CONCEPTUAL MODEL FOR USABLE MULTI-MODAL MOBILE ASSISTANCE DURING UMRAH

AHMED SHEIKH ABDULLAH AL-AIDAROOS

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Graduate School
of Arts And Sciences

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2017

Abstrak

Melaksanakan ibadah Umrah adalah sukar dan dijalankan dalam persekitaran yang teramat padat dengan manusia. Oleh itu, pelbagai usaha telah dijalankan bagi mengatasi kesukaran yang dihadapi oleh para Jemaah. Namun, usaha-usaha tersebut menumpu kepada memperoleh perspektif awal dan pengetahuan asas sebelum berlepas ke Mekah. Dapatan kajian awal menunjukkan usaha-usaha tersebut tidak menyokong kepelbagaian modaliti bagi interaksi pengguna. Kini keupayaan pengkomputeran dalam telefon pintar membolehkan ia menyokong keperluan harian manusia dalam pelbagai aspek kehidupan. Sehubungan itu, jumlah pengguna telefon pintar telah meningkat dengan mendadak dalam dekad yang lalu. Justeru, kajian ini menetapkan matlamat untuk mencadang sebuah model konsep yang lengkap bagi alat bantu mudah alih pelbagai-modaliti yang berguna ketika menjalankan Umrah dan dinamakan Pembantu Mudah Alih Pelbagai-modaliti ketika Umrah (MMA-U). Demikianlah, empat objektif dibentuk, dan Design Science Research Methodology telah diadaptasi. Bagi kebolehgunaan MMA-U, Systematic Literature Review (SLR) telah menemukan 10 ciri: kebergunaan, kadar kesilapan, kesederhanaan, kebolehpercayaan, mudah digunakan, keselamatan, fleksibiliti, kebolehcapaian, sikap, dan kebolehterimaan. Manakala, analisis kandungan dan perbandingan menghasilkan lima komponen yang membentuk model konsep MMA-U: struktur, komposisi kandungan, prinsip reka bentuk, pendekatan pembangunan, teknologi, dan teori reka bentuk dan kebolehgunaan. Seterusnya, MMA-U telah dinilai dan diterima dengan baik oleh 15 orang pakar. Kemudiannya, MMA-U telah digabungkan ke dalam sebuah prototaip yang dinamakan Mutawif Peribadi Digital (PDM). PDM dibangunkan dan digunakan sebagai alatan asas dalam ujian pengguna di lapangan. Dapatan ujian menunjukkan bahawa PDM membantu perlaksanaan ibadah Umrah dan berjaya memenuhi keperluan dan harapan Jemaah. Selain itu, Jemaah didapati berpuas hati dan yakin bahawa mereka memerlukan PDM. Malah mereka akan mencadangkan PDM kepada rakan mereka. Ini merupakan kesan daripada perasaan selamat dan selesa apabila menggunakan PDM semasa melaksanakan Umrah. Kesimpulannya, sumbangan teoritikal; model konsep MMA-U; boleh dijadikan panduan bagi membangunkan alat bantu mudah alih ketika melaksanakan ibadah Umrah.

Kata kunci: Ciri-ciri kebolehgunaan, Pelbagai-modaliti, Personal Digital Mutawwif (PDM), Alat bantu mudah alih Umrah, Mod arahan.

Abstract

Performing Umrah is very demanding and to be performed in very crowded environments. In response to that, many efforts have been initiated to overcome the difficulties faced by pilgrims. However, those efforts focus on acquiring initial perspective and background knowledge before going to Mecca. Findings of preliminary study show that those efforts do not support multi-modality for user interaction. Nowadays the computational capabilities in mobile phones enable it to serve people in various aspects of daily life. Consequently, the mobile phone penetration has increased dramatically in the last decade. Hence, this study aims to propose a comprehensive conceptual model for usable multimodal mobile assistance during Umrah called Multi-model Mobile Assistance during Umrah (MMA-U). Thus, four (4) supporting objectives are formulated, and the Design Science Research Methodology has been adopted. For the usability of MMA-U, Systematic Literature Review (SLR) indicates ten (10) attributes: usefulness, errors rate, simplicity, reliability, ease of use, safety, flexibility, accessibility, attitude, and acceptability. Meanwhile, the content and comparative analysis result in five (5) components that construct the conceptual model of MMA-U: structural, content composition, design principles, development approach, technology, and the design and usability theories. Then, the MMA-U has been reviewed and well-accepted by 15 experts. Later, the MMA-U was incorporated into a prototype called Personal Digital Mutawwif (PDM). The PDM was developed for the purpose of user test in the field. The findings indicate that PDM facilitates the execution of Umrah and successfully meet pilgrims' needs and expectations. Also, the pilgrims were satisfied and felt that they need to have PDM. In fact, they would recommend PDM to their friends, which mean that use of PDM is safe and suitable while performing Umrah. As a conclusion, the theoretical contribution; the conceptual model of MMA-U; provides guidelines for developing multimodal content mobile applications during Umrah.

Keywords: Usability attributes, Multimodality, Personal Digital Mutawwif (PDM), Umrah mobile assistance, Instruction mode.

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Ahmed Sheikh Al-Aidaroos

Dedication

This thesis is dedicated to **the almighty Allah**, the most beneficent, the most merciful for **His** benevolence and mercies towards me and my family,

And to

My father, Sheikh Abdullah Al-Aidaroos

My mother, Zainab Aidaroos Al-Kaff

My wife, Zainab Abo Baker Bosri

My daughter, Huda

My son, Mohammed

My brother, sister, and friends, for their sacrifices, love and prayers

With love

Ahmed Sheikh Al-Aidaroos (2017)

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List of Abbreviations

CAS	College of Arts and Sciences
CCCs	Content Composition Components
CS	Computer Science
DSR	Design Science Research
DSRM	Design Science Research Methodology
DT	Desktop Models
GPS	Global Positioning System
GQM	Goal Question Metric
HCI	Human Computer Interaction
IA	Information Architecture
IEHF	Institute of Ergonomics and Human Factors
IOS	International Organization for Standardization
IS	Information Systems
IT	Information Technology
ITM	Iterative Triangulation Methodology
J2ME	Java 2 Platform Micro Edition
KSA	Kingdom of Saudi Arabia
MA	Mobile Applications
MCMC	Malaysian Communications and Multimedia Commission
MDZ4H	Mobile Dua and Zikir for Hajj
MMA-U	Multimodal Mobile Assistant during Umrah
MMI	Multi Modal Interface
MMS	Multimedia Messaging Service
MSC	Multimedia Super Corridor
PDM	Personal Digital Mutawwif
QUIS	Questionnaire for User Interaction Satisfaction
SCs	Structural Components
SDK	Software Development Kit
SE	Software Engineering
SLR	Systematic Literature Review
SMMTC	School of Multimedia Technology and Communication

SMS	Short Message Service
SOC	School of Computing
SPSS	Statistical Package for the Social Sciences
SRS	Simple Random Sample
SUMI	Software Usability Measurement Inventory
TNOU	Tamil Nadu Open University
UCD	User Centered Design
UIA	User Interface Architecture
UUM	Universiti Utara Malaysia
W3C	World Wide Web Consortium
XML	Extensible Mark-up Language

List of Publications and Awards

Journals:

- **Al-Aidaroos, A. S**., Abdul Nasir, Z., & Che Mat, R. (2013). Development of Mobile Dua and Zikr for Hajj (MDZ4H). *TELKOMNIKA Indonesian Journal of Electrical Engineering, 11*(5), 2723-2730.
- **Al-Aidaroos, A. S.,** & Ariffin, A. M. (2015). Design of the Usability Measurement Tool for Multimodal Mobile Applications. *Jurnal Teknologi, 77*(29), 41–47.
- **Al-Aidaroos, A. S.,** & Ariffin, A. M. (2015). Personal Digital Mutawwif: A Multi-Modal Mobile Hajj Assistance Using the Location Based Services. *Jurnal Teknologi, 77*(29), 15–20.

Conference Proceedings:

- **Al-Aidaroos, A. S.,** Ariffin, A. M., Abdul Nasir, Z., & AbuHassira, M. M. (2013). *Users' Perceptions and Usability of Mobile Dua and zikrFor Hajj (MDZ4H).* Paper presented at the First International Conference on Applied Sciences, ICAS2013, Gaza, Palestine.
- **Al-Aidaroos, A. S**., Ariffin, A. M., & Abdul Nasir, Z. (2013). *A Study of Users' Perceptions Toward Mobile Dua and Zikr For Hajj (MDZ4H) Usability.* Paper presented at the International Conference on Advances in IT for the Holy Quran and its Sciences (NOORIC2013), Al-Madinah Al-Munawwarah, Saudi Arabia.
- **Al-Aidaroos, A. S.**, Ariffin, A. M., & Abdul Nasir, Z. (2014). *Speech Recognition Incorporation in a Multiple Input Modality Mobile Application for Pilgrims (MDZ4H).* Paper presented at the 2nd International Conference on Islamic Applications in Computer Science And Technology (IMAN2014), Amman, Jordan.
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Presentation:

1)	**Event**	International Conference on Interactive Digital Media
	Year\Venue	2012, Bayview Hotel, Langkawi, Malaysia
	Title	Development of Mobile Dua and Zikir For Hajj (MDZ4H)
	Resercher	**Al-Aidaroos, A. S**., Abdul Nasir, Z., and Che Mat, R.
2)	**Event**	Creative Industry International Conference
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	Resercher	**Al-Aidaroos, A. S.,** and Ariffin, A. M.

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Awards:

- **Best Paper Award**
  - International Conference on Interactive Digital Media (CIIC2015) 4 - 5 October 2015.
  - EDC Hotel, UUM, SIntok, Kedah, Malaysia
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  - Project Title: Doa Dan Zikir Untuk Haji.
  - Project Members: **Al-Aidaroos, A. S.,** and Ariffin, A. M.

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Since the invention of the Mobile phone by John F. Mitchell and Dr. Martin Cooper in 1973, the aspiration began to enhance and improve the mobile phone to be more than a tool weighing around 1kg that was able to make phone calls only. Great enhancement and advancement were made over the mobile phone such as reducing the weight (McLaren, Wright, Parkinson, & Jackson, 1999), improving the capabilities (Jin & Von Zedtwitz, 2008), and upgrading the service quality level. Since 2000, a lot of services have been provided by the mobile phone service providers such as the Short Message Service (SMS) and the Multimedia Messaging Service (MMS). Today, many more utilities have been added by mobile phone manufactures such as address book, calendar, planner, games, and calculator. Later, the blending of the characteristics of Personal Digital Assistant (PDA) and features of hand phones bring new powerful capabilities into mobile phones, in which it is called Smartphone (Aram, Troiano, & Pasero, 2012).

According to Nusca (2009), smartphone's computing abilities are very high. Those computational capabilities allows smartphones to carry out professional services and applications such as Global Positioning System (GPS) functionalities, E-Banking, email clients, and web browser besides to the typical functions like contacts, calendar, diary, notepad, and voice recorder (Charlesworth, 2009). Nowadays, smartphones can deal with more than personal communication and data services (Chen, 2011).

Statistics have shown the existence of more than 3.3 billion mobile connections around the world, and from day to day this number constantly increases (Rosnita,

Dalbir, & Rozilawati, 2013). This is because individuals prefer to perform their works using their smartphones (Sean, 2008).

While mobility in business has become a necessity, especially with the belief that there are around 1.5 million mobile employees (Stacy, Jaffe, Boggs, & Stephen, 2011), there is a necessity to mobilize the business activities to be competitive and sustainable (Azham & Kutar, 2009). Various benefits can be obtained from mobile applications including education (Basaeed, Berri, Zemerly, & Benlamri, 2007; Ally, 2009), health (Istepanian, Laxminarayan, & Pattichis, 2006), transportation (Lane et al., 2010), tourism (Brown & Chalmers, 2003), disaster (Hasegawa, Sato, Matsunuma, Miyao, & Okamoto, 2005), logistics (Chan & Chan, 2008), and management activities as well as monitoring projects (Holzinger & Errath, 2007; Monares et al., 2011; Ochoa, Bravo, Pino, & Rodríguez-Covili, 2011; Wang, Yang, Song, Yang, & Wang, 2011). It is important to note that mobile applications should not be useful only but usable too because they support the needs of different levels of users (Rosnita et al., 2013). Accordance to Jordan (1998), the usability of any product is very important to ensure it is useful.

1.1.1 Electronic Book (e-book)

E-book is a digital form of an already published printed book, consisting of images, texts, or both. It can be read on computers, mobile devices and other electronic devices (Gregory, 2004). E-books are widely used documents that are designed to be displayed on a computer screen (Desrosiers, 1996). It is defined as a "book" in the sense that it addresses a significant portion of a subject area and consists of chapters with an associated table of contents and an index (Desrosiers, 1996). The English Oxford Dictionary defines e-book as an electronic version of a printed book (Chen, 2010). A large number of user manuals and books are made available in digital form in CD-

ROMS or over the World Wide Web (Ozsoyoglu, Balkir, Cormode, & Ozsoyoglu, 2000). E-books are usually read on dedicated e-book readers. Personal computers and some mobile phones can also be used to read e-books or audio books (Taylor, 2004).

1.1.1.1 Audio Book

Audio book is a recording of reading the text of published book or magazine. It is not necessary that the audio book is match an exact printed book or magazine. This kind of books has been used in schools as well as in public libraries since 1930's. They help the illiterate people and unskilled readers to understand the contents of the books which have been converted to audio books. The reader can simply listen to the audio recording and follow the text in the book (Byrom, 1998). Only audio books in unprotected and audible format like MP3 can be played in iPod, iPhone as well as Android Smartphone (Stone, 2008). Therefore the concept of audio book will be used to enhance the proposed solution to help pilgrims who cannot read Arabic text to recite the required Duas and Zikrs in Umrah and Hajj rituals.

1.1.1.2 Mobile Book (m-book)

After the emergence of e-learning, the term m-learning has been introduced as an extension to the e-learning (Laouris & Eteokleous, 2005; Pachler, Bachmair, & Cook, 2010) with the fact that m-learning is completely different from e-learning in terms of timing, context, information access, and assessment (Feser, 2010). Feser (2010) defines m-learning as the usage of the mobile technology to assist in educating, referencing or information browsing useful at the moment to individuals or in an explicit context. According to Majid, Ali, and Amir (2012) the term m-learning needs the term m-books[1] in order to be completed, which means readers can download a

1 - M-book is another form of e-book (published or non-published books) which can be reading on Kindle, mobile phones and iPad, it can consist of texts, images, videos and audios or a mixture of them (Kissinger, 2011)

mobile application that allows them to read text, listen and\or watch the textbook. Consequently, academic staff in Tamil Nadu Open University (TNOU) were engaged to convert the hardcopy textbooks into m-books to support the m-learning in the university (Pachler et al., 2010). Eventually, at the beginning of 2013, the textbooks in TNOU were presented to undergraduate students in the form that can be read on their mobile phones as m-books (Majid et al., 2012).

The discussions in this section explain that e-books have been utilized widely across the globe. They come in different formats. Some with audio only and some incorporate audio and visual. Besides, the levels of interactivity also differ, in which some require users to only scroll to screen, while some others require and allow users to enter inputs. Although the e-books are useful in education, it is also useful in other domains such as communication. In addition this study anticipates that it is also useful in the context related to Umrah and Hajj.

1.1.2 Umrah and Hajj

In Islam, the fifth pillar is Pilgrimage (Hajj). Every adult Muslim who is able bodied is required to perform Umrah and Hajj at least one time in his life successfully and completely (Obaid, 2008; Haneef & Hashim, 2009). Hajj is the largest Islamic annual event in the Muslim world in terms of number of participants (Pilgrimages). More than three million Muslims go to Makkah to perform Hajj annually. According to the General Authority for Statistics GAS (2016) in the Kingdom of Saudi Arabia's (KSA) report, the number of pilgrims increases every year. It is reported that in 2012 (1433 AH), the total number of pilgrims was 3,161,573 pilgrims, with increase of 8% from those in 2011 (1432AH). While, in 2016 (1437 AH) it was only 1,862,909 pilgrims because of the renovation and expansion in the sacred places. It is also reported that more than 71% of the pilgrims came from countries outside KSA including Malaysia

and Indonesia (General Authority for Statistics KSA, 2016). The government of KSA allows only 1% of the population of each Muslim country to go to hajj. This indicates that Malaysia could send 29,700 pilgrims for Hajj (Bernama, 2016), whereas in 2016 the quota have been reduced by 20%, due to same reason of development. Meanwhile, in 2013, Indonesia was allowed to send around 211,000 pilgrims to perform Hajj, but the quota has been reduced to 178,000 pilgrims in 2016 (Ezra, 2015; Mitra, Natalia, & Aditya, 2016). However, countries keep on communicating with the KSA to increase their quota (Bernama, 2016; Mitra et al., 2016).

Furthermore, according to Al-Rabie, (2016), about 3.7 million pilgrims were arrived to Makkah for Umrah in the period between October 2015 and March 2016. In the other hand, the government of Saudi Arabia issued more than five million Umrah visas in 2013 and six million Umrah visas during 2015 (Haj Ministry Portal, 2015). Meanwhile, the Saudi Arabia government is planning to issue 1.24 million Umrah visas per month (15 million/year) by the end of the Grand Mosque expansion. However, this number is expected to increase to 60 million annually by 2018 (Arabian Business, 2015).

Umrah and Hajj are important events in every Muslims' life, which offers religious, educational, scientific, social, economical, political, and other benefits that are rewarded by Allah to Muslims (Khan, 2007). It is performed based on predetermined dates, times, and places. It is a demonstration of the solidarity of the Muslims and their submission to Allah. Pilgrims normally spend between 7 to 21 days to finish their rituals in Hajj by following an explicit route. Pilgrims who fail to finish their rituals completely and successfully within those dates, times and places are required to repeat their pilgrimage immediately in the next year. The holy places are very small comparing with the number of pilgrims (Mandourah, Al-Radi, Ocheltree, Ocheltree, & Fowler, 2012). Particularly, the area of Saie Place (Masa'a) is around 7.9 square kilometers only (394.5 m in length

and 20 m in width), while the place of Tawaf (Mataf) is a circle, with 95 meters in diameter, the area of Mina is 2.9 square kilometers. The Arafat is approximately 10.4 square kilometers while Medina is 589 square kilometers. Physically, Umrah and Hajj rituals are very demanding plus to be performed in a very crowded environment (Deris et al., 2010; Mohd Shafry et al., 2011; Ali, 2012). Currently, the Government of KSA plans to expand the area of Mas'aa and Mataf. There is also a plan for the expansion of the Haraam Mosque in order to accommodate 2.5 million worshipers at the same time (Al-Siddiqui, 2009; Saudi Gazette, 2013). This indicates that more pilgrims are allowed to perform Umrah and Hajj soon.

The discussion about Umrah and Hajj in this section visualizes that the context of Umrah and Hajj is different than the other context. There are many people doing similar thing simultaneously. In this kind of situation, the usability aspects of interactive products to be used should be considered very specifically.

1.1.3 Usability

Usability is known as a quality attribute, which can measure how User Interface (UI) is usable for various users' profiles (Juristo, Windl, & Constantine, 2001). Formally, the International Organization for Standardization (IOS) defines the usability as "the capability of a product to be understood, learned, operated and be attractive to users when used to achieve certain goals effectively and efficiently in specific environments" (ISO 9241, 1998; Abran, Khelifi, Suryn, & Seffah, 2003).

Consequently, the usability of an application can usually be verified through the user interface (Bertoa, Troya, & Vallecillo, 2006). From the definition of usability, four factors can be extracted. Those factors which are (1) users, (2) tasks, (3) environments, and (4) technologies can strongly influence the usability of mobile applications

(Rosnita et al., 2013). The first factor is the variety of user profiles (novice users, knowledgeable intermittent users, and expert users) (Bertoa et al., 2006). This means different skill levels can directly affect the product usability. As an example one application can be usable for the expert users but it is not for novice users. In other words the previous experience with the product itself or similar product is likely to affect the usability of the product (Roda, Borel, Gentchev, & Thomas, 2005). Similarly, it may be easy for expert users to complete a particular task but it is difficult for novice users. Additionally it is clear that a product which is usable for the able-bodied users will not necessarily usable for disabled users. So new technology must allow the special needs users to use some products easily (Jordan, 1998).

The second factor in the definition of usability is task, which refers to steps to do in achieving objectives. In different cases, objectives require a set of steps. Some developers prefer to give the users the possibility to perform a task using more than a single way; they embrace all the possible ways to perform the task in order to be helpful to the users. But unfortunately, this causes chaos and overcrowding (Jordan, 1998). Three levels of task can be defined as frequent tasks, less frequent tasks and infrequent tasks, and the complexity of a task is indicated by the number of steps to complete that task successfully (Bertoa et al., 2006). Frequent tasks can be performed in a single action by pressing a button or key and so on, but less frequent tasks involve two actions only, whereas infrequent task requires more than two or three actions (Shneiderman, Plaisant, Cohen, & Jacobs, 2010). As an example of a three-step task, this paragraph brings a sending an SMS scenario. The users need to press one key to call one phone number from favorite numbers list. When he wants to send an SMS, he needs to write the message by keying-in several keys then he needs to key-in the receiver's phone number or selects it from the contact numbers, finally he needs to press the send button.

The third usability factor is environment, which refers to the periphery or the conditions which the product uses in performing the user's task (Sauro & Kindlund, 2005). Also, it refers to the data and the device capabilities and connection's consistency (Biel, Grill, & Gruhn, 2010). It can be factors such as user's social conditions, noise, temperature, bandwidth, and network connectivity between the connected devices (Rosnita et al., 2013). Finally the last usability factor is technology, which refers to the device's specifications and features, and software and hardware. For example the input and output mode of data have direct effects over usability. According to Rosnita et al. (2013), more than 27 attributes were found in previous studies of the mobile usability. Some of those attributes can be referred to, combined, or considered as other attributes. The most commonly used attributes are effectiveness, efficiency, and satisfaction (ISO 9241, 1998; Jordan, 1998; Rosnita et al., 2013). While the efficiency and effectiveness are clearly mentioned in the usability definition (Bertoa et al., 2006), satisfaction has been implicitly mentioned by using the word "attractive" (Sauro & Kindlund, 2005). Effectiveness refers to the extent of success of task. Also, effectiveness in some cases simply means success or failure of tasks. As an example, in a condition the user task is to play a sound file. It is successful if the sound file is started and the sound is audible. In contrast, it is a failure if it is not. Nevertheless in some cases, effectiveness of tasks could be measured by the percentage of the achievement of a particular goal, for example in network if the sender's goal were to send 100 Kb per second; as a result the effectiveness level is 90% if sender was able to send 90 Kb per second.

Meanwhile, efficiency refers to the cost or the efforts required to perform required tasks or to achieve the goal. It is refers to the time spend to perform the task or the number of steps or errors to complete the task. In other words, it refers to the complicity of performing tasks. Generally, the greater number of errors or the more

time taken reduces the efficiency. For example, when sending 100 Kb or 90 per second, it is less efficient if the processor is reserved completely for the task only more than if the processor still can perform another task while performing the task (Jordan, 1998; Nayebi, Desharnais, & Abran, 2012).

On a contrary, satisfaction refers to the user's comfortable feeling level when using a product and the users' acceptance of the product in terms of achieving their requirements and goals (Roda et al., 2005). Higher than the effectiveness and efficiency, satisfaction is a more subjective aspect of usability and it is the most complicated to assess. There have been many cases where satisfaction is the most significant usability consideration, but the importance of satisfaction does not eliminate or reduce the importance of effectiveness and efficiency (Jordan, 1998; Nayebi et al., 2012).

