses only on Arab culture.

2- Usability: Usability is an important attribute of any UI and measures how easy the interface is to use (Nielsen, 1994). This definition contains three important elements, namely, task, user and environment (Koohang & Du Plessis, 2004). This study focuses on user and usability, which can be characterised by the following (Nielsen, 1994):

(a) Memorability: The system should be easy for a casual user to remember even if the system has not been used after a long period. Therefore, relearning how to use the system will not be needed.

(b) Learnability: The system should be easy to learn so that the user can quickly begin using the system from the first time.

(c) Satisfaction: The system obtains approval and satisfaction from the user when using the system. In this study, satisfaction is the degree to which elderly Arabs are satisfied in using a UI based on their culture, as measured by 21 items from the evaluation questionnaire (Appendix C) and 14 interview questions (Appendix D).

(d) Efficiency: The system and resources should be efficient to use and compatible with the users' goals.

(e) Errors: The system must have a low error rate so that users make few errors by interacting with the system and can easily recover from these errors. In this study, the usability of the design and developed mobile application was tested amongst elderly Arab people.

3- Ease of use: This refers to the degree to which an individual believes that using a particular system would be free of mental or physical effort (Davis, 1989). In this study, ease of use is the degree to which elderly Arab users believe that using UI based on their culture would be free from effort, as measured by the seven items from the evaluation questionnaire (Appendix C).

4- Usefulness: This refers to the degree to which an individual believes that using a particular system would enhance his or her job performance (Davis, 1989). In this study, usefulness is the degree to which elderly Arabs believe that using a UI based on their culture would be useful, as measured by the six items from the evaluation questionnaire (Appendix C).

5- Attitude: Attitude is a description of a person's positive or negative behaviour towards novelty adaptation (Triandis, 1979). In this study, the elderly Arab users' behaviour towards the mHealth app was measured using a four-item questionnaire (Appendix C).

6- Behavioral intention: Behavioral intention is defined as 'the strength of ones intention to perform a specified behaviour' (Davis, 1989). In this study, the elderly Arab users' behavioral intention towards the mHealth app was measured using a three-item questionnaire (Appendix C).

7- Elderly people: This is defined as the later part of life and the period of life after youth and middle age. Most developed countries accept the chronological age of 65 years as a definition of elderly or old person (Gorman, 1999). The current study focused on elderly Arab users aged 60 years and above and have experience in using mobile applications. The sample of the preliminary study comprises 40

participants, whilst the sample for the evaluation of this study comprises 81 participants.

8- Mobile applications: A software system operates on mobile devices, such as smartphones and tablets, rather than desktop or laptop computers, thereby making ubiquitous information accessible at any time and place (Brown & Kim, 2018; Kaasinen, Aaltonen, Kolari, Melakoski, & Laakko, 2000). Mobile applications have many types, such as learning, health, games and navigations. Health application was used in this study because this category relates directly to the health care structure and is important for elderly users.

9- mHealth application: This application is defined as the use of mobile devices, such as mobile phones and personal digital assistants, and their integration with mobile medical services and health care systems via wireless devices (Istepanian & Lacal, 2003; Prinja et al., 2017). In this study, an mHealth application was designed for elderly Arab users to manage their medicine and provide them with medical information about common diseases in Arab countries. This mHealth application limited to the Android OS and a display size of 5–5.7 inches.