1.2 Motivation of Study

Since there is a difference between the characteristics of handheld devices or mobile phones and computers, it is recognized that the usability of handheld devices (Smartphones and PDAs) and their applications are completely different from other computer applications and systems (Nayebi et al., 2012). The midst of the dramatic evolution of smartphones, has made smartphones live up to the personal computers' level. Significantly, the hardware specifications of smartphones nowadays has been improved (4 cores processing 1.5 GHz, RAM size 1GB, and GPU) and are enhanced with multiple sensors plus actuator interface such as capacitive multi-touch screens, multiple wireless communication interfaces, accelerometers, GPS, and camera. In some applications, the user's experiences are fundamentally altered by integrating mature multi-touch user interfaces smoothly (Cuadrado, 2012). In accordance, users become more participative as opposed to being merely consumers. This evolution generates competitiveness among developers when distributing their products on

online mobile application stores like Android Google play and Apple's App Store. However, regardless of the utilities, users prefer to choose applications that are easy to learn, consume the lowest time to carry out their tasks and are user-friendly because most of them are computer illiterate (Chittaro, 2011; Nayebi et al., 2012).

On the other hand, according to Forest Interactive website (2013), a Multimedia Super Corridor (MSC) status company, supported by Malaysian Communications and Multimedia Commission (MCMC), the number of mobile phone subscribers in 2013 was 41.9 million. Meanwhile, the number in Indonesia was 216.8 million subscribers. This means mobile penetration rate in Malaysia is 132.93% and 104.25% in Indonesia. It is even higher in Singapore with 150.61%.

In addition, at the beginning of January 2013, the Malaysian government, through MCMC launched a campaign called Youth Communication Package announced by The Prime Minister in the Budget 2013 to encourage young people to own Smartphone's especially in rural areas. This explains that MCMC spent around RM300 million [RM1 = US$0.33] for approximately 1.5 million Malaysian youths aged 21-30 to purchase 3G Smartphones. This is done through a rebate of RM200 for every youth to buy 3G Smartphones. As a result, 460 thousand youth have signed up for the rebate in May 2013, and it took 4 to 6 months to serve the 1.5 million (MCMC, 2013; National Information Technology Council, 2013).

The previous paragraphs explain that the utilities and applications in mobile phones are rich and getting richer. On top of that the infrastructure supports are also sufficient in making sure the utilities and application run well. Hence, the advantages of the advanced mobile phones and their utilities should be utilized by the community at the most optimum level. In conjunction, the government takes an interactive to enable the young generation to venture into the arena. With reference to this section, this study

anticipates that applications on mobile phones will reach a large population. Further, this anticipation accelerates the motivation to carry out this study. It is strengthened by the problems described in the problem statement section.

1.3 Initial Study

In order to gain the pilgrims' feedback, perceptions and their opinions about the form of assistance they need, an initial study has been conducted at the beginning of 2013 and lasted about one month (exactly 4 weeks). The first purpose of the study was to validate the contents of such application and identifying the users' requirements. Secondly, to develop an initial solution (mobile application called MDZ4H) and evaluate it among the pilgrims to gather their feedback in terms of usability. Table 1.1 show the objectives of initial study and the method used to achieve these objectives. Therefore, as a preparation to the initial study, the existing related studies were explored.

Table1.1

The Objectives of the Initial Study and the Used Methods

No	Objective	Method
1	To find out the current problems in the conventional approaches which are currently used.	Direct interview
2	To collect and organize the required information (Duas and Zikr for Hajj) in the solution.	Literature survey and experts review
3	Identifying the appropriate device and platform of the solution.	Direct interview

1.3.1 Findings

The initial study findings are divided into two findings. The first one is the findings of the interview with 30 pilgrims in identifying the problems which help to choose the appropriate device and platform, while the second findings are the evaluation results of the users and experts (30 users and 6 experts).

1.3.1.1 Findings of Interview

The results of data analysis indicate that in terms of gender of the respondents, 26.7% were males while 73.3% were females. Altogether, 80% were youth (15-40 years old) while 20% were old (41 and above). It was found that only 3.3% of the respondents were able to read Arabic text without orthography, while majority (96.7%) of them cannot. The results also show that only 6.7% from the respondents preferred to use computers to perform their daily activities, while 93.3% preferred mobile devices. In terms of equipment's operating system, 6.7% use Windows, 10% use iOS, and 83.3% use Android. Therefore, Android operating system has been considered as the platform of the initial study. In terms of the fourth question in the interview, which concerned about the difficulties in performing the rituals of Hajj and the reasons that cause those difficulties, the results are summarized in Table 1.2.

Table 1.2

The Most Difficult Rituals in Hajj and the Reasons That Cause Those Difficulties

Ritual Name	Easy		Middle		Difficult		Reason of Difficulty if any
	N	%	N	%	N	%	
Ihram	29	96.7	1	3.3	0	0	- A need for step-by-step details
Tawaf	0	0	3	10	27	90	- Very crowded and Noisy. - Count the rounds numbers. - A need for step-by-step details
Saie	2	6.6	5	16.7	23	76.7	- Very crowded and Noisy. - Count the rounds numbers. - A need for step-by-step details
Staying in Mina	30	100	0	0	0	0	- Need to know what to do in free time
Staying in Muzdalifah	29	96.7	1	3.3	0	0	- A need for step-by-step details - Need to know what to do in free time
Wuquf	6	20	9	30	15	50	- Very crowded and Noisy. - Need to know what to do in free time
Jamarat Stoning	1	3.3	4	13.3	25	83.4	- Very crowded and Noisy.

Within the same context, the interviews results show that most limitations appear in the conventional approaches that are currently being used include the following:

- Difficult to find pages of the required Dua especially while performing rituals

that involve large crowd.

- Difficult to read Arabic text properly without orthography.
- In Tawaf and Saie, it is difficult to identify the exact number of rounds.
- No provision of detailed step-by-step recitation of the Duas.
- In the electronic gadgets the users are still required to refer to a booklet for the Arabic texts and translation.
- Some pilgrims state that the content's validity of the electronic gadgets is doubtful.

1.3.1.2 Findings of Prototype Evaluation

1.3.1.2.1 Experts Evaluation

The Descriptive Statistics and t-test have been used to analyse the data collected through the user evaluation questionnaires. The results show that all the mean values are 4 and greater (from the maximum 5) (see Table1.3). The results indicate that the user interfaces of the prototype have received high satisfaction by the experts.

Table 1.3

Descriptive Statistics for All Items in User Interface Satisfaction Questionnaire

No.	Item	N	Minimum	Maximum	Mean	Std. Deviation
OVERALL REACTION TO THE SOFTWARE						
Q1		6	3.00	5.00	4.3333	0.81650
Q2		6	3.00	5.00	4.5000	0.83666
Q3		6	4.00	5.00	4.3333	0.51640
Q4		6	3.00	5.00	4.0000	0.63246
Q5		6	2.00	5.00	3.3333	0.81650
Q6		6	3.00	5.00	3.6667	0.51640
SCREEN						
Q7	Reading characters on the screen	6	3.00	5.00	4.3333	0.81650
Q8	Organization of information	6	3.00	5.00	4.1667	0.75277
Q9	Sequence of screens	6	3.00	5.00	3.8333	0.75277
TERMINOLOGY AND SYSTEM INFORMATION						
Q10	Use of terms throughout system	6	3.00	5.00	4.3333	0.81650
Q11	Position of messages on screen	6	3.00	5.00	4.1667	0.75277
LEARNING						
Q12	Learning to operate the system	6	4.00	5.00	4.6667	0.51640
Q13	Exploring new features by trial and error	6	4.00	5.00	4.5000	0.54772
Q14	Remembering names and use of commands	6	4.00	5.00	4.5000	0.54772
Q15	Performing tasks is straightforward	6	4.00	5.00	4.5000	0.54772

Table 1.3 Continued

SYSTEM CAPABILITIES					
Q16 System speed	6	3.00	5.00	4.1667	0.98319
Q17 System reliability	6	3.00	5.00	4.5000	0.83666
Q18 System tends to be	5[2]	3.00	5.00	4.0000	0.70711
Q19 Designed for all levels of users	6	3.00	5.00	3.6667	0.81650

1.3.1.2.2 Users Evaluation

There are three attributes in the questionnaire to be measured which are Usefulness, Easy to use, and Outcome or Future use. The data collected from respondents' are analysed through descriptive statistics over the entire questionnaire's dimensions. The results of the Descriptive Statistics technique show that the tentative prototype is highly usable. It shows a high satisfaction in terms of usefulness and usability as well as the outcome/future use of the prototype (Table 1.4).

Table 1.4

General Outcomes of Data

Dimensions	Mean
Usefulness	4.4000
Ease of use	4.4467
Outcome / Future use	4.4833

Meanwhile, the results of t-test show that there is a significant difference between the new users and the used users for all the usability different attributes (Usefulness, Ease of Use, and Outcome and Future Use), with $p = 0.000$.

The new users have higher mean values for all the attributes compared to the used users (see Table 1.5). This is probably because the used users have been to Makkah and performed Umrah or Hajj, so they have the experience of using other approaches such as books, booklets and Hajj player to assist them to recite the Dua and Zikr. In contrast, the new users have never been exposed to any of the previously-mentioned approaches,

2- One of the respondents believes that this item is not applicable.

which results in the higher mean values for all the attributes compared to the used users.

Table 1.5

New users VS Used users

Measure	Group	N	Mean	Std. Deviation	T	df	Sig
Usefulness	New	15	4.4533	0.4373	39.441	14	0.000
	Used	15	4.3467	0.4688	35.907	14	0.000
Ease of Use	New	15	4.5467	0.4240	41.527	14	0.000
	Used	15	4.3467	0.5476	30.745	14	0.000
Outcome / Future Use	New	15	4.5500	0.3919	44.968	14	0.000
	Used	15	4.4167	0.4880	35.056	14	0.000

1.3.2 The Initial Study Resolution

In order to come out with a solution to all the above-mentioned problems and issues, this study decides to determine the suitable fundamental elements for mobile assistant for Umrah and Hajj that integrates audio and visual representations. The usability of this tool or application specifically is the main aim of this study. That means this study attempts to design the multimodal mobile assistant that is useful and usable for pilgrims in the Umrah and Hajj environment. To achieve that, some questions must be addressed and answered significantly such as what are the attributes makes this visual assistant is user-friendly to pilgrims? Are those attributes able to make the visual assistant usable? In other words, are those attributes effectively influencing the usability of the visual assistance? How those attributes can be incorporated into the design of the visual assistant? As it is outlined in the initial study that the demand is high for such tool for Umrah and Hajj, it is urgently in order to achieve the study objectives.

While it is in the demand, the design aspects should consider the context of use and users' computer illiteracy level. This is important to ensure that the visual assistance is usable in the context of use. Hence, the usability principles as partly described at the early part of this chapter and further discussed in Chapter 2 should be incorporated.

1.4 Problem Statement

Many efforts have been initiated and many techniques and approaches have been developed to facilitate the difficulties faced by pilgrims (Fathnan, Wibowo, Hidayat, Marenda, & Ferdiana, 2010; Mohd Fitri, Abdul Nasir, & Nor Fadziana, 2011; Mohd Shafry et al., 2011; Normala, Nazirah, Wan Malini, & Siti Dhalila, 2013). However, these studies focus on acquiring initial perspective and background knowledge about Umrah and Hajj before going to Makkah (Mohd Fitri et al., 2011). Mohd Shafry et al. (2011) developed an application for use during Umrah and Hajj. It is designed for desktop, which is quite impractical to use during Umrah or Hajj. In addition, these studies used modalities (such as interactive multimedia elements virtual and augmented reality) to interact with users to delivering the contents as well as buttons and menus to access the contents (Taileb et al., 2014). However, the findings of the initial study show lack of multimodality in the existing studies in terms of interaction modes. As a response to that, this study designs an assistant for pilgrims during Umrah using different platform on mobile environment. Besides, this study utilizes the available hardware and software features in smartphones (such as voice recognition function, location base services, and embedded sensors) as new interaction modes to support the usability of the proposed solution.

Hajj is performed based on predetermined date, time, and place. Pilgrims normally spend between 7 to 21 days to finish their rituals in Umrah and Hajj by following an explicit route. Pilgrims who fail to finish their rituals completely and successfully within those dates, times and places are required to repeat their pilgrimage immediately in the following year (Khan, 2007; Obaid, 2008; Haneef & Hashim, 2009). Therefore, to prevent the occurrence of any failure in the performance of rituals, pilgrims need an assistant that provides them the exact steps on how to perform the

rituals of Umrah and Hajj timely according to their locations.

Furthermore, since the proliferation of Islam in East Asian countries and Malaysia in the 14th century, the importance of Arabic language emerged and becomes a necessity to understand the doctrine and the commandments of Islam, and it is the language of Quran the holy book of Muslims (Ahmad, 2010). As a result, many approaches have been introduced such as reading, memorization, and Grammar-translation (Haron, Ahmad, Mamat, & Mohamed, 2010) in learning and teaching the Arabic language to ensure that new Muslims have a good understanding of Islam. However, those approaches led to the neglect of some linguistic skills in Arabic language (Haron et al., 2010).

According to Abdul-Hamed (2009), Malaysian students face many difficulties to apply the rules of Arabic language in the various tasks of the language (reading, writing, spelling, and speaking). In Malaysian Arabic language curriculum for non-native speakers, the Arabic grammar is integrated with morphology and orthographic systems. In fact, Abdul-Hamed (2009) found that Malaysian students have problems to convert their oral expressions to writing form without orthographic mistake. Besides, Su'aidi (1997) found that without morphology, Malaysian students cannot read or recite the Arabic text correctly. Nevertheless, some of the difficulties faced by non-native Arabic speakers while studying Arabic language include identifying the various shapes of letters in writing and pronouncing some of the letters such as Hamza "ء", Elgin "غ", Elain "ع" ,ha "ح", Z "ض" and Ů "ظ". They also have difficulties to identify and differentiate some of the letters which have been adjoined and similar forms of letters like (ع, غ, ح, خ, ج, ض, ظ) in the Arabic language. In addition, the writing style from right to left is different from other languages and also the Arabic single sentence structure is completely different and does not exist in majority of the world's languages (Sahrir, Yahaya, &

Nasir, 2012; Alsrhid, 2013). Even though it is difficult, Muslims still have to use Arabic language in prayers and performing Hajj and Umrah. While memorizing it is a must in prayers, reciting during Hajj and Umrah could be assisted with tools. Therefore, this study focuses on utilizing some modalities such as images, audios, and texts with morphology in addressing the difficulties faced by non-native Arabic language Muslims to support the usability of the proposed mobile assistance, which will be able to assist pilgrims to recite the required Duas during Hajj and Umrah.

At the beginning of the Dhual-Hijjah[3] more than 3 million Muslims flock to the Holy Land in Makkah to perform Hajj. Besides, more than 5 million Muslims arrive in Makkah for Umrah throughout the year (Himdi & Sandhu, 1997). As a preparation of Umrah or Hajj, Islamic communities in countries such as Malaysia and Indonesia conduct a one-month training on 'how-to' aspects and contexts. Pilgrims need to know and memorize the important prayers (Dua and Zikr) throughout the pilgrimage that need to be recited in every rituals of the Umrah or Hajj such as in Tawaf (Anad, 2009). Even though the training has long been organized, a lot of non-native Arabic Muslims still have difficulties in reading the prayers and supplications (Dua and Zikr) and pronounce them correctly (Sahrir et al., 2012; Alsrhid, 2013). They believe that Allah SWT requests no particular words to comprehend what they ask Him for (Obaid, 2008). But Muslims prefer to follow (not innovating) the Messenger of Allah our Prophet Muhammad SAW (May Allah bless him and grant him peace) by doing what he exactly did without any increase or decrease (Al-Aidaroos, Abdul Nasir, & Che Mat, 2013). Therefore, this study tries to investigate the attributes that must be available in the proposed mobile assistant which is able to support its

3 - Dhual-Hijjah or Zulhijah is the 12th month in Hjrah calendar.

usability during Umrah and Hajj by taking into account the circumstances of this crowded and noisy environment (van Leeuwen, 2015).

Nowadays, normally the Dua and Zikr are available in the form of books, booklets, leaflets, and even pages. Some of them are also available in the Internet. Some of the Dua and Zikr are grouped together as a book while some are separated based on the rituals to be performed. Even though these approaches have been the most popular and widely used approaches, there are some limitations to them. Among the limitations include difficulty to find the exact pages of the required Dua and Zikr especially while performing ritual such as Tawaf and Saie which involve large crowd. Some of the pilgrims are not able to read Arabic thus they are not able to recite the Dua and Zikr properly. When performing Tawaf and Saie, difficulty also arises in identifying the exact number of rounds. On the top of that, most of the approach did not provide detailed step-by-step recitation of the Dua and Zikr such as while performing the Tawaf and Saie. Meanwhile, those Dua and Zikr must be organized in appropriate way that makes it reachable, understandable, and simple. Further, it will support the usability of the mobile assistance proposed by this study. Therefore, this study utilizes the theories and principles of Information Architecture in organizing and representing the contents, while multimodality will provide multiple ways to access those contents.

Besides those printed materials, electronic gadgets have also been developed to cater for reciting Dua and Zikr for Umrah and Hajj. An example could be seen in Hajj Player that supports audio only (Alibaba, 2012). The Dua and Zikr are read in word without graphic. Hence, users are still required to refer to a booklet for the Arabic and translation texts of the Dua and Zikr. By using this player, the pilgrims have to carry the player as well as

the booklet. This does not really help the pilgrim especially while in a large crowd. On top of that, Hajj player is manufactured in Korea, thus the validity of the content is also doubtful (Al-Aidaroos, 2012). Thus, mobile phone has been considered as a viable alternative for developing the Dua and Zikr during Hajj and Umrah application.

With reference to the successful implementations of mobile application described at the beginning of this chapter, the Dua and Zikr could also be designed incorporating audio and visual, running on mobile phones, without having to carry booklets. When this idea was addressed to the pilgrims (through the training by Tabung Haji), their initial feedbacks were very positive. Briefly, they are happy if they could make use of the multimodal mobile assistance while performing Hajj and Umrah.

1.5 Research Questions

Referring to the problems described in the previous section, this study decides to venture into determination of appropriate elements for a Multimodal Mobile Assistant during Umrah (MMA-U) that incorporates audio and visual representations. Specifically, the usability of MMA-U is the main focus of this study. As such, the following questions should be answered:

i. What are the most appropriate usability attributes MMA-U?
ii. How to conceptualize the MMA-U?
iii. Is the MMA-U able to support usability from users' perspective?

These questions are significant to be answered urgently because the demand for tools for Umrah or Hajj is high as outlined in the initial study. In fact, answering them helps to support the achievement of the objectives as stated in the next section.

1.6 Research Objectives

This study aims at proposing a multimodal mobile assistant that assists pilgrims in performing Umrah or Hajj. While the context is extremely different than any other contexts (gathering extremely large crowds performing similar activity simultaneously), usability aspects of the product is highly specific. Hence, this study attempts to propose a conceptual model (MMA-U) specifically for assisting pilgrims doing ritual activities during Umrah. To accomplish that, the following objectives have to be achieved:

i. To identify the most appropriate usability attributes for MMA-U.
ii. To propose the conceptual model for MMA-U with the identified usability attributes.
iii. To validate the conceptual design model of MMA-U through expert reviews.
iv. To gather user feedbacks on the usability of a prototype that incorporates MMA-U.

This study decides to call the prototype as Personal Digital Mutawwif[4] (PDM).

1.7 Research Scope

This study focuses on constructing a conceptual design model of multimodal usable mobile assistant during Umrah. Therefore, to avoid any wrong perceptions or misperceptions, there is a need to clarify that this study abided by specific research scopes as follows:

1. The geographical regions of the study is Malaysia and neighboring countries, which reflects the following points:
    - The responders involved in this study were Muslims from Malaysia or neighboring countries.

4 - Mutawwif: A knowledgeable professional person appointed by the government of Saudi who can guide pilgrims during Hajj. Some of them are keen to assign prominent preachers who know the language of the respective pilgrims, to enlighten them on the rituals of Hajj in their own language.

- The rules and provisions of Madhhab Shafi'i and Lembaga Tabung Haji of Malaysia have been followed.
- Both Arabic and Malay languages were used in writing the contents and designing the interfaces.

2. The prototype of PDM was developed based on this criteria:
   - The targeted devices were the Android smartphones. This means that the other mobile devices (handhelds or wearable) are beyond the scope.
   - The Android SDK and Android Studio are used as a development tools to develop PDM. The logical code was written using Java 2 Platform Micro Edition (j2me) under Android platform while the interface was designed using XML.
   - The prototype utilizes the GPS and Google speech to text function as interaction mode, whereas sensors interaction mode was eliminated due the need for governmental permits to install infrastructure.
   - The Malaysian pilgrims faced difficulties in memorizing and reciting the required supplications (Dua and Zikr) in Umrah rituals. Therefore, PDM is designed to assist pilgrims to reciting the required supplications in Umrah rituals, not building the background knowledge about Umrah.
3. The study is concerned on evaluating the MMA-U as a guide for all levels of developers who interested in developing PDM. The evaluation process was conducted as the following:
   - The expert review method used to evaluate MMA-U.
   - An experimental study was implemented in the field to gather the pilgrims' feedbacks on the MMA-U through PDM.

1.8 Research Significance

Conducting this study is an endeavor to significantly contribute to the body of knowledge besides overcoming the deficiencies of the conventional approaches of assisting pilgrims during Umrah and Hajj. Generally, this study provides a well design and developed PDM. Specifically it will be beneficial for the pilgrims all Muslims in this world. Hereby, the following significant achievements can be fulfilled.

Flipping Pages: Pilgrims face difficulty find the pages of the required Dua and Zikr especially while performing rituals such as Tawaf and Saie which involve large crowd. However, the PDM overcomes this problem by utilizing the GPS and voice commands. The PDM tracks the pilgrims and automatically provides the appropriate Dua and Zikr according to their location. Besides of that, the voice commands mode in PDM allows the pilgrim to pronouncing the name of the required ritual to access the corresponding Dua and Zikr automatically.

Illiterate Pilgrims: This study also significant for pilgrims who cannot to read at all, as well as those who can read Arabic text but they cannot understand the maiming. Therefore, the PDM is very useful for these kinds of pilgrims. Firstly, the PDM use the recitation technique by utilizing the sound files to assist the non-educated pilgrims reciting the required Dua and Zikr. Secondly, the PDM provides a Malay translation of all Dua and Zikr for those pilgrims who can read Arabic text but cannot understand it.

Memory Load: Duas and Zikr associated with praying (Salah) can be memorized by repetition over time (5 times a day). Meanwhile, Hajj and Umrah are rarely repeated in the Muslim's life due to the considerable costs and a lot of competitions to get a traveling visa for Hajj and Umrah. In addition, Hajj and Umrah involve many rituals

accompanied Duas or Zikr that need to be recited. Therefore, memorizing a large number of Duas and Zikr is almost impossible. However, this study gives the pilgrims an opportunity to focus more on the performance of the rituals instead of preoccupation with memorizing the Duas and Zikr that accompanied with these rituals. This leads to minimize the memory load.

Inexpensive: PDM need no special equipment to bay (such as books, booklets, leaflets, or electronic gadgets). In addition, PDM provides acoustic instructions and automatic interaction modes (such as voice command and GPS) which eliminate the use of touch screen to interact or look for reading. The pilgrims need only to install PDM in their smartphone, then open the application and use their headset to listen to the acoustic instructions. Therefore, the pilgrim will be able to control their movement in the crowd safely and enjoy the rituals.

1.9 Research Theoretical Framework

Conducting any study must be based on the existing theories and concept in the related fields. Therefore, this study started with exploring the existing theories in usability and multimodality as well as the information architecture, after that the related concepts to those theories and other concepts related to the user-centred design and visual design have been explored too. Figure 1.1 illustrating visually the research theoretical framework of this study.

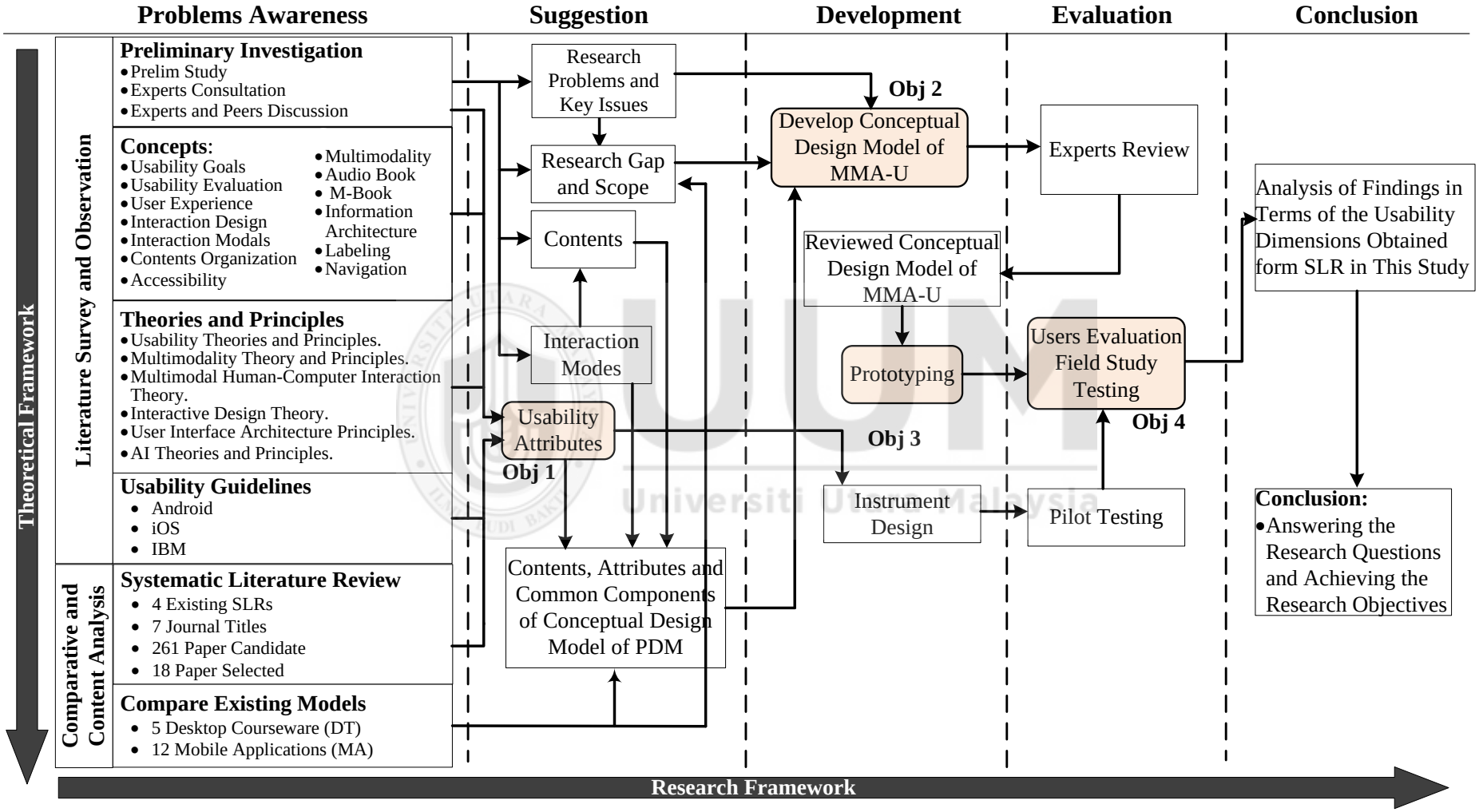


Figure 1.1. Research and Theoretical Framework

1.10 Terminologies and Operational Definition

The terminologies that are used in this study may have been used in other studies but to convey different interpretation. Therefore, this section provides the operational definition of these terminologies as following:

Umrah is a pilgrimage to Mecca that must be carried out at least once in a lifetime by every able bodied Muslim. However, technically it means to visit a sacred place for performing certain acts of worship (Ibadah) (Obaid, 2008; Haneef & Hashim, 2009).

Pilgrim is a person who journeys to Makkah for Hajj or Umrah.

Mutawwif is knowledgeable professional person appointed by the government of Saudi who can guide pilgrims during Hajj or Umrah. Some of them are keen to assign prominent preachers who know the language of the respective pilgrims, to enlighten them on the rituals of Umrah or Hajj in their own language.

Mode refers to the manner or the way in which something happens or done or is experienced (RHKW, 2001). Furthermore, from the point of view of user interface design, the mode can be another setting of an application or physical machine where the same inputs lead to different results of other settings (Kammer et al., 2011)

Multimodality is the combination of visual, textual, and audio modes with material and media to give a sense and meaning (Lutkewitte, 2013).

Interaction Mode is the way or the manner that enables users to access the contents in the application.

Interaction Design can be described as means creating interactive products able to support the people communication manners and their interaction ways in their working and daily lives (Sharp, Rogers, & Preece, 2011).

Multimodal interaction is refers to more than one way to interact with the system and providing several distinct methods for inputting and outputting data (Hunyadi et

al., 2011; Wechsung, 2014).

Usability is means empowering people who use the application to accomplish their tasks quickly and easily, it is focusing on the process of creating the best users experience by meeting their needs.

Usefulness is the user's perception that utilizing the proposed technology (PDM) will improve and enhance his performance.

Error Rate is the ability of preventing users from falling into mistakes or ease of recover from mistakes.

Simplicity is the intuitiveness and straightforwardness of the product (PDM) as well as the freedom of complexity in operating the product. It is also means the ability of being easy to understand.

Reliability is the product's accuracy and the ability of being trustworthy and depended on.

Ease of Use is the product's ability of being easy to operate.

Safety is the system's ability to protect the user from hazards during usage.

Flexibility is the system's adaptability and consistency with similar products.

Accessibility is the degree of how easy to access the contents of application.

Attitude is the users' feeling about the product.

Acceptability is whether the product acceptable among users or not.

1.11 Thesis Structure

Overall, this study consists of seven chapters. The following is a summary of the contents of each chapter:

Chapter 1: Introduction - As an introductory on the research topic, chapter 1 provides a brief overview of study that included the deliberations of the phenomena,

motivations, and issues that underlies the foundation of this study. In supporting the research gap, the findings of the initial study are discussed extensively, which then led to formulating the problem statement, research questions, and research objectives. This chapter also provides an explanation of how this study contributes to the body of knowledge, beside the research scope, operational definition, and terminologies, to avoid any wrong perceptions or misperceptions.

Chapter 2: Literature Review – A systematic and in-depth review on concepts, theories, general usability attributes, and usability evaluation methods are needed before starting with identifying the appropriate usability attributes for MMA-U and constructing the conceptual model. It is very important to ensure that proposed usability attributes is correspond and can be incorporated with the components and elements needed to construct the conceptual design model for MMA-U as well as complying the objective of this study. Therefore, reviews on theories and concepts underlying the study were comprehensively expressed in this chapter, as well as the meta-analysis on the previous model and how it implicate to this study were also discussed profoundly.

Chapter 3: Research Methodology - This chapter discusses in details the processes and techniques involved (from beginning to the end) in achieving the aspired research objectives of this study. Generally, triangulation methodology based on the design science approach in information system studies is used to produce artifacts. In addition, this chapter provides a detailed discussion on the relationship between the research objectives and the outcomes of each phase in the methodology.

Chapter 4: Conceptual Design Model for MMA-U – This chapter discusses how the SLR results are reported and identifying the most appropriate usability attributes

for MMA-U in achieving the first research objective, followed by the results of peer and experts discussion in selecting the appropriate interaction modes for MMA-U. Pertaining to objective 2 and 3 of this study, this chapter provides a detailed explanation of the processes involved in constructing the Conceptual Design Model for MMA-U, as well as the model validation process also discussed profoundly.

Chapter 5: Prototype Design and Development – To achieve the third research objective of this study, the proposed model for MMA-U needs to be validated through prototyping approach. Therefore, this chapter explains how the proposed conceptual design model of MMA-U is transformed into a working prototype called PDM.

Chapter 6: User Experience – In achieving the fourth objective of this study, the PDM prototype is involved in an experimental study through field user experience testing to measure the usability of PDM. This chapter elaborates the evaluation process of PDM starting from the instrument design, pilot test, field usability test procedure, data analysis, and hypotheses testing.

Chapter 7: Discussion and Conclusion – Finally Chapter 7 deliberates on the finding that leads to in-depth discussion and conclusion of the study.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Apparently, before starting to desired conceptual model in this study there is a need to know what is the meaning, the components and the important of the conceptual model. In the other hand, it is very important to ensure that the designed model is valid and easy to use. Therefore, this chapter implicates the existing theories, concepts and principles of the related fields such as multimodality, interaction design, users' experience, information architecture and usability. This chapter also, reviews the existing frameworks in usability evaluations as well as the latest empirical studies that identify clearly the usability attributes of the mobile applications.

2.2 Conceptual Model

The term *Conceptual* means dealing with definitions or the relations of the concepts of some field rather than dealing with facts (Amerircan Heritage Dictionary, 2011; Forsyth, 2014). Whereas the term *Model* generally means the representation of anything - for example theory, object, law or event - using anything else (such as a combination of tables, factors' matrices, or a mixture diagrams of boxes and arrows) (Hestenes, 1997). Models are not really the real world systems itself, but it helps humans to clearly understand the systems in real world. So generally models should have inputs, inputs processing, and finally results which is the expected outputs of the model. To come out with a good model the model developer should first simplifying the assumptions, then identifying the initial conditions of the representative system, and finally understand the scope of the model (Ford, 2000).

Hence the most appropriate for this study is going to develop a conceptual model of Usable Multi-Modal Mobile Assistance during Umrah. The following subsection will

discuss the definitions, benefits and components of conceptual model.

2.2.1 The Definitions of Conceptual Model

The term conceptual model refers to concepts that are represented graphically or the model of concepts, which also called conceptual framework (Effken, 2003; Joy, 2013). It broadly explains a phenomenon of interest, expresses assumption, and reflects a philosophical stance.The term conceptual framework is widely used in art (Eco, 1979), marketing (Jaworski, Stathakopoulos, & Krishnan, 1993), social sciences (Rodman, 1980; Moorstein, 2004), and applied sciences (Hobbs & Norton, 1996) to represent the crosses of contests and theories (large and small). As a result different definitions can be found.

In Computer Science, conceptual models refer to the representation of the system entities (concepts) and the relationships among those entities (Ganga, 2009; Hendriks, Schiffelers, Hüfner, & Sonntag, 2011; Rad & Jabbari, 2012). According to Joy (2013) conceptual models can be defined as a "descriptive model or diagram that shows the key elements in the system of interest and the hypothesized relationships between them". It implicates that a conceptual model is the graphical application's representation, which enables developers to have a full understanding of unimagined systems (Ariffin & Norshuhada, 2009). The purpose of any conceptual model is articulating the significance of both concepts and terms used by the field experts in order to discuss the problem, and discovering the right relationships among the various concepts (Embley & Thalheim, 2012). Conceptual model shows general representation of the various aspects of the application.

2.2.2 The Benefits of Conceptual Model

Conceptual models are very useful for example in learning and training, where it is used to simplify the complex topics in visual representation by abstracting the concepts (Maxwell, 2013) and showing the existing relations between the different elements in a very simple understandable manner (Tessier & Clausen, n. d.). According to Dan Brown (2009), the conceptual model or framework has six benefits in the application development process.

2.2.2.1 Highlighting the Buried and Hidden Aspects

During the discussion of the system's various aspects, it is possible that the developers expose some aspects or concepts extensively because they believe that it is critically important. As a result, some aspects or concepts are obliterated and buried in the debate (Ravitch & Riggan, 2016). Therefore, the conceptualization process must occur impartially of the implementation process to detect the key relationships between the various entities. It is possible to discover minor concepts, which have a radical effect on the other vital concepts (Craig Tomlin, 2009).

2.2.2.2 Shifting the Conversation

Conceptual model helps both (developer and client) parties to shift their conversation to think about the big issues, priorities, and strategies rather than thinking about the view of point of one solution itself. Such conversation will makes them able to talk about the system's real benefits setting the strategies and prioritize (Locke, Spirduso, & Silverman, 2013; Maxwell, 2013).

2.2.2.3 Distant Connections or Relation Drawing

During the development process of the conceptual model, some relations between some aspects seem not applicable, because the aspects seem distant. However, but

when looking deeply, a hidden direct or indirect relation appears between some concepts which have a strong effect on another aspects (Brown, 2009).

2.2.2.4 Usage of Active Verbs

Ignoring the taxonomical relations is not easy in the development process of a conceptual model, because there is a need to explain and define the belonging relationships to categorize the similar aspects or factors to ask and think about "what those factors do? Not about "what it is belong to?" So there is a need to the taxonomical relation, it is very important to change the thinking way by using a real active verbs such as "reveal", "limit", "conceal", and "enable", to convey something further than belonging and illuminating the effectiveness of the concepts instead of it is classification.

2.2.2.5 Non-Essential Concepts Elimination

A lot of concepts can be found in the problem domain; definitely all those concepts are not essential and give sense toward the solution. This concept is crowding, certainly will cause difficulty in understanding the problem that is illustrated by the conceptual model, which contrasts with the purpose of conceptual models. Therefore, there is a need for a selection and election process of the essential and important concepts that gives a sense to make the conceptual model easy to understand.

2.2.2.6 Collections of Ideas in Context

A lot of ideas can come during the discussions of the optimized solution. Some aspects are easy to say such as flexibility, feedback, and sharing. but it's very difficult to imagine. However bringing in to the context some loosely connected ideas will help to demonstrating wither that aspect is applicable or not. So conceptual model can judged wither the connections between concepts is valid or not.

2.2.3 Components of Conceptual Model

As mentioned above, the conceptual model refers to the representation of the system entities (concepts) and the relationships among them (Hendriks et al., 2011; Rad & Jabbari, 2012). In the other hand, Joy (2013) defines conceptual models as a graphical description "that shows the key elements in the system of interest and the hypothesized relationships between them". Therefore, Ariffin (2009) affirmed that conceptual models of dissimilar applications with special requirements are definitely not same, because different applications employed diverse technologies in diverse contexts and perhaps used by dissimilar users. It is very important to distinguish between the conceptual model and the user interface description because conceptual model is only a structure outlines the general concepts of the application and their interrelations which used to design and develop the product. Based on Sharp et al.,(2011) and Johnson and Henderson (2002) the conceptual model consists of the following components:

- The key analogies and metaphors (such as bookmarking and browsing) that help people in understanding what an application for and how to use the application for an activity.
- The concepts that will encounter the people through the application, including the created and manipulated task-domain objects, their characteristics as well as the operations that my carried out on them.
- The interrelations and links between these concepts, for example whether an object is contains or part of another object as well as the relative importance of actions to others.
- The relationships between those concepts, such as whether one object contains another, the relative importance of actions to others, and whether an object is part of another.
- The mappings between the concepts and the user experience the product is designed to support or invoke.

2.3 Interaction Design and User Experience

Interaction design (ID) means creating interactive products able to support the people communication manners and their interaction ways in their working and daily lives (Thackara, 2001; Sharp et al., 2011). In the other hand, Saffer (2010) confirmed that ID is the art of facilitation interactions between peoples and services via products.

Interaction design is considered as the umbrella term covered aspects such as user interface design, user-centred design, interactive system design and experience design. Furthermore, it is focus and concerns on practices of designing the user experiences. Therefore, there is no particular method of designing, but an encouragement to use a set of frameworks, techniques, and methods depending on the time and context (Thackara, 2001; Saffer, 2010). However, Sharp et al (2011) confirmed that the ID is the fundamental of all fields, disciplines and approaches which are related to building computer-based systems for humans. In fact, ID is empower with the theories, practice, and researches related to user experiences for all types of products, systems, and technologies, while HCI focus and empower with the design, implementation, and evaluation of interactive applications for people based on their surrounding phenomena. Therefore, ID is much wider than HCI, and HCI is considered as one of the components and scopes of ID.

The process of ID involves four main activities, which include (1) establishing requirements, (2) designing alternatives, (3) prototyping, and (4) evaluating. Those four activities involve iterations among each other's. Therefore, in order to create a well interaction design product, the designers need to have a well understanding of the product users in the real context (Sharp et al., 2011). Understanding the product users comes through understanding how they live, learn, and work by observing them in the real life and context. Therefore, this study utilized the observation technique to identify

the research problems and the pilgrims' requirements, by observing them during Hajj and understanding how they live, training, and performing the Hajj rituals traditionally.

Understanding the product's users will enables developers to identify the appropriate interaction modals that must be integrated in the product as well as the way of fission or fusion those models. The next subsection discusses the term multimodality and how different interaction modals can be integrated in the product to support usability.

2.4 Multimodality and Multi-Modal

The prefix Multi means "much", "many" or "more than one" (RHKW, 2001; Amerircan Heritage Dictionary, 2011). In addition, the term Mode refers to the manner or the way in which something happens or done or is experienced (RHKW, 2001). According to Kress and Bezemer (2009), images (such as icons or figures, and animations), speech, text, and layout, can be considered as examples of modes and mode can be defined as a socially and culturally shaped resource for making meaning. Although the characteristics of the environment playing critical rules in the mode formatting, but the requirements and cultural values have the same contribution. Therefore, each mode has dissimilar modal resource because each mode has different limitations and meaning (Kress, 2010). Further, from the point of view of user interface design, the mode can be another setting of an application or physical machine where the same inputs lead to different results of other settings (Iding, Klemm, Auernheimer, & Crosby, 2002; Kammer et al., 2011).

On the other hand, the term *Multimodality* refers to the combination of visual, textual, and audio modes with material and media to give a sense and meaning (Giberson & Moriarty, 2010; Lutkewitte, 2013). Even though, media are concerned, multimodality means the usage of several different media (modes) to generate and

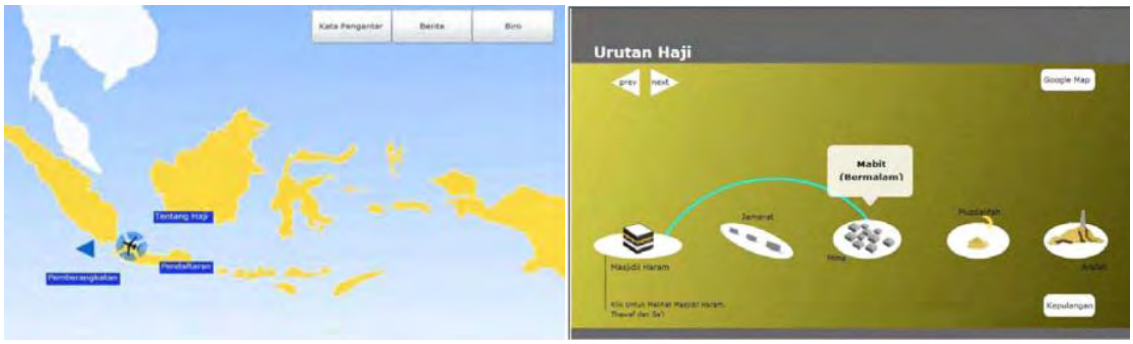
produce an artifact (Lutkewitte, 2013). The usage of such mixture of elements and modes shows the effectiveness of multimodality in simplifying the concepts and ideas presented and increase the audience's absorption (Lutkewitte, 2013). Therefore, the arrangement of the images and other elements of the application contents can create a sense and meaning. This comes as a result of shifting from the usage of the isolated abstract text as major source of communications, to the usage of images that has been widely exploited in the digital world (Lutkewitte, 2013). Nowadays multimodality has been widely used in various fields such as composing practices, communications (Bateman, 2008), literacy (Welch, 1999), education (Takayoshi & Huot, 2002), and training (Kress, 2010). The next section shows how some previous empirical studies that have been utilized multimodality to support usability.

2.4.1 Multimodal Related Studies

Many studies have been conducted in various fields such as healthcare, social interactions, people tracking, and education to utilized multimodality to support usability. This section explores some of the previous studies to show what and how the various interaction modalities been adapted and utilized to improve the interactive design of those applications and users. The following are descriptions about the models, followed with a meta-analysis of the model in Table 2.1.

- Researchers from the Electrical Engineering and Information Technology Department of Gadjah Mada University in Indonesia have developed web-based Hajj Simulation software. It is an interactive application that enhances the Hajj performance's usefulness by delivering a new media in the education of Hajj for pilgrims. Their study indicated that although benefits could be gained from their work but there would be an increased in the management system of Hajj organizing

process. The cost of organizing Hajj would be reduced and the surplus cost will be used to support other training activities (Fathnan et al., 2010). The application (Figure 2.1) has been published on the internet and it is accessible to all pilgrims.



Main Page Hajj Sequence

Figure 2.1. Snapshots of Web-Based Hajj Simulation Software
Source: (Fathnan et al., 2010)

- Other researchers at Universiti Utara Malaysia have developed V-Hajj, a courseware for learning to perform Hajj, Umrah and Ziarah. V-Hajj encompasses all the requirements, steps and procedures in performing Hajj and Umrah. As seen in Figure 2.2, it incorporates interactive multimedia and virtual environments, which enable users to learn Hajj and Umrah in a step-by-step procedure, as well as participate in 3D environments in enhancing user experience in performing the Tawaf, Sa'ie and Jamarat stoning (Mohd Fitri et al., 2011).

Tawaf in V-Hajj Sa'ie in V-Hajj

Figure 2.2. Snapshots of V-Hajj
Source: (Mohd Fitri et al., 2011)

- A research on developing a comprehensive module for Hajj has been conducted by Hameed (2010). He has proposed a comprehensive Hajj model which consists of three components; Hajj database module, Hajj educational module, Hajj emergency and guidance module. This comprehensive solution offers religious, educational, scientific, social, economical, political and other benefits for Muslims. Besides that, an architecture for a Web services-based Hajj information system has been proposed by Harmain et al. (2004). The implementation of this system provides background knowledge about Hajj and its environments to most of the pilgrims. It also helps on updating the latest information on Hajj and guiding people during the Hajj season.

- One of the previous studies has been conducted by group of researchers at the Universiti Utara Malaysia (Nur Afiqah, Abdul Nasir, & Nur Fadziana, 2011) to propose courseware of Road Safety Education for children in Malaysia. The study has been conducted based on a courseware utilizing mixed learning environments such as interactive multimedia, Virtual Environment (VE), and Augmented Reality (AR) technologies. Therefore, modalities such as text, graphics, audios, videos, and lights have been used to representing the proposed courseware contents. The study confirms that using multimodality in the proposed courseware of road safety can reinforce the understanding of traffic regulations and road safety.

- Two researchers Penhaker and Kijonka (2012) from the Department of Cybernetics and Biomedical Engineering of Technical University of Ostrava in Czech Republic have developed a healthcare multimodal mobile based application. This multimodal interaction application provides visible information of the user's health status. The application gathers all the required data about the personal health status form user's surrounding area via the embedded mobile sensors and the other health care devices. The application processes the gathered

data and produces interactive visual information about the user health as well as trend data about the surrounding area (such temperature, oxygen saturation, pressure, position, and weight). To represent the various types of information the application uses video, images, maps, icons, back light, fonts, back light, curves' speed rate, and colours. The study confirms that the proposed application is ready to use for personal health care and self-monitoring for elderly and young people.

- Another group of researchers (Normala et al., 2013) from Faculty of Informatics and Computing at University of Sultan Zainal Abidin in Malaysia developed Virtual Umrah application that aimed to be implemented as guidelines for developing another virtual environment products. This interactive application have been developed based on five components which are contents, user profile, modalities, virtual reality (VR), and usability evaluation. Therefore, this application is very close to the proposed prototype in this study. The use of VR technology in this software allows presenting a realistic experience for Muslims in performing Umrah. In this application, modalities such as texts, images, animations, audios, and videos have been utilized to representing the contents. These modalities facilitate the information capturing for users in an efficient way effectively, which leads to high usability earned the users' satisfaction.

- A group of researchers (Hasimah et al., 2013) at the Universiti Sains Malaysia have developed M-Umrah, a mobile application guide to performing Umrah. M-Umrah encompasses all the requirements, steps and procedures in performing the Umrah. It incorporates interactive multimedia and virtual environments (augmented and virtual reality) which enable users to learn step-by-step Umrah procedures as well as enhancing user experience in performing the rituals of Umrah. Later, the same group come out with M-Hajj DSS (Hasimah, Muhammad Rafie, & Muhammad Dzulhilmi, 2016) M-Hajj is an Q and A mobile application based on

Android platform for Hajj decision support system. It is developed to help pilgrims making decision when any problem happens during performing the Hajj ritual.

- One of the recent studies has been conducted by group of researchers (Aronowitz et al., 2014) from IBM in US and China. The study utilized the user's biometrics such as chirography (hand writing), fingerprint, voice, and face to reduce the hazard of fraud, by indicating and verifying the user identity and proofing the user authentication in the transaction. The study introduces a multimodal mobile application based on a policy manager combined with fusion of numerous biometrics. Multimodalities (biometrics) have been used in this study such as chirography, voice, and face with a fusion strategy that based on inter-modality score level fusion by taking into account the quality of voice.

- In KSA a group of researchers (Taileb et al., 2014) at King Abdulaziz University (KAU) come out with a location-based augmented reality mobile application called Manasek to facilitate the rituals of Hajj and Umrah as well as to overcome the difficulties faced by the pilgrims. Manasek employs augmented reality to display information about the surroundings of the holy places in a mobile camera view.

Table 2.1

Meta-analysis of the Related Studies in Multimodality and Interactive Multimedia

Name and Year	Purpose of The Study	Type	Modalities Used
Web Services-Based Hajj Information System (Harmain et al., 2004)	Building background knowledge about Hajj by giving the latest information on Hajj and guiding people during the Hajj season	web-based Application	• Interactive Multimedia (texts, images, audios, videos, and animations).
Web-based Hajj simulation (Fathnan et al., 2010)	Providing an interactive application to enhance the Hajj performance's usefulness by delivering a new media in the education of Hajj for pilgrims	web-based Application	• Interactive Multimedia (texts, images, audios, videos, and animations).

Table 2.1 Continued

V-Hajj (Mohd Fitri et al., 2011)	Enhancing the user experience in performing Hajj and Umrah.	Desktop Application	• Interactive Multimedia (texts, images, audios, videos, and animations). • Virtual Reality.
Road Safety Education for children (Nur Afiqah et al., 2011)	Providing road safety courseware utilizes mixed learning environments for children in Malaysia	Desktop Application	• Interactive multimedia (text, graphics, audios, videos, and lights) • Virtual Environment • Augmented Reality
Personal healthcare mobile application (Penhaker & Kijonka, 2012)	Utilizing the embedded mobile sensors and the other health care devices to monitoring the personal healthcare of user and describing the surrounding area.	Mobile Based Application	• Interactive Multimedia (texts, images, audios, videos, and animations). • Embedded sensors.
Virtual Umrah (Normala et al., 2013)	Integrating components such as contents, user profile, modalities, virtual reality, and usability evaluation to providing a realistic experience for Muslims in performing Umrah	Desktop Application	• Interactive Multimedia (texts, images, audios, videos, and animations). • Virtual Reality.
M-Umrah: An Android-Based Application to Help Pilgrims in Performing Umrah (Hasimah et al., 2013)	The study tries to provide a solution to the problems posed by pilgrims about the rules and procedures of Hajj rituals by utilizing the smart phone technologies.	Mobile Based Application	• Interactive multimedia. • Location base services. (GPS) • Augmented Reality
Biometrics for Mobile Authentication (Aronowitz et al., 2014)	The study utilized the user's biometrics in verifying the user identity to reduce the hazard of fraud in transactions	Mobile Based Application	• Chirography (hand writing). • Voice. • Facial expression.
Manasek AR: A Location-Based Augmented Reality Application for Hajj and Umrah (Taileb et al., 2014)	The study utilized the Augmented Reality in a location-based mobile application to facilitate the difficulties faced by pilgrims while performing Hajj and Umrah.	Mobile Based Application	• Interactive multimedia. • Location base services. (GPS) • Augmented Reality

2.4.1.1 Critiques on Existing Models of Umrah or Hajj

Notwithstanding the foregoing studies, some of these studies introduced in the form of courseware or simulation that focus on acquiring initial perspective and background knowledge about Umrah or Hajj before going to Makkah. On top of that, Mohd Shafry et al. (2011) attempted to develop an application for use during Hajj. Unfortunately it is

designed for desktop, which is quite impractical to use during Umrah or Hajj. In addition, in some of these studies the mobile devices is not the context, which means different platforms and constraints as well as the usability testing carried out in another discipline and different environment (crowded and noisy). However, some studies develop mobile applications that provide comprehensive information about how to perform Hajj, in which the navigation system is based on menus, buttons or mobile camera for the augmented reality applications. Based on the experts' consultation and peers discussions, such interaction mode (the manual mode) is not suitable for extremely crowded environment in Umrah or Hajj due the following reasons:

- The pilgrim has to look and read from the screen
- The pilgrim has to use his hand to interact with the application.
- It does not overcome the limitations of the conventional approaches.

On the other hand, interaction modes such as embedded sensors, chirography, voice commands, facial expression and GPS have been proposed by many studies. As a response to that, this study combines those interaction modes in a multi-modal mobile assistant. Definitely, this study concerns on the usability of this mobile assistant. Therefore, the study utilizes the theories and concepts of multimodality, usability and information architecture.

2.4.2 Multimodal interaction

Since 1980, with the emergence of the Graphical User Interface (GUI) in computers by Macintosh, a new specialty call Human Computer Interaction has been emerged (Card, Moran, & Newell, 1980). HCI focuses on the methods in which the human interacts with the computer, it is involves all of the researches, planning, design and

use of the interaction between users (human) and computers or machines (Dix, Finlay, Abowd, & Beale, 2003; Stephanidis & Antona, 2013). HCI is a mixture of several sciences and studies such as behavioral sciences, computer science, art, and other fields of study (Sinha, Shahi, & Shankar, 2010), that conjuncts of both humans and computers (Grudin, 2011).

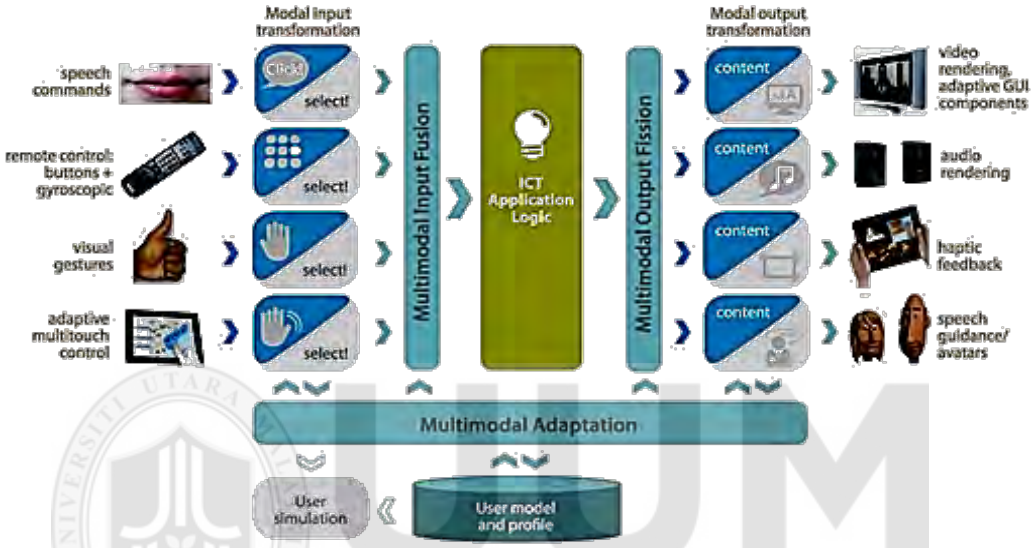


Figure 2.3. An Example of Multimodal Integration System
Source: (Biswas, 2012)

Multimodal interaction refers to more than one way to interact with the system and providing several distinct methods for inputting and outputting data (Hunyadi et al., 2011; Wechsung, 2014). Figure 2.3 shows some distinct methods used in a multimodal system to input data and output the information.

Multimodal interaction which is known as Multimodal HCI, can be defined also as the "interaction with the virtual and physical environment through natural modes of communication" (Bourguet, 2003). It means the involvement of the five human senses in the interaction modes (Ferri & Paolozzi, 2009) which means more freedom in interacting with automated systems in a natural way via the input and output channels (Stivers & Sidnell, 2005). Generally, users can interact with multimodal systems

through several modalities of input and output, which provides an efficient, flexible and usable interaction environment (Sowa, Kopp, & Latoschik, 2001; D'Ulizia, 2009), such as hand gesture, handwriting, body motions, speech (Vo & Wood, 1996). Additionally, gaze and sensors can also be utilized as user input modals to interact with system, whereas sounds, lights, smart graphics, speech synthesis (Andre et al., 1998), and vibration can be considered as output modals delivering information to users (Caschera, Ferri, & Grifoni, 2007b; Blumendorf, Roscher, & Albayrak, 2010).

The process of recognizing the inputs through the various input channels and combining them in order interpreting them is called *Multimodal Fusion* (Sun, Shi, Chen, & Chung, 2007; D'Ulizia, 2009; D'Ulizia, Ferri, & Grifoni, 2010). The flexibility and naturalness of the various input modals or channels may cause ambiguity because the combined inputs can have more than one interpretation (Caschera, Ferri, & Grifoni, 2013). Usually a lot of factors can cause the ambiguity in the inputs' interpretation such as inaccuracies, sudden movements, hustle, and noises. Therefore, many researches have been conducted to solve the interpretation ambiguities (Spilker, Klarner, & Görz, 2000; Chai, Hong, & Zhou, 2004; Caschera, Ferri, & Grifoni, 2007a; Caschera, 2009; Caschera et al., 2013). Whereas the process of dividing or selecting the output channels to distribute the information through the available outputs and according to the user profile and environmental context is called *Multimodal Fission* (Honold, Schüssel, & Weber, 2012; Biswas, Duarte, Langdon, Almeida, & Jung, 2013). Unfortunately, there are not many studies interested in multimodal fission as opposed to multimodal fusion (Costa & Duarte, 2011; Honold et al., 2012; Biswas et al., 2013). Figure 2.4 illustrates the processing chains of the input fusion and output fission in the HCI loop in the multimodal systems.

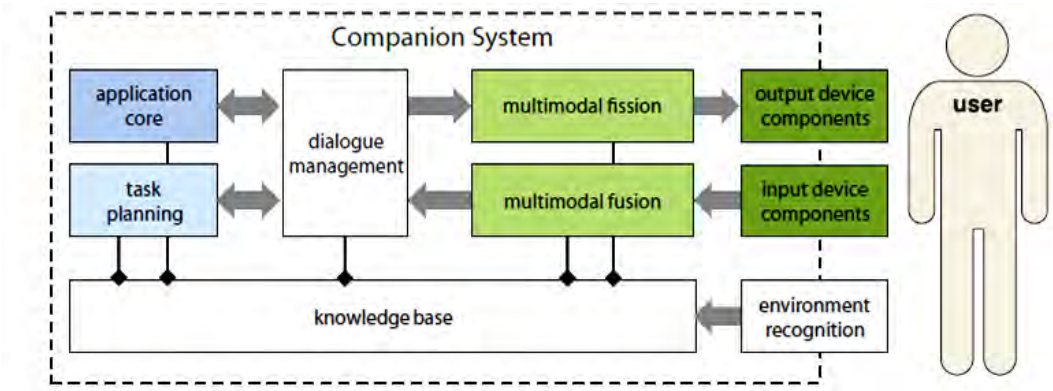
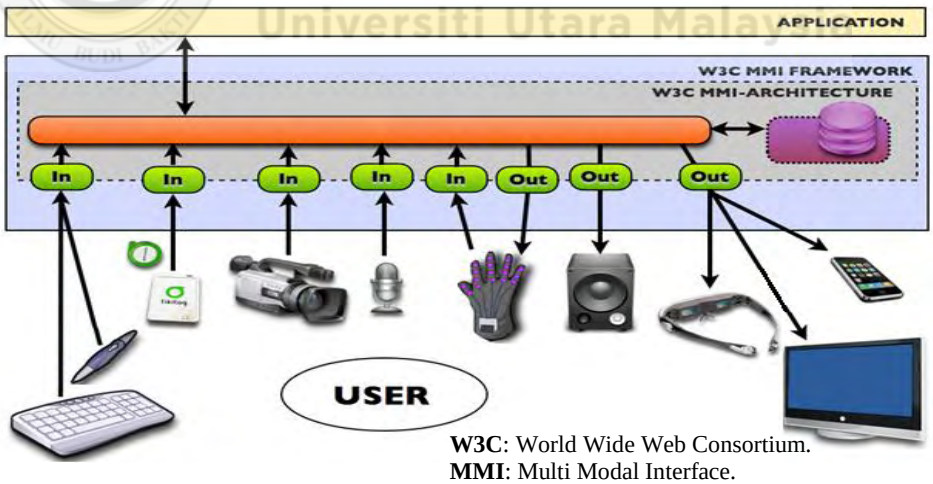


Figure 2.4. The Input Fusion and Output Fission Processes in Multimodal Application
Source: (Honold et al., 2012)

In multimodal interaction systems, the multimodal interfaces can be divided into two merged major groups (as shown in figure 2.5), one considered as input channel, which is only used to pass data and commands to the machine. The second one is combined as input, same as the first group and output channel, which is used to deliver the information and results to users in the same time (Vassiliou et al., 2000; Rodriguez, Wiechno, Dahl, Ashimura, & Tumuluri, 2012).



W3C: World Wide Web Consortium.
MMI: Multi Modal Interface.

Figure 2.5. Example of the Input and Output in Multi-modal System
Source: (Rodriguez et al., 2012)

2.4.3 Multi-modal Input

The most important purpose of computer innovation is facilitating the human life and makes their tasks and work routines easier (Kaleen & Allwood, 1991). Naturally humans

interact with each other through the five senses and body motions; they speak, hear, touch, gesture, point, and move. Therefore, developers in computer science field should facilitate the interaction between human and machine by providing multimodal input interface (Lucente, Zwart, & George, 1998). Traditionally, mouse and keyboard are considered as input devices in computers whereas monitors are considered as output devices (Kettebekov & Sharma, 2001). Currently, new input modals such as speech, touch, gestures, pen, gaze, and body and head motions should be innovated (Kettebekov & Sharma, 2001). Therefore, developers need a combination of visuals (for example mouse, keyboard, and monitor) and audio (such as speech synthesis and recognition) modalities (Vassiliou et al., 2000), because the implication of more than one input modal in the system gives the users more than a choice to do the same thing and provides alternatives in case of any failure in any modal, which leads to increase the accessibility (Vitense, Jacko, & Emery, 2002). As a result the multi-input modals make the human interactions with computers easier and increase the usability of the multimodal interaction systems (Vassiliou et al., 2000; Kettebekov & Sharma, 2001; Vitense et al., 2002).

2.4.4 Multi-modal Input\Output

Addition to the usage of the auditory and visual cues as a primary output modalities, the designers started using the contemporary output modalities such as olfaction and touch in order to increase the redundancy and synergy of the output modalities in the multimodal system, trying to include all the five senses in the interaction process between users and machine to increase the usability (Oviatt, 2012). To represent the complex information, several modalities needed to be merged, which leads to an increase in the bandwidth of information transmission in the same process (Bauckhage, 2002; Ismail & O'Brien, 2008). Currently, the purpose of multimodal output is to improve the attention management of the data-rich environment, where

the operators face large demands for visual attention. In addition, it is used for ameliorating the natural mapping between content (tasks and information) and modalities (Sarter, 2006; Burns, Ho, & Arrabito, 2011).

According to Starter (2006), there is a big difference between the auditory channel and vision. The auditory channel is unidirectional and always reserves especially in mobile phones. Speech output as an example of the auditory information attracts much attention and can be used as output modal. It should be used for representing short messages, which need instant responses and will not be referred to later (Michaelis & Wiggins, 1982). Another example is that speech output can be found in vehicles to present the navigational instructions as well as in airplane cockpits to warn pilots.

On the other hand, the sense of touch has been utilized as a communication medium since 1950s (Geldard, 1957). It is considered as an inimitable and helpful communication modal, better than the traditional senses (vision and hearing that are utilized wildly in HCI). The sense of touch is the best in terms of feeling, perceiving, and perception of objects; it also effectively and flexibly supports the control and disposition of the things in interactive environment (DePue & Hein, 2006). Besides, sensor technologies such as cameras, ultrasound, and infrared are widely also used nowadays. Sensing technology gives users the advantage of knowing the surrounding environment and its changes, such as changes in temperature, pressure, location, and as well as the distance between the users and the objects around him. This gives him the opportunity in taking the right action at the right time. Meanwhile, vibrations, pulses, and changes in the surfaces' temperature are examples of tactile signals, which are used such as in mobile phones (Sarter, 2006).

2.4.5 The Ambiguity in Multimodal Interpretation

Interaction occurs between users and multimodal systems through the user's actions and commands to generate the multimodal inputs or multimodal message (Caschera et al., 2007b), which must be understood and interpreted by the system. By taking the consideration of cooperation types between the various modalities (Martin, 1997), the relation period between the cooperative modalities (Allen & Ferguson, 1997), and the connection between the information chunks and it is related modalities (Bellik, 2001). The multimodal messages can be generated by merging the information received from various modalities. These messages are considered the medium, which makes the communication possible between users and multimodal systems.

The presence of more than one interaction modalities such as sense of touch plus visual and auditory modalities provides the multimodal input. Therefore, there is a need for a natural mapping between these inputs and information and tasks. This natural mapping is a subject of the typical problems such as misunderstanding and misinterpretation, which lead to the ambiguity just like the human-human communications. The ambiguity appears when there is more than one possible interpretation of the input. According to Caschera, et al. (2013), the multimodal ambiguity can rise in the multimodal level when one modality provides an element with multi-interpretation, and/or in the semantic or syntactic level when the input elements having a univocally interpretation, but the information referred to different modalities are semantically or/and syntactically incoherent (i.e. a single multimodal message has dissimilar meaning or more than one syntactic structure).

To get the accurate interpretation of user's input and clarify the ambiguities (Caschera, Ferri, & Grifoni, 2008), the user's input are classified in to three classes: prevention, a-posterior resolution and approximation resolution methods (Chai et al., 2004; Caschera et al., 2013). Prevention approaches (such as the procedural method (Lee & Chin, 1995)

and improving (Ferri & Rafanelli, 2005) and reducing (Calcinelli & Mainguenaud, 1994) the language grammar expressive power) depends on the imposition of a predefined interaction behaviors obligates users to follow them according to the transitions between different allowed situations. The a-posterior resolution method designed to solve ambiguities by using the mediation approaches and techniques (Dey & Mankoff, 2005) such as choice (Mankoff, Hudson, & Abowd, 2000), granularity of repair (Suhm, Myers, & Waibel, 1999) and undo (Spilker et al., 2000), and repetition by modality (Dey & Mankoff, 2005). While the approximation resolution approaches depend on the usage of some theories such as Bayesian Networks, Fuzzy Logic, Hidden Markov Models, and Markov Random Field in clarifying the ambiguities without any intervention from the user side (Chai et al., 2004; Caschera et al., 2013).

2.5 Usability

The applications that we use every day has become complex in terms of functions and tasks that they contains. This complexity in functions and tasks maybe a result of the vast amount of functions that must be accomplished to achieve a particular goal, or the number of steps that must be performed sequentially to accomplish as specific task. To gain the benefits of the features provided by these applications, developers should take into account the requirements and limitations of the use of these applications (Jordan, 1998). Today, users become more aspiring to easy to use interactive applications, they are unable to endure the difficulty of using applications (Paul, Kumar, Chatterjee, & Rajesh, 2014). In addition, the 'technical wizardry' only is no longer attracting users any more. Thus, HCI and Usability Engineering become significant roles in the applications developments process (Holzinger, 2014). In recent years, it is clear that the issues related to usability received considerable attention demonstrated by the wideness of related literature (such as books, journals, newspaper articles, and magazines) plus the large number of the

international conferences and seminars also devoted to discuss the usability related issues. For example the Institute of Ergonomics and Human Factors (IEHF) (the Ergonomics Society Conference) in the UK and the Human Factors and Ergonomics Society Conference in the USA. This serious interest on usability issues forced the developers to have an awareness of these issues by putting users in the design process center and involving the specialists in human factors and interaction design (Jordan, 1998).

Commercially, when there is a set of similar or equivalent applications in terms of usefulness and the functional and technical specifications are available, users definitely would prefer to buy the applications that are easy to use and user-friendly, even if the price was slightly higher compared to those difficult to use (Johnson, 2011). Nowadays, usability is considered one of the most important areas of competition between developers to obtain user satisfaction. Therefore this study focus on usability of a multimodal mobile assistance during Hajj and Umrah by identifying the most appropriate usability attributes of that application and designing a conceptual model. According to Nielsen (2012b), usability is as important as utility, and both of them determines whether this product is useful or not see Figure 2.6. It is not beneficial to have something easy to use but without value and you do not need it. In the other hand it is not beneficial also to have hypothetically a system really can do what do you want exactly, but its user interface is complex and too difficult to use (Mangal, 2013).

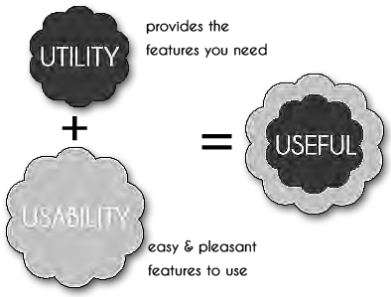


Figure 2.6 The Important of Usability and Utility
Source: (Mangal, 2013)

2.6 The Importance of Usability

Some developers believe that usability is gratuitous expense. While the integration of usability in the application development process early have a positive impact in reducing expenses and it is beneficial to both users and developers (Klein, 2006). According to Bias and Mayhew (2005) and Anand (2015), the cost of redesigning or correcting a product in the development phase reducing the cost 10 times compared to their cost in the production stage, while the costs are 100 times less compared to hold adjustments after the product's publication, Figure 2.7 illustrating the percentage increase in cost based on development phase. The integration of usability testing in the development process enables the developers to get the users feedback to enhance the product before delivering to the final users (Bias & Mayhew, 2005).

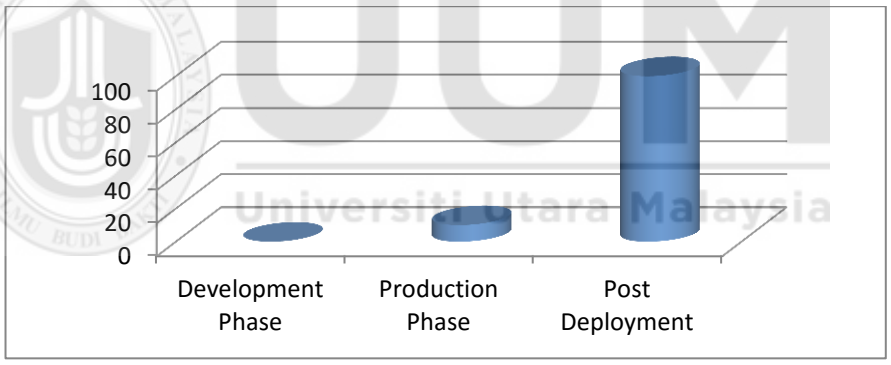


Figure 2.7. The Percentage Increase in Cost Based on Development Phase
Source (Klein, 2006)

On the other hand, the usability test sponsors to reveal the contradictions, pitfalls and gaps in the product interaction with users and some of it is functions failures or unexpected errors. Therefore, the implementation of the amendments based on the usability text findings will enhance the product and will be beneficial to both developers and users (Klein, 2006; Dwivedi & Dubey, 2014; Werder, Haake, & Maedche, 2014). Table 2.2 shows some of the benefits of the usability test to the product users and developers.

Table 2.2

The Usability Test Benefits for Users and Developers Adapted from Klein (2006)

Benefits to the User	Benefits to the Developers
Increased ease of use	Simpler products / Fewer product iterations and revisions
Improved productivity (reduced time to complete a task and reduced errors)	Fewer customer service calls / Decreased support costs
Higher customer satisfaction	Increased traffic / More sales / Increased appeal
Higher customer retention	Reduced risk of abandoning the product
Increased trust in the product and company	More customer loyalty

Since the main purpose of any product is convenience, facilitating the human's life and enjoyment, those products must be satisfactory and easy to use. So usability lack will causes several troubles which will might infuriate and discourage users, also it may be product life-threatening (Jordan, 1998). Nowadays, the public awareness of usability issues increases, and usability has become a factor in the procurement decisions (Jordan, Thomas, McClelland, & Weerdmeester, 1996). The design issues are considered one of the competition areas between developers, where the design's beauty, smooth and consistency are playing a significant role in users' satisfaction (Bias & Mayhew, 2005; Rubin & Chisnell, 2008).

2.7 Usability Factors

From the definition of usability, four factors can be extracted. Those factors which are users, tasks, environments, and technologies can strongly influence the usability of mobile applications (Rosnita et al., 2013).

2.7.1 User (The Human Factor)

Any product is designed for a group of people in order to help them to accomplish their tasks. As a result, the usability of this product depends entirely on how easy to

use this product for this group of users. Therefore, the first factor affecting the usability is the user, where there are several of user characteristics and profiles (novice users, knowledgeable intermittent users, and expert users) by which the designer can know how difficult or easy the interface to use for these users (Bertoa et al., 2006). The user characteristics which can affect the product usability are:

2.7.1.1 Experience

The user previous experience can be divided into two types, the user experience with the product itself and the user experience with similar product. In both cases, the user previous experience plays a critical role in the product usability evaluation (Albert & Tullis, 2013). The expert users can use easier, better, and faster than the novice users and knowledgeable intermittent users. This means that the user's performance will be improved with the repeated use over the time (Bevan, 2009). Moreover, the user will find himself is proficient in accomplishing the repetitive tasks easily over the time, While he find himself is lower proficient in accomplishing the advanced and non-repetitive tasks (non-recurring) in the same product (Jordan, 1998). Overall, the experience in accomplishing a certain task enables the user to accomplish the similar tasks in the same product. The same rule can be applied to the similar products, as the experience in the use of a certain product would enable the use of the similar products effectively and easily (Sonderegger & Sauer, 2010). For example if the user is expert and familiar with sending Emails using the email service provided by Google, this user also can send Emails using the Emails services provided by the other providers (such as Yahoo and Hotmail) easily and effectively. The principle of the experience can be used to increase the usability by generalizing the similar tasks within the same product to be executed similarly. For example, tasks such as Open, Save, and Save As in MS Word are similar so they are similar in execution, so when the user learn how to

perform one of them he will not need to learn the others. This way of generalization is known as consistency which enables to generalizing from one state to another successfully (Becker & Mottay, 2001; Lidwell, Holden, & Butler, 2010). Again the consistency can be used to enhance the usability in the similar products by making the execution of the similar task unified. For example, change the font style is all most same in the all word processing products (Lidwell et al., 2010).

2.7.1.2 Domain Knowledge

The computer systems is designed the assist people to accomplish their real life tasks and facilitate their work. Thus, people who are performing tasks without the computer assistance will be able to accomplish those tasks better and faster (easily and effectively) if they use a computer system (Zhang, Johnson, Patel, Paige, & Kubose, 2003). The domain knowledge means the previous knowledge relating in how the user perform the task in the real world without the computer assist (Følstad & Hornbæk, 2010). Therefore, by taking advantage of the domain knowledge, the designers will be able to design applications with high usability. Those applications will have high usability for those users who have this knowledge, whilst maybe not for those who does not have (Xie & Joo, 2012).

2.7.1.3 Cultural Background

Cultural background refers to the customs and traditions (population stereotypes) which govern a group of people. Those population stereotypes usually are similar in same region, but it can directly influence the products usability (Sonderegger & Sauer, 2013). For example, the lettering color of the emergency exit signs (Exit button in application) is red color in USA, while it is green Europe and United Kingdom. Factors such as people's values, beliefs, behaviors, and the other population stereotypes are controlling

the people's instinctive behaviors' and their thinking way (Hertzum et al., 2011). Therefore, in emergencies many people resorting to these instinctive behaviors to deal with the situation. On the other hand, the peoples' physical characteristics (such as body size and finger size) are different from race to another (Nielsen, 1993). Besides, Muslims in East Asian countries such as Malaysia speaking local languages, but they learned Arabic language because of their religion in order to read Quran correctly.. The majority of Malaysians can read the Arabic text which was written in the same style of holy Quran (font format and morphology). Su'aidi (1997) found that without morphology, Malaysian students cannot read or recite the Arabic text correctly.

2.7.1.4 Disability

It is clearly that the product which is usable for able-bodied users will not be necessarily usable for disabled users (Alcantud, Coret, Jimenez, Marquez, & Moreno, 2014). On the other hand any product designed for users with special needs will be usable for the able-bodied users also (Jordan, 1998). Therefore, paying attention to disabled users' needs and taking into account their special requirements will increase the product usability, which will give the opportunity to increase the product's scope include the largest number of users, rather than restricting on able-bodied users only (Lim, Kim, Kim, & Lee, 2012). Nowadays, modern technologies allow users to interacting with products without using their hands and increasingly they become available in many applications in the same context (Konno, Kato, & Kosaka, 2013; Mehla & Aggarwal, 2014).

2.7.1.5 Age and Gender

Human characteristics change with advancement in age over the time. The characteristics of old people may be completely different from the characteristics of young people. For example, with the advancement of the human age the senses of

hearing and vision begin weakens. Therefore, different ages will lead to different eye tracking which will affect the user performance and reduce the product usability (Romano Bergstrom, Olmsted-Hawala, & Jans, 2013). For example, the normal font size maybe not readable for the old people which will affect the application usability, so as a solution of this issue the font size should be changeable subject to increase and decrease as required by the user (Arnhold, Quade, & Kirch, 2014). In addition, different human generations have coexisted with different generations of technology (Vuong et al., 2012). Besides, the people attitudes are subject to change according to the human age or gender (Belanche, Casaló, & Guinalíu, 2012).

Similarly, certainly the different genders have different tendencies and attitudes (Lee, Shin, & Sundar, 2011). This difference may come from the way of rearing boys which is quite different from the way of rearing girls (Kim & Christiaans, 2011). For example, in education field boys are encouraged to focus and concentrate on the scientific subjects, like computer science, physics, and mathematics, while girls are brought up to pay attention on the arts subjects, like languages and literature (Jordan, 1998). Usually, female users concerned with the appearance issues and the product's aesthetics. Thus, the satisfaction of the female users which is one of the most usability components will be dependent on the product's appearance (Lan, Sung, & Chang, 2013). While male users prefer products with soft language and high-tech, so the product's usability is subject to the tech level and language flexibility (Alaşehir, Sezgin, & Özkan, 2013) .

2.7.2 Task

The second factor in the definition of usability is task, which refers to steps to do in achieving objectives. In different cases, objectives require a set of steps. Some developers prefer to give the users the possibility to perform the task using more than a

single way; they embrace all the possible ways to perform the task in order to be helpful to the users. But unfortunately, this causes chaos and overcrowding (Jordan, 1998). Three levels of task can be defined as frequent tasks, less frequent tasks and infrequent tasks, and the complexity of a task is indicated by the number of steps to complete that task successfully (Bertoa et al., 2006). Frequent tasks can be performed in a single action by pressing a button or key and so on, but less frequent tasks involve two actions only, whereas infrequent task requires more than two or three actions (Shneiderman et al., 2010). As an example of a three-step task, this paragraph brings a sending an SMS scenario. The users need to press one key to call one phone number from favorite numbers list. When he wants to send an SMS, he needs to write the message by keying-in several keys then he needs to key-in the receiver's phone number or selects it from the contact numbers, finally he needs to press the send button.

2.7.3 Environment

The third usability factor is environment, which refers to the periphery or the conditions which the product uses in performing the user's task (Sauro & Kindlund, 2005). Also, it refers to the data and the device capabilities and connection's consistency (Biel et al., 2010). It can be factors such as user's social conditions, noise, temperature, bandwidth, and network connectivity between the connected devices (Rosnita et al., 2013).

2.7.4 Technology

Finally the last usability factor is technology, which refers to the device's specifications and features, and software and hardware. For example the input and output mode of data have direct effects over usability. According to Rosnita et al. (2013), more than 27 attributes were found in previous studies of mobile usability. Some of those attributes can be referred to, combined, or considered as other attributes.

2.8 Usability Characteristics (Attributes)

Usually usability is closely related to the product's functionalities. Some researchers are trying to simplify the usability definition by making it confined to the easy to use only, but this simplification does not provide a full guidance to the user's interfaces designers (Quesenbery, 2006).While another group of researchers believe that usability can be defined as understanding of user requirements, formulating the usability goals, and selection of appropriate technologies that can be used in the usability assessments (Quesenbery, 2001). In this case, understanding the five characteristics of usability (5 Es) - efficient, effective, engaging, easy to learn, and error tolerant - will be a helpful guide in the design task in order to produce a usable product. These 5 Es which provided the best description of the user's requirements can be used as checklist to assess the user interface design for satisfaction and success (Lu, Kang, Hsieh, & Shiu, 2009). The balance between the 5 Es (the need of each one) according to the users' requirements helps in conceiving and directing the design choices. Figure 2.8 illustrate how the 5 Es affect the product usability.

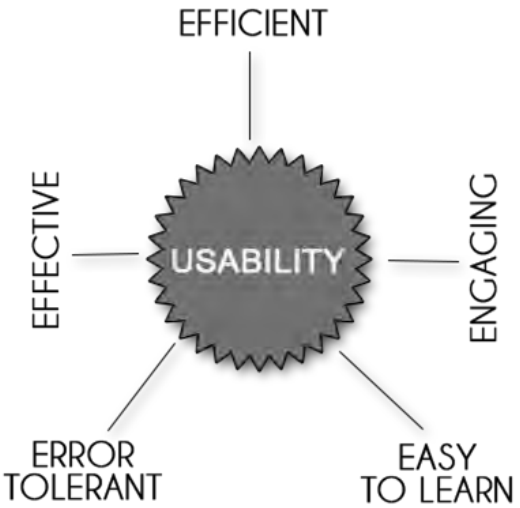


Figure 2.8. The Multifaceted Characteristics of Usability or the 5 Es
Source: (Mangal, 2013)

2.8.1 Efficient:

Efficiency means the ability of users to accomplish the main tasks that the product developed for rapidly with accuracy. In other words, it means the speed of users (the time required) to fulfill the tasks with high accuracy. Efficiency concerned about the total resources consumed in a task (ISO 9241, 1998). The metrics of efficiency includes effort factor (the numbers of keystrokes and clicks required) and time factor (Duration of completing the task) (Mangal, 2013). Defining a task must be out of the user's point of view, rather than looking at it as a single task. In this case, the large and complex tasks can be divided into several simple short tasks. For example in admission process, instead of looking to the task of complete and submit the application form as a single task, it can be broken down into multi simple short tasks such as personal information, academic qualification, language qualification, working experience, payment, and submission. Another example in Umrah the ritual of Tawaf includes seven rounds around the Ka'aba, each round can be considered as a single task Instead of looking at the whole ritual Tawaf as one task. Moreover each round of Tawaf can be divided into subtasks such as receipting the black stone, walking from the black stone to Iraqi corner, and so on.

The design of the navigational elements such as menus, buttons, and links has direct effect on efficiency. Properties such as name, location, size and color of the navigational elements would make the design more intuitive if they are well designed and clearly reflect the actions. So the users need a little time and effort to choose the appropriate actions and making a smooth navigation (Bergman, 2000). To get the most efficient design of the application, the right choices in building the design must be taken based on understanding the users (such as needs, profiles, and capabilities) and their favorite ways (modalities) of interacting with the application (Quesenbery, 2001). For example, the interface designers must know whether the users of the application are primary (infrequent users) or habitual

users (proficient) who can learn the system shortcuts and hidden controls. In addition designers need to know what are the input devices (modalities) used by users. For instance, the keyboard shortcuts will be an extremely efficient interface for proficient users who work intensively with the application, but it will not efficient for primary users who are unfamiliar with the application and keyboard as input device. Therefore, multimodality interface design with a set of modals and hierarchical choices is the best solution for infrequent or one-time users (Bergman, 2000).

2.8.2 Effective

Effectiveness means the completeness with accuracy which allows users to achieve specified needs. It is also refers to the extent of success of task. So, effectiveness in some cases simply means success or failure of tasks. It can be measured by looking into the extent of success of product in achieving the user's goals and how it functions work correctly. For example, in a condition the user task is to play a sound file. It is successful if the sound file is started and the sound is audible (Bertoa et al., 2006). In contrast, it is a failure if it is not. Nevertheless in some cases, effectiveness of tasks could be measured by the percentage of the achievement of a particular goal, for example in network if the sender's goal were to send 100 KB per second; as a result the effectiveness level is 90% if sender was able to sent 90 KB per second (Nielsen, 1993).

It is very difficult to separate and differentiate between efficiency and effectiveness, they seem the same but they are not. Effectiveness is primarily concerned with the quality of the performance (the degree of completeness and accuracy of the work). In other words, it refers to the complexity of performing tasks. Meanwhile, efficiency looks at the cost and the efforts required to perform required tasks or to achieve the goal. It is concern about the time spend to perform the task or the number of steps or errors to complete the

task. Generally, the greater number of errors or the more time taken reduces the efficiency (Jordan, 1998; Nayebi et al., 2012). Effectiveness can be strongly impacted based on the quality of assistance provided to the user that built into the product interface. For user-friendly, interface enables the user to navigate without any problems, the interface must be more informative and the presentation of the navigation elements and choices should be understandable evidently to the user. In addition, it is better to use the user's national language or any appropriate language to the task in the interface terminology (Quesenbery, 2001). Moreover multimodality is considered as one of the strategies for increasing effectiveness as well as efficiency, especially in an ambiguous situation. Providing more than one way of interaction lead the same outcomes correctly will be the best solution for infrequent or one-time users (Bergman, 2000).

2.8.3 Engaging

An interface is engaging (attractive) if the design is neat in appearance, pleasant in interaction, and satisfaction in usage (Batra, Brunel, & Chandran, 2009). The graphical interfaces and the visual effects are the most prominent element this characteristic. Where the design elements such as the visual display styles, functions, types of the graphical images, colors and sounds are represent the most important factors in determining the user's instant reaction (Quesenbery, 2001). However the engaging interface can be affected by some subtle aspects such as readability and the way of chunking and presenting information. Wither the interface is game-like simulation or a simple menu-command the interface style is equally important (Banga & Weinhold, 2014).

Just like all the characteristics of usability, engaging interface must be commensurate with the context, users, and tasks. When there are multiple levels of users' profile it is normal that there will be a diversity and variation in the users' requirements. In this case, the interface design must meet and focus on the requirements and expectations

of the main users who must use the product permanently (Quesenbery, 2004).

2.8.4 Error Tolerant

The ultimate goal of any system development process is to develop a system without errors or failure. Nevertheless, the computer systems are often far from perfect; because the developers of these programs are human beings who are unable to be perfect as well. So having some errors or failure is a normal matter (Quesenbery, 2003). For these reasons, the application's user interface design must be an errors tolerant design to prevent failures caused by users' interaction with the application and helping them to recover from those errors if they occur (Rusu, Roncagliolo, Rusu, & Collazos, 2011).

In order to get a user interface design highly usable the, error messages should not demonstrate the problem or error only, but gives a full description of how to overcome these problems and gives a solution to correct this error. Errors may occur as a result of the design did not cover all the possible ways of user interaction with the system (Saparova et al., 2013). For instance, if the user simply forgets to fill in an important data the design should inform the user about the necessity of filing this data by using non-arbitrary way such as wizard without any disciplinary language (Falge et al., 2001). However, the interface design can be intrusive and predictive by filling certain data (which are saved from previous users' inputs) automatically (Qin, Ma, Herawan, & Zain, 2011). There may be some uncontrolled errors -such as system failures or disasters – in the users interface design, in this case these errors can be resolved by guiding the user gently on how to help the system to recover from these problems quietly (Zhu, Nakata, Sivakumar, & Grewal, 2013).

According to Quesenbery (2003), there are several techniques that can be used to avoid mistakes during user interaction with the system, including the following :

- ***Reduce the possibility of incorrect actions:*** Through the use of clear and distinct buttons, links with a clear usage indication, and use a clear and easy language far from the technical jargon. In addition, by making the dependent and related choices and fields close together.
- ***Reduce the possibility of irreversible actions:*** By enabling users to undo, return back, reverse actions, and evade dead-end screens.
- ***Reduce the possibility of invalid actions:*** by reducing the number of choices to maintain only the correct choices when this is possible, show the appropriate navigation options only, and give examples of the input data clearly.
- ***Planning for the unexpected:*** By allowing users to add new inputs, and allow them to take an exceptional paths and unexpected choices.

2.8.5 Easy to Learn (Learnability)

Easy to learn means the users' ability to perform tasks and functions easily in the first time of using the product. It is also refers to how easy the interface enables users to construct their acquaintance without any significant effort through the usage of the product. It is useful that the system includes a general built-in assistance describes the necessary instructions to accomplish the advanced and difficult tasks in the system, but including an instant help elements and just in time training hints connected to the domain knowledge bases will be critically leads to an effective use (Quesenbery, 2006).

Learnability is not only allows users to build on their previous knowledge of mobile applications, but it is also allows the other interactions styles that have been learned through the frequent use in a predictable style. Predictability is considered the complementary to obtain the consistency of the interfaces design (Paul et al., 2014). To ensure the interface design consistency terminologies should not be changed, and comparable functions working similarly. In addition the design controls and elements

should be located in a familiar position and indicate the same functions. In other words predictability can be referred as the placement process of controls, navigations elements, and information in the right place according to the user expectation (Sajedi, Afzali, & Mahdavi, 2008). Finally, to obtain a predictable and easy to learn interface design the designers need to observe and analyses users carefully to find out where the user is expected to place the elements of new functions (Lew, Olsina, & Zhang, 2010).

2.9 Usable Design's Principles

Users are interacting with any product through it is interface, therefore the usability of the product depending on the usability of it is interface. The interface design should be usable in order to be intuitive design, satisfied and competent. The interface design must be controllable, comprehensible, and assisting users to complete their tasks efficiently and successfully. Based on the interaction between human and computer many researches has been conducting to find the designing principles used to achieve the effective user interface (Nielsen, 1994; Gerhardt-Powals, 1996; Constantine & Lockwood, 2002; Cooper & Reimann, 2003; Shneiderman & Plaisant, 2005; Saleem et al., 2007; Blair-Early & Zender, 2008; Lidwell et al., 2010; Thimbleby, 2010; Niu, Yang, & Deng, 2013; Eskridge, Still, & Hoffman, 2014; Tognazzini, 2014). From this long history and the large collection of published studies in the fields of cognitive psychology, HCI, and the best practices in designing the principles listed below has been extracted:

2.9.1 Usefulness (Value and Relevance)

When an application contains a wide variety of features it is important to give some priority to certain features or tasks when designing the application user interface depending on their importance which is called features' prioritization process. Those

features must be given a special attention in the design base on its value and relevance (Nielsen, 1994). The relevancy and value of the design can be achieved as following:

- **Value**: The real users' needs and the necessary utilities must be provided.
- **Relevance**: provide relevant information and functions to the context and user's tasks.

2.9.2 Consistency and Compatibility

Consistency means standardized similar tasks and functions to be performed in similar way. The implementation sequence of the tasks must be consistent with the implementation of the similar tasks in the application itself, other application in the same package and the application platform and environment (Lidwell et al., 2010). In Microsoft Word for example, similar tasks like copy and cute a text are performed similarly, since both tasks need highlighting the required text and selecting the appropriate command from Edit menu. On the other hand, performing a task in an application must be compatible with performing way of this task in other applications in the same package or platform, for example text copy in Microsoft Word must be performed the same way as text copy in Microsoft Excel (Microsoft Office package) and Notepad (Windows OS) (Constantine & Lockwood, 2002). The consistency of the design can be achieved through the following aspects:

- **Consistency and Compatibility:** Follow the platform's conventions and the standards of the application suite or package and make sure of using the same terminology, action and commands within the application itself (or the applications suite and platform).
- **Real-world Conventions:** The information should be presented in a logical order and natural manner and following the real-world conventions (if applicable) and

using common and understood terms, concepts, and metaphors.

2.9.3 Simplicity and Explicitness

Simplicity means making the design simple. Simplicity in the design makes the interface easy to learn, easy to remember, self-heuristics and self-evident. Therefore, the information (both labeling and feedback) should be presented in such a way that enables users to read quickly, easily and clearly without any confusion. This includes where the information should be presented, how the information should be presented (test's size, color, and font type), when the information should be presented, and what is the amount of information that should be presented in particular site without confusion and cluttered (Jordan, 1998; Niu et al., 2013). The design simplicity can be achieved through the following aspect:

- **Simplicity:** Eliminating the irrelevant or unnecessary elements as well as reducing clutter in information and elements.
- **Visibility:** Highlight the most important information and keeping the most frequently used options visible and the other options are easily reached.
- **Self-evident (Explicitness):** The interface should be able to use without any training or instructions. The design should be clear and obvious to the targeted user. The operation methods of the application must be comprehensible based on the subject-matter knowledge and the users' prior experience in the real world.

2.9.4 Communication and Feedback

The system should provide a suitable, meaningful and clear feedback to inform the user about what is going on and see the results. To allow the user to communicate faster with the system place the interrelated tasks and information together, for

example in Microsoft Word all the tasks related to formatting the text grouped under format menu. Furthermore, in the tasks which contain sequential sub-tasks, those sub-tasks must be organized sequentially so the user will know where he is exactly. It is important that the system provide users with on time help when it is needed. This help must be focused, short and concise (Jordan, 1998; Thimbleby, 2010). To enhance the communication between the product and users the following aspects must be considered:

- **Feedback:** Make sure to inform the user about what is going on by providing a suitable, meaningful and clear feedback.
- **Structure:** Place the interrelated things (information and tasks) together and separate the unrelated things.
- **Sequencing:** Organize the sub-tasks sequentially so the user will know where he is exactly.
- **Help and documentation:** Providing on time, focused, short and concise help.

2.9.5 Error Prevention and Handling

The system's users are humans, so from time to time it is certainly that they going to commit some mistakes (intentionally or unintentionally) when they are using the system which will cause errors or system failure. Therefore the system must be designed in such a way that can minimize the possibility of occurring (or at least handling) these errors of failures (Gerhardt-Powals, 1996; Leon, Aponte, Vega, & Romero, 2013). Many aspects can be used to handle these errors such as forgiveness, recovery and undo as following.

- **Forgiveness:** Preventing users from falling into error as much as possible and

allowed them to confirm their inputs that are probably will cause a destructive action. For example, instead of using text boxes to input some information we can use lists or combo boxes.

- **Error recovery:** Providing instantaneous hints or messages that describe the error clearly and suggesting the appropriate solution to recover the problem.
- **Undo and redo:** Providing emergency exits enables users to overcome the problem or return to the nearest safe point and abandon unwanted action. Those emergency exits (such as undo, back, exit, cancel) will reduce the users anxiety and encourage them to explore the unfamiliar options in the system.

2.9.6 Efficiency

Over time via the frequent usage of the system the user's knowledge constantly increasing and building the user's skills. Therefore, the advantages of this incessant advancement in the users' skills and knowledge must be taken into account and accommodated in the system design. Techniques such as shortcuts and user control will enhance the system and users performance by reducing the operation time and increase the user's comforts and allowing advanced authorities in usage controlling and monitoring (Shneiderman et al., 2010). The product efficiency can be enhanced by aspects such as:

- **Efficacy:** Accommodating the increment in user's knowledge and skills.
- **Shortcuts:** Providing some techniques to reduce the operating time such as function keys and abbreviations or other accelerators such as macros and wizards to tailoring and customization the frequent actions.
- **User control:** Gives the user some advanced authorities and responsibilities such as initiating and terminating the actions and gives him the feeling that he controlling

and monitoring the system not just a responder to the system.

2.9.7 Workload Reduction

Computers applications as well as mobile application come to facilitating the humans' life and reducing the workload. Therefore, no need to make user focus on unnecessary thinking or asked him to memorizing data which will increase the workload and makes users feel bored (Jordan, 1998; Saleem et al., 2007). Workload can be reduced through the following aspects:

- **Supportive automation:** Automating the undesirable workload and make the tasks simpler, easier, faster and enjoyable.
- **Reducing the memory load:** Do not demand users to memorizing and remembering information by allowing recognition instead of recall. The displayed data should be in simple, consolidate and brief manner, and presenting the new information in summarized meaningful explanation.
- **Eliminating the unnecessary cognitive thinking:** No need to engage users in the cognitive thinking (such as comparisons, estimations, mental calculations) in the high level tasks or any unnecessary thinking to avoid uncertainty.

2.9.8 Usability Judgment

According to the nature of the task, developers might need to complicate the design of some tasks or violate the design principles to give priority to some important issues (such as security and privacy) to protect the user. In this case, developers need to weight and tradeoffs between the design and the ease-of-use and these issues depending on their experience (Takahashi et al., 2014) as following:

- **It depends:** Balance between the design simplicity and the other important

issues such as security and privacy.

- **A foolish consistency:** Deliberate violation of some design principles and guidelines when it is appropriate.

2.9.9 Technology Transferring

Some technologies (hardware and software) are designed to some purposes or areas, but over time the developers find that those technologies can be used to something else and bringing many benefits. Therefore, the developers' creativity plays a significant role in transferring the appropriate technologies from one area to another without significant problems (De Waal & Knott, 2013) as following:

- **Innovation:** Incorporating two or mere technologies to produce a new technology.
- **Adaption:** Use the current technology developed to certain context to serve another context.
- **Adoption:** Modify and improve the current technology or change it is purpose to something else new.

2.10 Usability Testing or Evaluation

Evaluation means assessment. In other words, it is the judgment process about the value, number, or amount of something (RHKW, 2001; Amerircan Heritage Dictionary, 2011). While test is a critical evaluation procedure and it is means the process of determining the quality, truth or presence of something (RHKW, 2001). Furthermore, usability refers to the user's experience quality when they interacting with systems or products such as application, websites, or devices (Department of Health and Human Services, 2014). On the other hand, usability testing is one of the hallmarks of the user-centered design (Lazar, 2006) and the usages of User Centered

Design (UCD) principles are the key to develop a highly usable product, but usability is not means easy to use only but it is a combination of many qualities formed by product attributes (definitely, ease of use is one of them) and user attributes in a particular context of use. Furthermore, usability testing is unlike the other testing types such as code walkthroughs, functionality testing which focusing on whither the technologies used in the system are actually working or not, but whether the those technologies are easy to use (Lazar, 2006). Therefore, the usability evaluation means the assessment process of the product or system in terms of ease of use, effectiveness, efficiency, and overall user's satisfaction (Cockton, 2013) and sometimes usability testing is called usability engineering (Lazar, 2006). In other words, it is the process of assessing the users' experiment and impression while using the product. Since the usability evaluation focuses on the ability of the product to meet its intended purposes. So the evaluation results can be obtained via the personal observation while conducting the evaluation process or as an output of an accurate measuring instrument, and the results will be either categorical results, qualitative (which means yes/no), or quantitative results (a value) (ASTM, 2014).

2.10.1 Mobile Usability Evaluation Frameworks

Many studies have been conducted to develop models or frameworks assess the usability of mobile applications and determine it is contextual factors (Coursaris & Kim, 2011; Treeratanapon, 2012; Rosnita et al., 2013). However, these frameworks are more general which may not be applied to some specific mobile application due to their complexities and lack of appropriate descriptions on how to choose usability measurement such as usability attributes, criteria and metrics. These frameworks are presented and critiqued in following subsections:

2.10.1.1 Coursaris and Kim (2011)

Coursaris and Kim (2011) reviewed about 100 empirical studies in the field of mobile usability in a qualitative meta-analytical review. The main objective is to introduce a framework which can be used to evaluate the usability of the mobile computing context. The results show the usability contextual factors and it is 16 attributes see Figure 2.9.

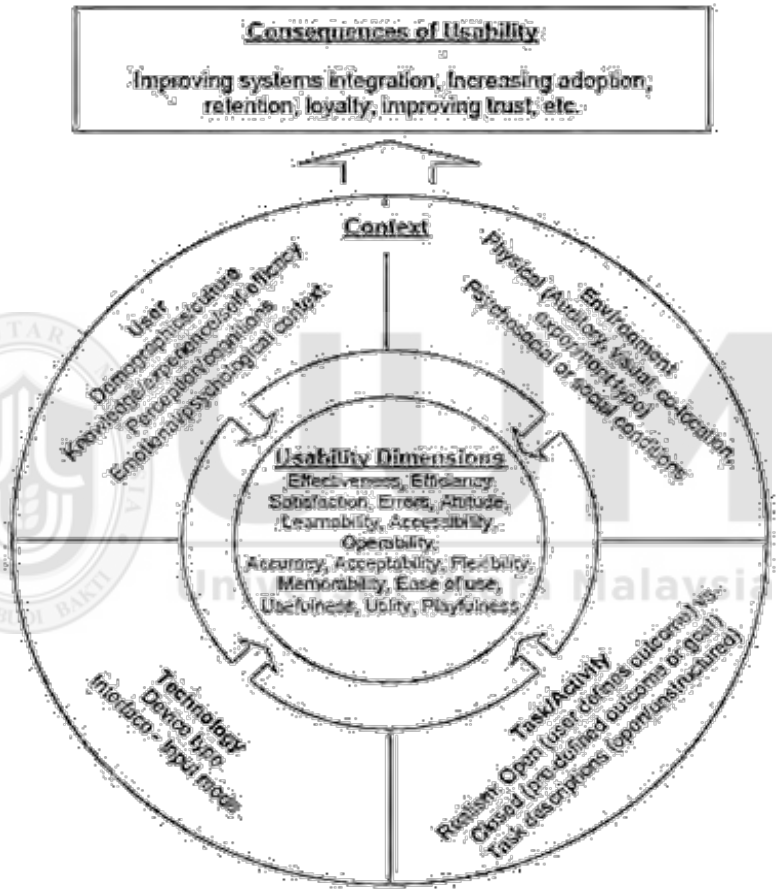


Figure 2.9. The Mobile Usability Framework
Source: Coursaris and Kim (2011)

The usability attributes proposed in the framework are quite comprehensive, though lacks appropriate descriptions on which usability attribute is to be chosen for a specific mobile application. Moreover, there should be supporting metrics for each of the defined usability attribute and descriptions on how each metric is related to its corresponding

criteria. This will enhance easy understanding and applicability of the model in practice (Jooste, Van Biljon, & Mentz, 2014; Kunjachan, 2012). Therefore, in the absence of supporting metrics for each dimension and guidelines for choosing suitable dimensions for a particular mobile application, it might be difficult to apply this framework in Umrah and Hajj context for usability evaluation. In addition, it appeared that the framework has not been tested to determine its applicability and accuracy.

2.10.1.2 Treeratanapon (2012)

Another study conducted by Treeratanapon (2012), he try to develop a framework to evaluate the usability of mobile applications which designed by the free developers in the various platforms. The framework was adopted from TAM (Technology Acceptance Model) model and the ISO 9241 standard. Treeratanapon's study relied on three dependent variables and two independent variables to measure usability. The dependent variables of the study were efficiency, effectiveness and satisfaction while the group of users and the mobile operating system were the independent variables. According to Treeratanapon (2012), he use the time required to finish the tasks to measure the efficiency and the correctness to measure the effectiveness while the satisfaction was assessed by asking the respondents about their satisfaction immediately after using the application and finishing the tasks. IOS and Android were the platforms conducting Treeratanapon's study, whereas the participants in this study divided in to three groups: novice, experience, and expert. However, the model used the mobile operating system to refer to the environment and time to refer to efficiency, while the environment of Hajj or Umrah (extremely crowded environment) is the contextual environment in this study not the mobile operating system. Therefore, the framework proposed by Treeratanapon (2012) is not the right

framework to evaluate the usability of PDM.

2.10.1.3 Rosnita et al. (2013).

In 2013, three researchers from Universiti Kebangsaan Malaysia had conducted a study aimed to propose a set of usability attributes that should be considered during the mobile applications designing and evaluation processes (Rosnita et al., 2013). In that study, the relevant previous studies were reviewed then analyzed using the content analysis approach. The analysis process found that there are 25 attributes directly affect the usability of the mobile applications. Based on their importance, these attributes have been prioritized and re-synthesized to select the most important ten to be used in the proposed model (see Figure 2.10) which can be used as guideline to develop a usable mobile application. However, the model is designed for general mobile applications. Even though the model is well equipped with the relevant attributes, it lacks adequate descriptions on how the model can be used to evaluate a specific mobile application such as PDM, Mobile applications are different both in term of features, functions and sometimes even the type of its users (Coursaris & Kim, 2011). As such, there should be comprehensive guidelines that may support usability practitioners on how to choose certain attributes within the model to evaluate the usability of a specific mobile application as suggested by Tan et al. (2013). Also, the model does not provide supported metrics for each attribute defined in the model to support convenient and effective usability evaluation approach particularly for a defined mobile application. Therefore, evaluating Hajj and Umrah applications with this kind of model requires an extra effort by a domain expert to provide relevant measurements for effective and valid evaluation (Seffah et al., 2006).

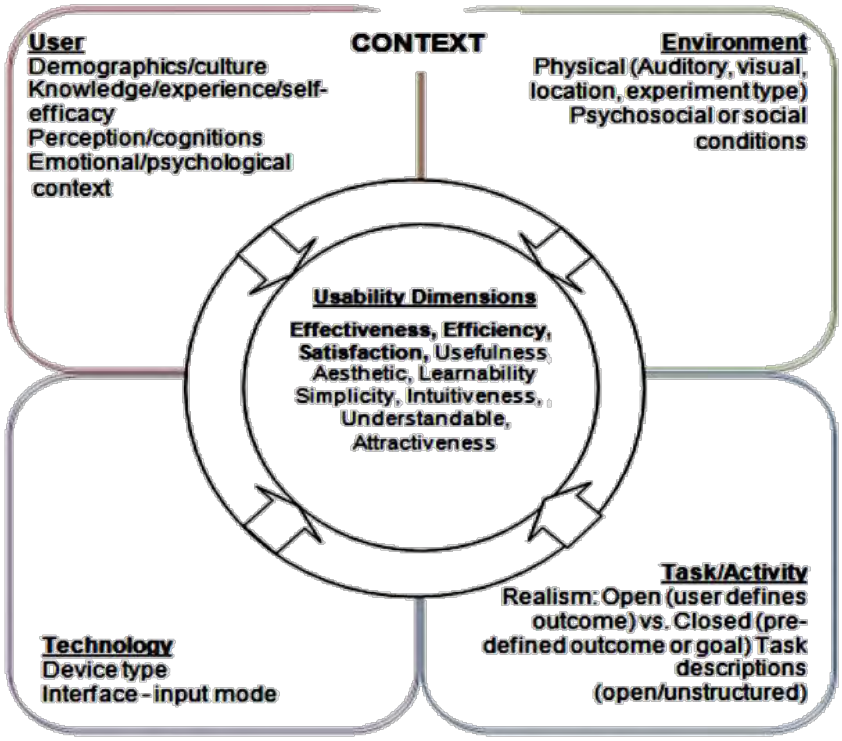


Figure 2.10. Model of Usability Dimension Base-on Four Context Factors
Source: (Rosnita et al., 2013)

2.10.2 When to Conduct a Usability Test?

Depending on the time of conducting the test, usability testing can be subdivided in two types of testing: formative testing (during the development process of the product) and summative (after the product has been finished) (Barnum, 2011). Formative testing is used typically in small studies during the development process to diagnosing problems and providing the solution to fix it. Therefore, the development process will include a repetition of evaluation and enhancement stages to get the final product (Sy & Miller, 2008). On the other hand, summative testing used to investigate wither the product meet is it intended purpose and the user requirements or not. So this type of testing required a large amount of statistical validity (West & Lehman, 2006). According to Lazar (2006) even a good guidelines have been followed in designing the product's interface, it is not possible to predict the aspects that will be problematic and guessing the way of interacting users with the product's interface. Therefore, even in

the large-scale systems (not only in small studies) conducting the usability testing early in the development process is saves money (Lazar, 2006) and the results will gain highly users satisfaction (Navarre, Palanque, Ladry, & Barboni, 2009).

2.10.3 Where to Conduct a Usability Test?

According to ISO 9241 (1998) which define usability as "the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments". So the usability testing is evaluating the effectiveness, efficiency and users satisfaction when they trying to use the product in specified environment to achieving an intended goals (Kaikkonen, Kekäläinen, Cankar, Kallio, & Kaikkonen, 2005). Furthermore, changing context is one the limitations in mobile devices, this environment changing makes the usability testing guidelines used to test desktop applications are not directly valid to evaluate the mobile applications it should be adopted first commensurate with this context (Zhang & Adipat, 2005). Therefore, the application's nature plays a vital role in choosing the usability testing environment (Duh, Tan, & Chen, 2006). Usability testing can be conducting in lab, field, or remotely (Barnum, 2011). The finding of many comparative studies shows that each one of the environments can provide benefits as well as it has some limitations (Kaikkonen et al., 2005; Duh et al., 2006; Barnum, 2011; Ma et al., 2013). The following paragraphs will discoursing the benefits and limitations of each test environment and how to choose the appropriate test environment as well as how to incorporate two or more environments together to conduct the test.

2.10.3.1 Laboratory Usability Testing

Usability lab is the venue of the usability testing where users trying the interacting with the product. Depending on the nature of the product the user is sitting in front of the product interface (personal computer, mobile device, or any type of interface),

accompanied by another person (this person is called facilitator) dictating him the required tasks to be performed. In another room a set of persons called observers sitting behind one way mirror (or using devices such as a set of mounted cameras, video beamer, video monitor, or loudspeakers) watching and make notes about the interaction, the whole session must be receded (Kaikkonen et al., 2005). Laboratory testing can be done in formal labs which can cost a lot or in informal labs which can be set anywhere and very little cost (Barnum, 2011). The formal labs cost a lot because it is need special equipped rooms which can cost nowadays about US$6600; whereas informal lab needs nothing more than multipurpose room to be reserved without and special equipments such as one-way mirror, eye-tracking or mounted cameras.

2.10.3.2 Field Usability Testing

Field testing refers to going to the actual work environment (field) to test the product. It is related to observing users when using the product in the real environment unlike the field studies which means going to the field to gather information about tasks and users before the product have been developed (Barnum, 2002). Some researchers argue that field testing is bringing the lab to users in field (Rowley, 1994). On the other hand, some researchers consider that field testing is more reasonable and highly realistic, because the observers watching what is the users really do and how they interact with the product in the real work environment (Barnum, 2002). While little researchers believe that usability testing should be done in laboratory first by the experts and users (to fix the technical and unexpected scenarios problems) after that in field by final users to focus on the problems that related to environmental aspects (Bastien, 2010; Riiser, Løndal, Ommundsen, Sundar, & Helseth, 2013). Consequently, the data collected about the users' performance in the field will be more meaningful than the data collected in the laboratory or typical environment (Oztoprak & Erbug, 2008; Barnum, 2011; Smashing,

2012). Therefore, this study will conduct the usability testing lab first by the expert users who have been in Makkah for Hajj or Umrah after that going to Holly places in Makkah (field) during the season of Hajj or Umrah to test again in the real work environment.

2.10.3.3 Remote Usability Testing

Remote usability testing is used when the test parties (developers, users, observers, and evaluators) are in different locations, countries, or time zones (Liang, Song, Fu, Cai, & Zhang, 2011). In this case conducting traditional laboratory usability testing will be very difficult and costly (Lee & Kim, 2005). Remote usability testing can be done in two ways synchronous and asynchronous (Chalil Madathil & Greenstein, 2011; Alghamdi, Al-Badi, Alroobaea, & Mayhew, 2013). Synchronous remote usability testing means conducting the usability test when both users and evaluators are sitting synchronously (in the same time) but in different places. Technologies like remote applications (such as TeamViewer or WebEx), video conferencing (such as Go-to-meeting or Skype) or any real time one-on-one communication technology can support this type of remote usability testing and facilitating the communications between evaluators and users (Moulin, Sugawara, & Fujita, 2013). While the asynchronous remote usability testing mean conducting the usability test when both users and evaluators are working separately in different places and time. In this case the interaction between users and the application (such as click streams, user logs, or any subjective feedback) will be recorded automatically (Alghamdi et al., 2013).

2.10.3.4 Comparison between Laboratory, Field, and Remote Usability Testing

Each of the environments of the usability testing has advantages and disadvantages. Therefore, conducting usability testing without any obstacles is impossible (Lee & Kim, 2005). Table 2.3 showing the advantages and disadvantages of each environment (Duh et

al., 2006; Alghamdi et al., 2013), but the nature of the product and the targeted audience determines the appropriate place of conducting the usability testing (Barnum, 2011).

Table 2.3

A Simple Comparison between the Usability Testing Environments

Test Environment	Advantages	Disadvantages
Laboratory	• Save time • Small number of users (5 only) • Providing a typical environment to conducting the test. • Enables developers to test the products that cannot run outside the organization (secret products). • Building credibility of tasks. • Providing quantitative data • Identifying the design problems	• Very high cost. • It is depending on simulated use environment which sometimes cannot to attain. • Does not support the environment changes. • Usually used to test the entertainment and leisure products not the contextual products.
Field	• Low-cost and cheap. • Identifying problems in the tasks. • Providing a real word environment. • Providing a qualitative data about the targeted users.	• Takes more time. • Required large number of users. • Conducting in non-controllable environment. • Large amount of data to be analysed.
Remote	• Cheap • Save time • Providing qualitative and quantitative data. • Enables to cover wide users' profiles. • No need to meet with participants or the test team. • Flexibility in the test and analysing time.	• Cannot see the interaction between the product and participants. • Required a long setup-time. • The materials at the participants side needs to be planned and managed. • It is established in problematic scenarios. • Under the mercy of the internet.

2.10.4 How to Perform a Usability Testing (Testing Methods)?

Nowadays, many methods have been developed to conduct usability testing which can be divided into two types depending on the users' participation in the test (Jordan, 1998). In some methods which called non-empirical (or analytics) methods there is no need for any participants at all (Farooq & Zirkler, 2010), in this case the investigators will simple gives their expert estimation or a structured checking will

be made. However, the majority of the usability testing methods which called empirical methods (Böhm & Wolff, 2014) require users' participation which shows the uncovered startling problems (Wieringa, 2013) even though an efficient and reliable design guideline has been followed (George, 2008). Nevertheless, some circumstances make it is impossible to use any empirical method for example when finding the appropriate and right participants is very difficult or in cases of confidentiality issues (Jordan, 1998; Böhm & Wolff, 2014). Therefore, each method (empirical or non-empirical) has a set of properties such as the level of knowledge and skills required, time, equipments to run the method, and the number of participants to got a useful and meaningful data. Appendix C provides a brief overview about each method and its properties such as the techniques that used to collect data, number of participants, advantages, and disadvantages.

2.11 Information Architecture

Generally, *Information* is a term refers to anything that informs. It also refers to a collection of relevant knowledge or data to a particular subject. Meanwhile, it has dissimilar meanings depending on the context (Floridi, 2010) as well as it is related closely to concepts such as constraint, data, communication, knowledge, mental stimuli, meaning, perception, and representation. According to Floridi (2005), in computer science, information refers to the result of data processing. Whereas, according to Stevenson and Waite (2011), *Architecture* is a term refers to the process of constructing or developing (planning, designing, and building) any structure (such as buildings, roads and systems).

For the first time in 1975, both terms *Architecture* and *Information* have been formulated in one term called *Information Architecture* (IA). The new term IA which introduced by Richard Wurman describes the necessity of representing data to a meaningful

information usable by people (Dillon, 2002). Unfortunately, the term IA was not widespread until the surfacing of the World Wide Web in 1990, when the need of information organization and structures has emerged widely and urgently. The web designers need of IA come into vogue because the necessity of finding a communication manner for sharing the accessible digital information among connected organizations (Brancheau, Schuster, & March, 1989). Therefore, many definitions for IA can be found in literature. The next sub-section explores some of those definitions.

2.11.1 Definitions of IA

Many definitions of IA can be found in literature. One of these definitions states that it refers to the structural design of the environments of shared information. However, the Information Architecture Institute (2013) defines IA as the art or science of labeling, organizing and figuring out software, intranets, websites, online communities to sustain usability and making information easy to find (findability), which mean bringing in and applying the principles of architecture and design on the digital landscape practically. Furthermore, Morrogh (2003) believes that usability as well as IA does not come by chance, but IA is one of the design and usability disciplines. Morrogh (2003) affirm, that IA aimed to figuring out and systematize information in a meaningful and service-oriented manner, he also confirmed that IA is ultimately the construction blueprint of the product. Morrogh (2003) defined IA as the art and science that figuring out and labeling both of the system's functionalities and contents in a such structure enables users to navigating the system easily, realizing what to do and capturing the presented information quickly. Moreover, Morville and Rosenfeld (2007) offered a set of four different definitions of IA, which caused an emergence of some doubts and wonders about: what is IA exactly? Those definitions are:

1. The art and science of forming and modeling experiences and information products towards supporting the contents findability and the product usability.
2. The combination or mix of navigation schemes, labeling, organization, figuring out and search inside an information product.
3. The structural design of the informational space or shared information environments in order to facilitate and expedite the completion of tasks and reach the content intuitively.
4. The new discipline that is engaging and involving the principles of architecture and design to the digital information landscape.

By linking the above mentioned definitions, it is clear that IA as professional discipline aims to support and strengthen the information accessibility on the product, increase the relevancy and usefulness to users. However, IA consists of a variety disciplines such as user experience design, content management and development, user interface design, as well as usability see Figure 2.11. Therefore, Morville and Rosenfeld (2007) used the term *information* specifically to differentiate the information architecture from knowledge management as well as data. Data refers to figures and facts, while knowledge refers to the stuff in human's minds, and knowledge management refers to the incentives, processes, and tools that used to convince humans to share their knowledge. Thus, information is existing in a messy middle where there is no a single answer to any given question. In the other hand, Dillon (2002) tried to contain the above mentioned diversity in the definition approaches of IA by presenting an open definition of IA as a procedure of designing, implementing, and evaluating information spaces that are humanly and socially acceptable to their intended stakeholders. Meanwhile, many different definitions can be found in books and other sources (Brancheau et al., 1989; Dillon, 2002; Brown, 2003; Willett, 2008). Therefore, this study adopts the definition that describes IA as the

discipline of organizing and figuring out functionality and content of the application into a structural design that enables users to navigate intuitively.

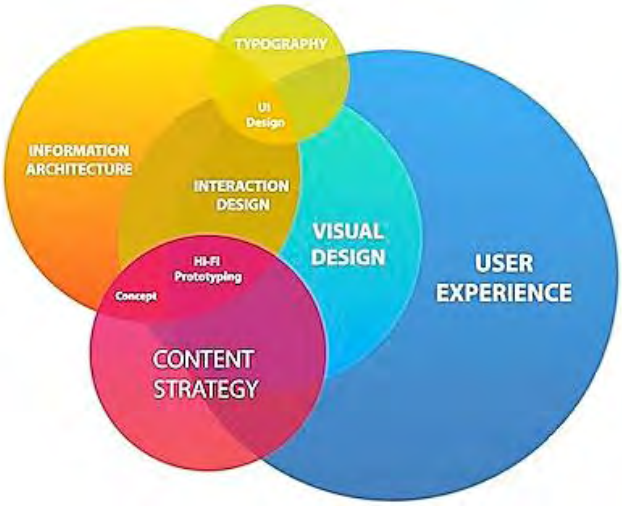


Figure 2.11. The Disciplines Included in IA
Source: (Pal, 2015)

2.11.2 Components of IA

Understand the industry standards of any discipline are a prerequisite to success in that discipline. In developing IA there is a need of understanding the variety of tasks and concepts. Therefore, it is necessary to illustrate and elaborate all the IA components. In the other hand, understanding standards such as creating, accessing, storing, and presenting information are a prerequisite to success in IA (Morville & Rosenfeld, 2007). IA components refer to any element in the information system that gets people to contents. According to Morville and Rosenfeld (2007), there are four main components of IA, but Zimmermann (2005) affirmed, that there are five components of IA (as listed below) because the fifth one is the invisible element of IA:

2.11.2.1 Organization Systems

Nowadays, because of the content's diversity plus the massive amount of information a need has been emerged to organizing information in such effective way enables

people to access and retrieve them easily and quickly (Dillon, 2002). Therefore, the content must be cataloged and categorized first into several structures, after that labeling the produced structures. Organization system consists of organization structures and schemes (Morville & Rosenfeld, 2007) as the following:

- ***Organization schemes:*** Organization schemes can be divided into two types exact organization schemes and ambiguous organization schemes (Morville & Rosenfeld, 2007). In the exact organization schemes all the common characteristics of content elements must be defined, after that all the comparable content elements must be logically grouped or categorized depending on their characteristics (Chen & Lin, 2014). It is also can be defined as a firm arrangement (it maybe chronologically, alphabetically or geographically) of the content elements (Chou, 2002). Therefore, in the exact organization schemes each content element must belonging to one and only one logical group (Chen & Lin, 2014). Meanwhile, in ambiguous organization schemes do not own this restriction which means there are no clear classification rules or strategy (Williams, 2004; Chen & Lin, 2014), so every content element can belonging to more than one logical group. Therefore, sorting process in the ambiguous organization schemes done possibly based on topics, tasks, audiences or metaphors (Morville & Rosenfeld, 2007).

- ***Organization structures:*** Organization structures are refers to defining the connections and relationships among the predefined groups or categories in organization schemes (Morville & Rosenfeld, 2007). Mainly the relations among those groups are parent-child-relation which called as the hierarchical relationships. Frequently, the parents in the hierarchical structures contain broader scope of content items, while the children contain a narrower scope of content (Chen & Lin, 2014). In the other hand, information categorization can be done in

by using card store technique to produce a good user-centered organizational structure, in which the content headlines are written on cards first, after that the information architects with the help of several users have to organize those cards in an expedient way. However, there are six models or patterns of information structure. These structure models will be explained in the Table 2.4.

Table 2.4

The Information Structure Patterns

Model\ Pattern Name	Model \ Pattern Description	When it is used?
All -In –One Pattern	A very simple structure pattern, in which all content presented and located in a single screen or page.	It is used in case of small content amounts.
Flat Pattern or Monocline Model	A one level pattern, in which all pages or screens are in same level and accessible from each other's.	Used when having a few standard topics in a simple website.
Index Pattern	Similar as Flat pattern, but with a little difference where one page or screen defined as an index to the other pages or screens.	It is soliciting when the content is akin to a directory.
Hub-and-Spoke Model	Similar as Microsoft's wizards, so the user will start from the index point, goes via several steps and return back to the start point again.	It is used in case of linear workflow and several distinct.
Strict Hierarchy Model	This pattern is the best structure represented the corporate organization scheme or taxonomy with strict hierarchy. In this model the relation between parent and child nodes is 1: N and child nodes can be accessible via its parent only.	This pattern fits when having strict hierarchy structured product.
Poly-hierarchy or Multi-Dimensional Hierarchy	Similar as Strict Hierarchy pattern, but more flexible with a little difference where the relationship between parents and child have been replaced for 1: N to N:M. Therefore, instead of having one parent for each child now they can have more than one parent.	This pattern fits when having strict hierarchy structured product but with more flexibility. Child nodes can be accessible from more than one category.

In conjunction of the organization schemes and structures that mentioned above, organization system of IA in this study will done used the exact organization schemes, hub-and-spoke model, and multi-dimensional hierarchy pattern as illustrated in Table 2.5.

Table 2.5

The Information Structure Patterns That Will be Used in This Study

Structure \ Scheme Name	How	Justification
Exact Organization Schemes	The application's contents will be categorized depending on rituals. Therefore, every screen will be related to only one ritual.	Because every ritual involved different Duas and steps.
Hub-and-Spoke Model	This pattern will be used in rituals such as Tawaf and Sa'ai in which the pilgrims have to follow sequential steps to perform these rituals. Therefore, each step will be fits in one screen that can be accessible from the previous screen only.	Because every ritual in Umrah or Hajj has a sequential steps, which is started from a certain starting point (faith) down to the end of that ritual.
Poly-hierarchy or Multi-Dimensional Hierarchy	Since there is no sequential order in the most Umrah or Hajj rituals, pilgrims for example can perform Tawaf after or before Sa'ai. Therefore pilgrims can chose one ritual from main menu and started in a flexible style.	Because the majority of rituals in Umrah or Hajj have sequential order among each other, so some rituals can be performed before or after another rituals.

2.11.2.2 Labelling Systems

Labels refer to the given names that represented bulks of information. In another words, labels refer to the optical demonstration of the organization structure and scheme, so the benefit of labeling systems is to facilitate understanding of the full range of labels together in the space of information. Labels divided into two types: textual (such as headings, hyperlinks, menu titles, navigation options and index terms) and iconographic labels (such as visual aspect of graphics or icons) which are usually used as design or layout elements. Dansereau and Simpson (2009) and Hum et al (2011) believe that visual aspect which depended on the audience understandings and expectations is more worth than thousand words. However, visual aspect can be misunderstood easily. Therefore, to have good labeling system labels must be specialized terms or organizational jargon that used by the field's specialists themselves not by audience only, meanwhile the following rules must be followed in designing the labels:

- Using consistent labels.

- Using a narrow range of information as far as possible.
- Realizing and awareness of variations in perceptions and languages.
- Avoiding the perceptible gaps in the labeling system.

In this study, the specialized terms of Umrah and Hajj (such as the rituals names and holy places names) will be used in the textual labels, while live pictures and interactive diagrams of Umrah and Hajj will be used to design the iconographic labels.

2.11.2.3 Navigation Systems

In any space, the navigation system is the most curial for users. Therefore, in the information space the navigation system is considered the most important IA components, because it is the component that enables target audiences to access the content of the information space by combining the usable and visual functionality of the labeling and organization system (Morville & Rosenfeld, 2007). According to Zimmermann (2005) bad navigation system directly affecting the product's usability and acceptance as well as it is a reason leads to lose customers and dissatisfaction of users. Bad navigation system makes users wanderers among content without value, which means less effectiveness and efficiency. Meanwhile, bad navigation system is a source of users' frustration, because it leads them to gets lost in the information space, accessing undesirable information and wasting time of users. Therefore, users will run away to any competitor product having easier navigation system, which means that the product obtained less satisfaction and acceptance than it should. Based on Morville and Rosenfeld (2007), navigation system has three main approaches which are: (1) embedded, (2) supplemental and (3) advanced navigation approaches.

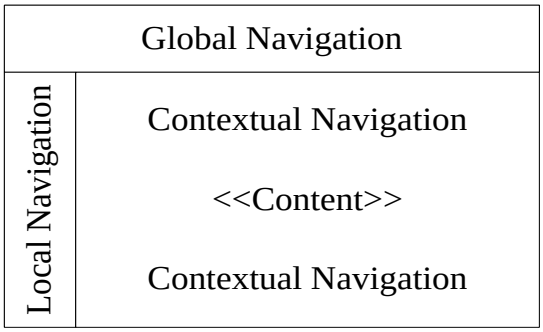


Figure 2.12. Popular Navigation Schemes layout
Source: (Morville & Rosenfeld, 2007, p. 119)

Embedded navigation systems refer to navigation elements that placed jointly with content contained by the information space. Based on the location navigation element (as showed in Figure 2.12) and where it takes the navigators, the embedded navigation systems can be divided into three types: (i) contextual navigation, (ii) local navigation and (iii) global navigation (McCool, 2006). The *contextual navigation* such as breadcrumb navigation or hyperlinks is placed within the content and it has a special granularity and used for navigate through the content itself. In the other hand, *global navigation* is placed in unique and identical location (usually the top of the screen or page) and it is used to browsing the major areas in the information space. Meanwhile, *local navigation* is placed in changeable location (depending on the designers and topics, but usually at the left or right side the screen or page) and it is used to browsing the actual area in the information space.

The *Supplemental navigation* is typically placed nearby the content. It may consist of indexes, sitemaps and wizards or guides (Lupash & Wlad, 2001; McCool, 2006). Furthermore, Supplemental navigation makes content directly accessible in the information space in dissimilar ways (McCool, 2006). Therefore, Supplemental navigations are attached to the overall organization system in different way nearby the content such as bird's eye view or alphabetical order (Morville & Rosenfeld, 2007).

Even though *embedded and supplemental navigation systems* are widely accepted and necessary (Morville & Rosenfeld, 2007), but in some cases both of them may not be sufficient. Thus, in some niche markets new approaches called the *advanced navigation approaches* have been aroused. However, generally those approaches did not suit as an accepted navigation systems, because they are difficult to implemented, the lack of user experience, and it is narrow scope in usability (McCool, 2006).

In this study both of embedded and supplemental navigation systems will be utilized, because according to McCool (2006), Morville and Rosenfeld (2007) these types are the most utilized navigation systems in information spaces specially in websites. However, Morville and Rosenfeld, (2007), stated that six principles must be consider to design a good navigation systems as the following:

1. The user must know where he is all the time.
2. Differentiating hyperlinks clearly from content.
3. The user must clearly know where he can depart from this point.
4. Let user sees where he has already been.
5. Let the user know what to done explicitly to get somewhere.
6. Designate what will happened when the user clicking a link. obviously

2.11.2.4 Search Systems

The search functionality refers to the supplementary component of IA that aimed to find a specific content in the information space. In fact, searching function is an additional component of IA that can be exists on not depending on the need of such function. Therefore, the main IA components (such as organization systems, labeling system and navigation systems) must be fitted and well-designed first, after that a search system can be implemented if there is a need. Zimmermann (2005) affirmed, that search system is not always considered as the silver bullet that improving the information space

navigation. He clearly stated that the search functionality may not efficient when users get lost usually in the information space, but it is helps them in retrieving content and information from the information space easily and quickly. Meanwhile, according to Morville and Rosenfeld (2007) there are some cases necessitates the existence of a search engine in the product, the following cases are example:

i. If the information space contains a massive amounts of information,
ii. In the fragmented or forked sites,
iii. When the content is highly dynamic.
iv. When it is expected by users or they really need it.

In this study the search system will not include in the model or prototype, because there is no massive amount of information to be presented and the information are not dynamic or fragmented. Furthermore, some users expected a search engine in the prototype of the primly study but they are very few. In fact, only one participant form 30 participants expected the search function, which mains 0.3% of users expected the existence of search system in the prototype.

2.11.2.5 Metadata and Controlled Vocabularies

Metadata and controlled vocabularies are the invisible parts of IA, which are used to authorize and empower retrieving the information from the information space. Metadata such as author, publication date, language and keywords are considered as descriptions for content or invisible attributes, that the search engines used to evaluate and produce the search results in the advanced search by filtering the search results according to those metadata. In the other hand, controlled vocabularies are useful in performing the semantic search, in which the search engine tries to retrieving not only the meant information, that syntactical matched but all the relevance information. The semantic search utilizes the semantic hierarchical, associative and the equivalence relations (such

as synonyms, sub categories, or short names) between the controlled vocabularies and the search keywords to retrieve any equivalent content in the information space.

2.11.3 Styles of IA

According to Barker (2005) and Wu (2006), top-down information architecture and bottom-up information architecture are the main styles of defining the information architecture of any product specially websites. The top-down information architecture style needs a broad understanding of the users' requirements and the business context strategies, polices and constants before defining the structure's levels and identifying the highest level of the structure as well as the relationships between content in detailed. This means understand the whole information space first and then goes deeply in detailed to the lower levels. In the other hand, the bottom-up information architecture style needs to understand the detailed relations and communication between content and drawing the product's storyboards to illustrating how the product will maintain the specific requirements of user, after that goes to the structure's higher level that can support those requirements (Wu, 2006).

Both styles are essential in this study; because ignoring the top-down style may leads to a well-organized and findable content but does not support the requirements of business or users (Barker, 2005). While ignoring the bottom-up style may leads to designing a product that enables users to access information without providing the opportunity of exploring the related content (Wu, 2006).

2.11.4 Principles of IA

According to Brown (2010), the new emerged discipline that called IA is still in infancy and rediscovering itself constantly. Furthermore, IA does not have any well-established theory that can be used to driving the designing process of the products'

structures. For example, in graphic design field a set of principles and theories such as theory of color and typography helps the designers to come out with a well graphic design, but what are the theoretical frameworks, principles, or guidelines of IA that can help and guide architects to come out with good information architecture of the information space. Therefore, Brown (2010) provides a sketch principles, and he believes that these handful of principles will help and guide architects to make their design decisions just as occurred to him, Table 2.6 shows these principles and explains where it come from and how it can be implemented. However, these principles were based on the assumption of that IA is one of designing structures' practices. Therefore, these principles can guide and help in the structures' designing only, because they assume the following:

- The structure itself is the primary goal of the architect, because his job is designing maps and flow charts. Secondarily, representing this structure on screens.
- The architect must have well understanding of the product's users and how they would like to relate the contained content and functionality in the structure.
- The architect must understand the range of both content and functionality that the structure must be support.

Table 2.6

The Information Architecture Principles

The Principle	Brief Description	Where it comes from?	How to use it?
Objects	Deal with content as dealing with living objects whose has attributes lifecycle and behaviours.	This comes from the object oriented programming languages, in which any program is divided into a discrete logical objects, where each object has it is own methods and properties.	It can be done by identifying the content types and common structures. For example, in a commercial product content types will be products, customers or services.

Table 2.6 Continued

Choices	Providing meaningful choices that focused on one task.	More choices leads to more thinking (cognitive effort) which means extra anxiety. People imagine that they like to have a lot of choices, but really they do not.	It is very useful to design an information hierarchies and displaying in each level it is own choices only.
Disclosure	Display clear and sufficient information.	Disclosure is one of common concepts of design which built based on the idea of human can processing much information one time, and they can anticipate what will happen from what they have. This comes out form a book titled	Progressive disclosure can be done by giving hints about content as layers and presenting the same content in different layers in different areas.
Exemplars	Displaying examples that explaining the contents of categories.	It is come from the cognitive science which concerned by how humans categorize things. Psychologists believe that human brains representing categories as good examples' networks.	This can be done by providing examples in each category that show what the content in this category and how to deal with it.
Front Doors	Assuming that about 50% of users will access content without going through the main screen.	This come from the search power which may give a direct links to desired content without the need to goes through the main screen or home page.	In each page or screen inform users about where they are? And what they can do here?
Multi Classification	Offering many diverse classification schemes to navigating the content.	Surely people have variety of mental models and motivations. Therefore, they are looking to information by different ways. by	It can be done by allowing multiple ways to access content.
Focused Navigation	Do not mix oranges and apples in the navigation scheme.	This come from the design team's misunderstanding of the meaning of the general labels. Therefore, those menus or labels lose their purpose when it is named based on it is location in the template.	It can be done by establishing one strategy to access and fined content.
Growth	The small amount of information today will not be as well tomorrow	It is coming from the growth of the WWW content. The mount of the information in WWW today is not the same amount last week, it is increasing daily.	It can be done by designing a structure able to accommodate times as much information today to cover the expansion of content.

Source: (Lidwell et al., 2010)

2.11.5 An Effective IA

Developing effective information architecture is the way that enables designers to build a successful system confidently (Barker, 2005). Therefore, in order to create effective information architecture to build information system, there is a need to understand the context goals and constraints, nature of content, and the targeted audience's requirements (Morville & Rosenfeld, 2007). Those interdependent three factors are called the information ecology or the three circles of IA which are visualized in the following Venn diagram see Figure 2.13.

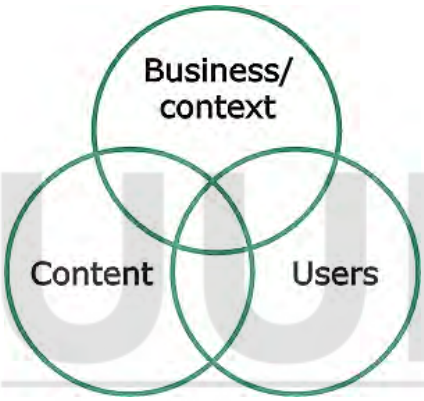


Figure 2.13. The Information Ecology or the Three Circles of IA
Source: (Barker, 2005)

2.11.5.1 Context or Business

The context understanding is essential before thinking in creating the information architecture of that business. Therefore, it is necessary to understand all matters relating to the targeted business or context such as the business goals, politics, constraints, culture, resources and technologies (Wu, 2006). However, understanding the context comes through many techniques including:

- **Reading and understanding the existing documentation of business:** Looking to the business organizational charts mission and vision statements and the previous researches or any related documents is the fastest way to understand

the system's environment (Robertson, 2003).

- **Interviewing the business stakeholders**: Based on Robertson (2003), talking with stakeholders can providing an important insight about the business context, it can also reveal the not known issues and objectives previously.

2.11.5.2 Content

In order to produce effective information architecture first of all there is an urgent need to understand the content through conducting an inventory of the system content, whereby the architects able to understand the quantity and quality of that content (Robertson, 2003). Content inventory refers to the process of identifying the possible content of the proposed system, by knowing who owning the content, where it resides currently, and what the obtainable relationships and communications between content. On the other hand, the content inventory technique is usually used to aid within the content migration procedures from the old system to the new one (Wu, 2006).

2.11.5.3 Users

By understanding and reflecting the thinking way of the targeted users or how those users think regarding the subject matters, the architects able to build effective information architecture commensurate with those users (Zimmermann, 2005). However, card sorting and card-based classification evaluation are the common techniques used to getting the user's participation in the information architecture creation process (Robertson, 2003).

The card sorting technique shows the possible ideas of grouping, arranging and labeling the information (piece of functionality or content). This can be done by representing that information in cards and giving these cards initial labels, after that involving the targeted users to group, arrange and relabeling (when it is needed) these cards in a such manner

that make sense to them. In the other hand, the technique of card-based classification evaluation usually used to testing and evaluating the information architecture first before it has been implemented (Wu, 2006). This can be done by labeling the information architecture levels in large cards, after that involving the targeted users to perform information seeking tasks using the architecture (Robertson, 2003).

2.11.6 Steps of Creating Effective IA

There are eight steps to creating a great and effective information architecture (Sharlin, Tu, & Bartus, 2009) as the following:

2.11.6.1 Defining the Objectives of Key Stakeholders

Key stakeholders refer to the first party of the product development contract who put the product's goals and the responsible party for giving the required approvals at the different stages of the development process. Therefore, the first step of creating effective IA is defining clearly the aims of key stakeholders from conducting this project (Jepsen & Eskerod, 2009), the functional requirements and the targeted audiences. The architects start by asking the key stakeholders the following questions:

1. Who are the product's key audiences? In other words, with whom they want to communicate through the product? by specifying the following:
    1.1. The primary audiences: The main or the critical audiences who this product have been developed or optimized for them.
    1.2. The secondary audiences: The non-critical audiences who might be this product can be beneficial for them.
2. What are their expectations from creating or optimizing this product?
3. What are the functional requirements that they need in the product?

2.11.6.2 Identifying the Audiences Objectives and Expectations

As mentioned early that designing effective information architecture refers to arranging and labeling information in a manner that enables the targeted users to access the required information in the expected place at the expected time. For example, in websites by explaining responsibilities' area by topic, the design will enable visitors to know the person in charge regarding the current matter without reading the staff biographies. Therefore, the interview (Livingstone, 2010) is the best technique to identifying the objectives and expectation of the targeted users, but it is very rare (almost impossible) owning an adequate amount of money and time to interview all the targeted users. Therefore according to Sekaran and Bougie (2013), when the audiences' number is very large and dispersed in a spaced geographic locations, a sample (selected subset) can be used by researchers in representing the whole targeted audiences. Furthermore, this selected sample would accurately represent the targeted population via estimation and reflect all its characteristics, because an accurate and correct selection of the sample definitely will lead to obtain an accurate and correct data. For farther information see sampling section in chapter three.

2.11.6.3 Defining the Content Areas

This will help in the development of the navigational structure, and can be done by three to five persons who will analyze the current content and identifying the required and expected content of the targeted users (Vacca & Vacca, 2005). The content area brainstorming activity can help in defining the content areas by doing the following steps:

1. Analyzing the available content that already owned either in printed or digital form. This sub-activity can performed as the following:
    1.1. Identifying the new information that must be added in the product.
    1.2. Updating the current information that will be very useful to the targeted users.

1.3. Discarding the overabundant or non-useful information to the targeted users.

2. Identifying the information that expected by users. This can be done as the following:

    2.1. Analyzing the interview findings in last step to realizing the topics that expected by sample.

    2.2. If there is no interviews have been conducted with any of the targeted users, the developers can imagine what the information that users will need to find in the product.

    2.3. Adding the information that the key stakeholders want to be included.

2.11.6.4 Organizing the Content Areas

After getting all the content that must be included in the product, those contest must be organized in a way that makes it easy to be accessed by users. This can be done by the activity of grouping content (Miller, 1956; Katsanos, Tselios, & Avouris, 2008), in which the similar and related contents together, and given a name to each group of content. These names might be the same items' names of the navigational menus in the subsequent steps.

2.11.6.5 Creating the Product Map

Labeling the content groups can help in drawing the initial map of the product which is a visual representation show the arrangement of the content areas (Pongnumkul, Wang, & Cohen, 2008). This map shows how the content areas have been arranged in a hierarchical manner in parent/child relationship form. Therefore, not all nodes in the map have child, but all nodes have parent (defiantly not the main node). Once the product map has been completed, it must be shown to the selected sample of the targeted audiences to test the structure logic and applied the required adjustments accordingly.

2.11.6.6 Outlining the Navigation Structure

The navigation structure can be built when the product map is ready. Depending on the product map the sub titles must be listed under the main headlines (Krug, 2013). Have a look to similar successful and easy to use products can help in outlining the navigational scheme of the product (Fang & Holsapple, 2007). Therefore, it is useful to incorporate and use the design ideas of the successful products in the market to support the design of the new product.

2.11.6.7 Labeling the Content Areas

Labeling the content areas refers to the process of given the names to the content areas. In the other hand, those labels are words, so it must make sense to the targeted users. Therefore, labels must be accurate, clear and meaningful to the referred content areas. Meanwhile, these labels must be succinct not longer than three words (Wright & Jorm, 2009). The accuracy, clarity and meaningful of labels can be tested by showing the labels to the targeted users and asked them what they expected from these labels.

2.11.6.8 Creating Wireframes

Wireframe is a hand-drawn blueprint or sketch narrowly represents how contents elements will be organized in the real product's screens or pages. This wireframe sketch can guide the developers for incorporating and well-organizing all the necessary elements of the product's screen in functional manner. Therefore, each screen should have it is own wireframe. According to Reichenauer (2005), the importance of wireframes is that can use as roadmap between stakeholders, developers and designers and guaranteeing that there is not inadvertently changing or obscured in the information architecture during the processes of designing and developing the product.

2.12 User Interface Architecture

The term user interface architecture is completely different from the term information architecture (MacDonald, 2008). The information architecture is concerned about the information flow in the application, while user interface architecture is concerned about users and how to representing that information flow. According to Stallmeister (2012), both of the traditional building architecture and user interface architecture must take into account a number of factors as well as participants. Meanwhile, both of them linking and bringing aesthetics into technology as well as design into implementation. Therefore, UIA forces designers to re-evaluate their work way constantly and view it in a broader context. However, The International Business Machines Corporation IBM (2001) has developed and define rules of UIA in their environment (Windows) to make the design more consistent and ease to use, these rules have been categorized into guidelines and principles. According to IBM (2001), principles refer to beliefs and fundamental ideals that help in decision making and workflow to obtain predefined objectives, while guidelines refer to explicit courses of acts mainly based on a group of principles. Furthermore, principles are abstract fairly, and needs an extensive knowledge and experience in interface design to be understood and interpreted. Meanwhile, guidelines can be considered as good practices within a specific domain or environment. Therefore, the principles introduced by IBM (2001) can be useful in this research, the their guidelines are no so, so these principles will explained in the following sub-sections.

2.12.1 Affinity: Fetching Some Objects to the Life via a Well Visual Design

Understanding the visual design principles can allow utilizing these principles to revive the objects or elements of the product's user interface. Besides, the main purpose of including the visual design in the product user interface is to embody the IA principles. It must sustain the user model and reporting its functions clearly without ambiguities.

Furthermore, it must be an integral part of the design process not as ″the icing on the cake″. However, IBM (2001) confirmed that following the principles visual design principles listed below can promoting visual simplicity and clarity of the user interface.

- **Subtractive design:** Eliminating the unnecessary visual elements that do not directly contributing to the desirable visual communication.
- **Visual hierarchy:** The purpose of visual hierarchy to organize the user's tasks based on its importance (Djamasbi, Siegel, & Tullis, 2011), by giving additional visual prominence to the vital objects. Therefore, using a relative position and distinguish in size and color can visually highlighting the critical objects.
- **Affordance:** Affordance refers to the visual clue that shining and flashing the object's functions (Amerircan Heritage Dictionary, 2011). Thus, the purpose of displaying the objects in a good affordance to help users to realize easily appropriate actions that can be taken with the object.
- **Visual scheme:** Designing a visual scheme that can mapping to the model and allowing users to adapt the interface (Shyu, 2006). Avoid eliminating the additional white space in the images to save the space, but keep some to provide visual ″breathing room.″

2.12.2 Assistance: Offer Proactive Aid

Assist users to perform a set of tasks. It's believed that there is a great disparity between users in their knowledge of the application and their ability to deal with the tasks. Therefore, it is useful to make the design of the system able to realize the personal abilities of user and providing appropriate assistance (Kamper, 1999).

The proactive assistance aims to enables users to complete their tasks efficiently and

easily. Therefore, the proactive assistance must be flexible in forms such as system help, hints or captions. Meanwhile, the information provided in the proactive assistance must be task-oriented, simple, brief and concise. According to Kamper (1999), the application should be capable to improve the users' capabilities and guide them to become independent users.

2.12.3 Availability: All Objects must be Available at Anytime

All the objects inside the current view must be accessible at any time in any sequence. For example in windows, the Open dialog box allows users to access any object within the view. In the other hand, avoid the use of modes that can restrict the interaction with the system. For example in windows, Print dialog box locks the user to return to the application until he finish or cancel the printing task which causing a tremendous inconvenience (Stadler & Lorenz, 2008).

2.12.4 Encouragement: Making Actions are Reversible and Predictable

Use images and terms that enable users to understand each object and its relation in the task accomplishment. Therefore, understanding the tasks, goals and expectations of the user can help to guarantee that each action have been taken by user leads to what the user expects. However, make every action does not leads to irreversible consequences by providing features such as actions for viewing the result as well as delete, reverse or cancel an action which encourage and makes users to feel comfortable to exploring and navigating the system with confident (Shneiderman, 1997). Furthermore, do not grouping actions together in a way that make users might not expect the influence of the grouped actions.

2.12.5 Familiarity: Build on the Prior Knowledge of Users

To come out with a user-friendly interface, the system's interface must enables users learn easily how to accomplish any task by applying the concepts and techniques that learned from the similar tasks.

Before designing the user interface it is important to understand users' expectations as well as their experiences with similar and other systems that work in the same environment. This will ensure that the design of the user interface is user-friendly because it is use the interaction techniques that are already known and expected by users. In the other words, the interaction techniques and visual designs have been represented and reinforced in the design to support users' experience (Stadler & Lorenz, 2008).

2.12.6 Obviousness: Keep Controls and Objects Intuitive and Visible

Avoid the artificial representations whenever possible and using the realistic representations that inspired by the real world to representing the objects in the interface. For example the icons of trash cans and calculator are excellent examples of realistic representations; it tells the users clearly about the object function and the user realize instinctively the related task (Lunney, 2001). In the other hand, the system's controls must be visible clearly and simply indicate their functions; this can be done by using textual or visual cues to facilitate users realize functions. Furthermore, avoid the indirect procedures, interaction or techniques whenever possible and force on the natural or direct interaction.

2.12.7 Personalization: Allow the User to Personalize their Interface

It is obvious that each user has individual abilities or maybe own tasks that differ from each other. Therefore, allowing users to customizing their interface based on their individual desires and needs. Personalizing the interfaces increase the users productivity

and makes the interaction with the system more convenient. This can be done through enabling users to modify the default values to the desired values which will save time and effort of performing the frequently-used functions (Stadler & Lorenz, 2008).

2.12.8 Safety: Keep the User a Way form Troubles

Good user interface design that keeps users from pitfalls which leads to making errors. There are many techniques practiced by designers to protect users from falling into these pitfalls such as lists of choices, reminders, visual cues, contextual help, and other aids. However, reduce the memory load whenever possible and do not prompt the user to remember already known details such as file names or previous settings. Furthermore, enabling mutual and collaborative communication between the system and the user can help in clarifying any ambiguity, correct a problem, confirm a request or define the user's task objectives. For example the Microsoft spelling checker highlighting the potentially misspelled words and provide some suggestion while editing the document.

2.12.9 Satisfaction: Create the Sense of Progress and Achievement Pleasure

Reporting the actions' results immediately and providing an instant feedback will enable users to determine whether the results meet their expectations or alternative actions must be taken immediately. Such instant feedback will make the user feel and enjoy the progress which leads to satisfaction.

2.12.10 Simplicity: Do Not Relinquish Usability for Functionality

Make the user interface straightforward and very simple by:

- Keeping the vital functions simple and clearly apparent as well as complex functions easy to learn.

- Minimizing the number of actions and objects in the interface whenever possible by showing tasks that carried out daily, but the other tasks reachable.
- Organizing the system's functions in such a way easy to use and access.

2.12.11 Support: Enable the User to Control the System

Placing the user in control means gives the user the required power to run the system based on his self-defined setting to accomplish tasks. In the other words, do not force the user to follow the formal and correct way of performing and limiting the choices which must be offered to the user. This can be done by permitting users to maintain and establish steady working context which showing clearly the recent status of the system and what action that can be performed. Furthermore, the stability feeling must be given to the user be making the system responds to the user actions whenever the user decides to leave at any moment, provided that the system remains stable or current when he returns.

2.12.12 Versatility: Support Alternate Interaction Approaches

There are many user skills, work environments, physical abilities and interaction approaches or techniques. Besides of that, some interaction device or equipments have been optimized for specific users or uses and there is no superior interaction way for all situations. Therefore, the system must enable users to choose the appropriate interaction method for each situation and exchange between methods. Meanwhile, the system must allow user to only one input device to complete a single step or sequence of steps. Moreover, provide a variety of interaction techniques with height efficiency that can work in different environments and support different abilities of users as well as enables users to utilize features such as shortcuts, macros, or wizards for frequently-used actions.

2.13 Summary

Usability is known as a quality attribute, which can be measured through user interface.

It means the capability of a product to be understood, learned, operated and be attractive to users when used to achieve certain goals effectively and efficiently in specific environments. The literatures show that numerous studies on usability have been carried out with their respectable objective and positive results. This includes applications and courseware that are intentionally designed to assist pilgrims during Hajj and Umrah. Digesting them is necessary before commencing the model construction. Accordingly, this study managed to review a number of the desktop and mobile applications that are developed particularly for assisting pilgrims during Hajj and Umrah. The results highlight the lack of usability consideration in those applications. Therefore, this study utilizes multimodality and information architecture by proposing some new interaction modes to support the usability of multimodal mobile assistance during Umrah. Briefly, topics being reviewed include existing theories, concepts and principles of the related fields such as multimodality, interaction design, user experience, information architecture and usability. This chapter also, reviews the existing frameworks in usability evaluation and usability attributes of mobile applications. In short, Figure 2.14 visualizes the topics this study reviewed as foundation of model development.

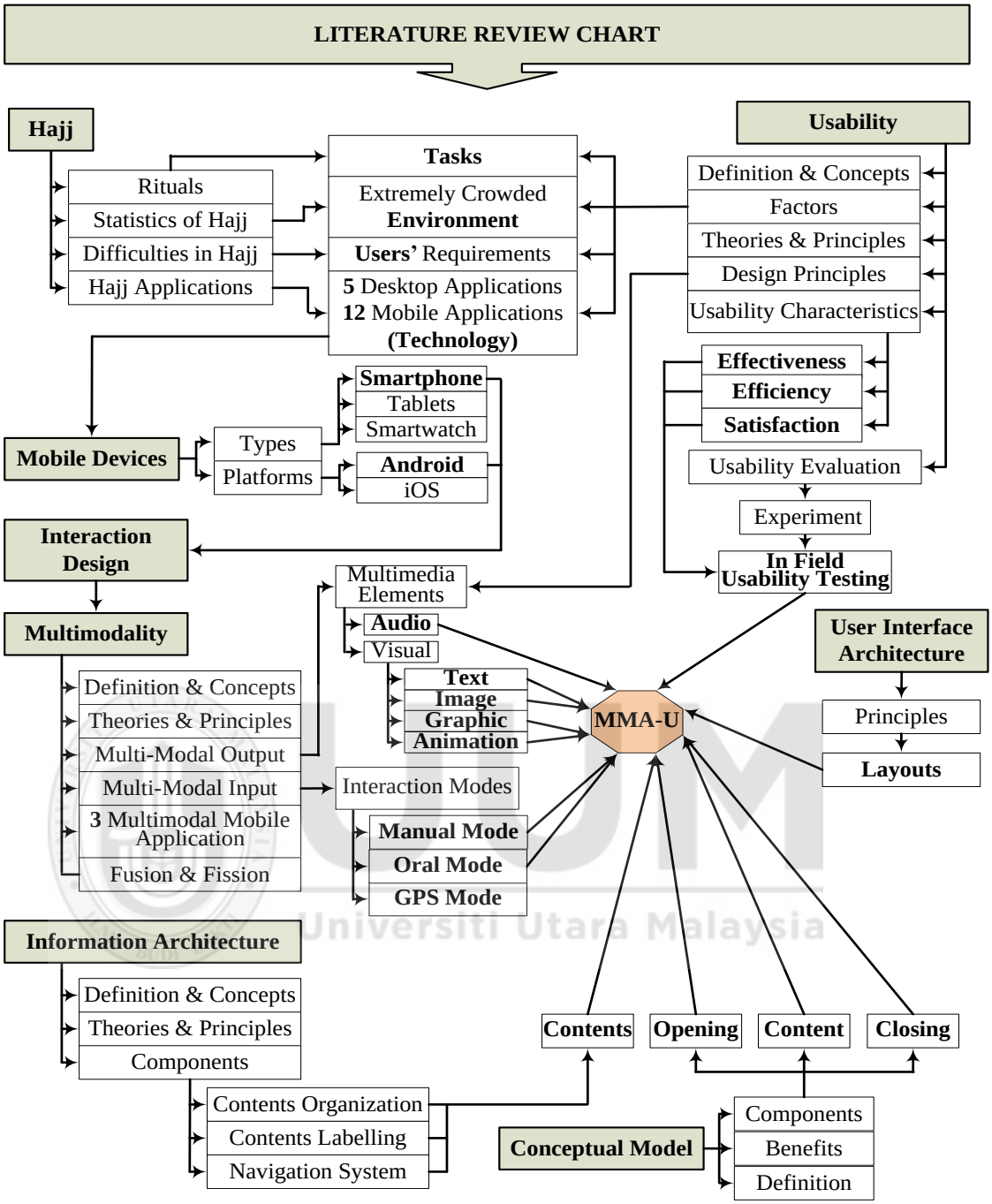


Figure 2.14. *Overview of Related Topics*

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the theories, methodological approaches, process, techniques, and instruments used conducting this study and shows how the objectives of this study have been achieved. The research methodology is very important to come out with a good and useful study (Ardakan & Mohajeri, 2009), but it is not just a set of steps to perform a study or to develop an application (Mohrman, 2007). According to Petter and Gallivan (2004), research method refers to a systematic procedure for capturing data accurately by the involvement of different approaches. Hence, this chapter details and discusses the different phases of the research method. Also, it discusses how the outcomes of each phase answers the research questions and achieves the research objectives. The main objective of this study is to contribute a conceptual model for usable multimodal mobile assistance during Umrah or Hajj.

3.2 Research Design

According to Oppenheim (1998), the research design is a set of research process that solves a specific problems or issues researchable by finding the answers of particular questions. It is agrees, March and Smith (1995) who earlier underlined that scientific research design can be defined as a set of process aimed at producing and applying scientific knowledge of tasks or situations in order to create effective artifacts. Meanwhile, from the perspective of Siti Mahfuzah (2011), the research design can be considered as “research improvement” because research design can improve the performance and solve problems. On top of that, to enhance the validity of any study, more than one method (as well as theory) are required to be used to study a

phenomenon, which is known as triangulation in social science (Jick, 1979). In fact Norshuhada and Shahizan (2013) affirms that to attain the objectives of the research design, it needs to repeat the theoretical, developmental, and empirical aspects in the research process. Besides, Ariffin (2009) also agrees that an iterated process should be applied in theoretical, methods, data sources, and data analysis. Literatures reveal that since 1979 and depending on literature reviews, the Iterative Triangulation Methodology (ITM) (Figure 3.1) has been used, adopted, or implicated in many studies such as Jick (1979), Lewis (1998), Ariffin (2009), Siti Mahfuzah (2011), and Norshuhada and Shahizan (2013).

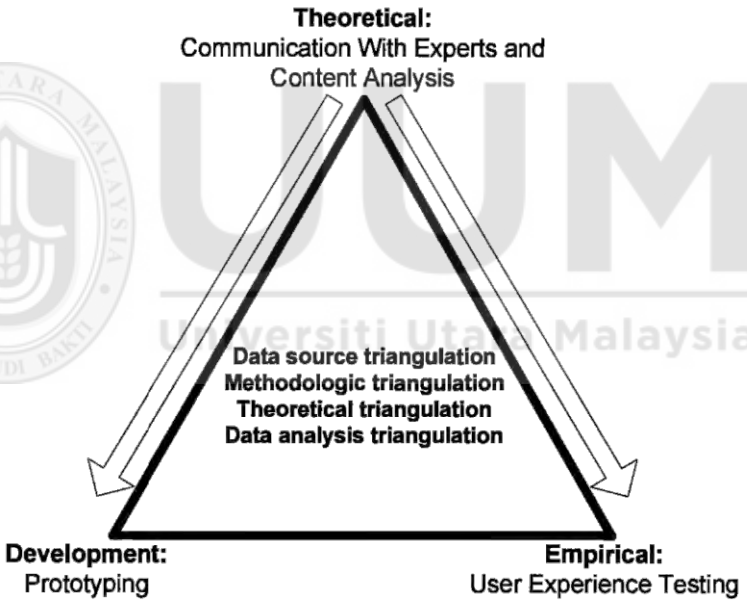


Figure 3.1. The Basis of Methodology
Source: (Ariffin, 2009)

Further, this study considers one of the most famous research methodologies in Information Systems (IS), which is called The Design Science Research Methodology (DSRM) to apply the ITM in answering the research questions and achieve the objectives listed in Chapter 1. DSRM consists of five steps as can be seen in Figure 3.2 developed by Vaishnavi and Kuechler (2008).

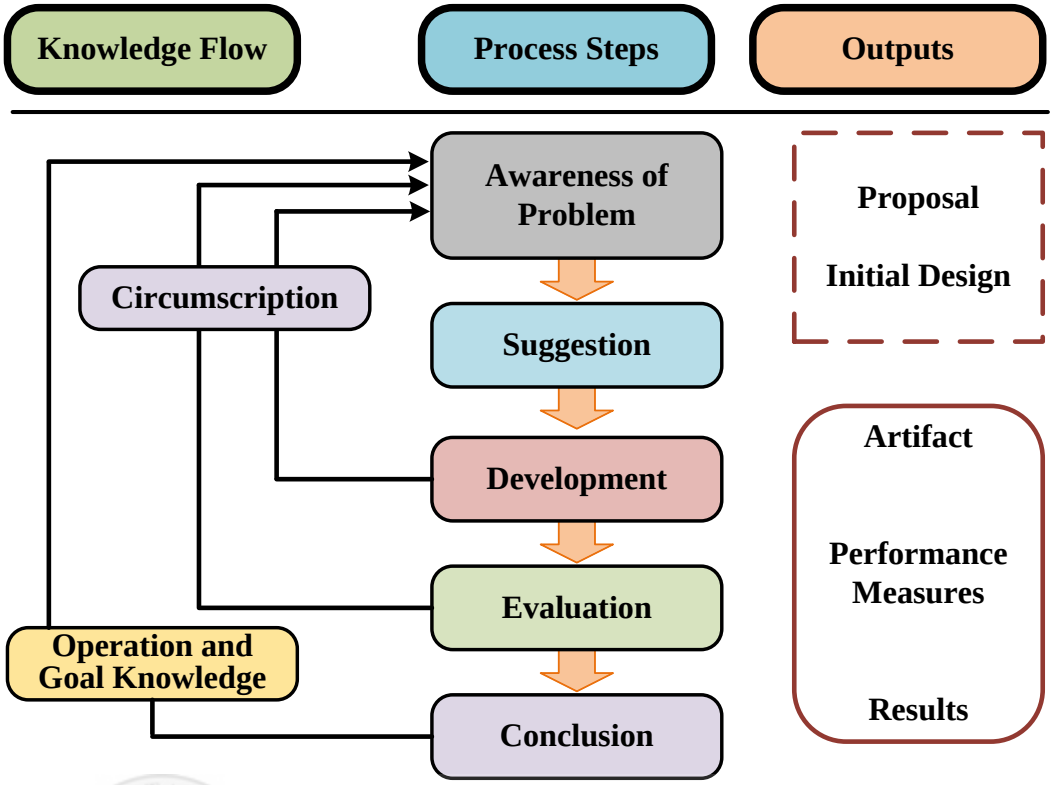


Figure 3.2. The Design Science Research Methodology
Source: (Vaishnavi & Kuechler, 2008)

3.2.1 Justification of Using DSRM in this Study

This research primarily focuses on the development of a conceptual model of a usable multimodal mobile assistance during Umrah. To achieve this objective an information system artifact called Mobile Personal Digital Mutawwif (PDM) has been developed (Gericke, 2009). DSRM specifies a phase for it development. In fact, Alzaza (2012) affirms that DSRM is the appropriate methodology to conduct a scientific study if it “emphasizes the knowledge generation inherent in the method of development”. Also, Kabbany, Ming, and Radwan (2011) found that DSRM is useful in "improvement-based research". Additionally, Hevner et al. (2004) prove that both design science and behavioral science paradigms are constituent the IS discipline, where technology, organization, and people are congregated. With regards to that, this study includes of theoretical and empirical parts, in which theoretical part

ensures the available knowledge and technologies were employed to understand the problem domain and providing the solution accordingly (Jamil, 2013).

Therefore, DSRM is appropriate for this study, with an aim at providing a useful artifact in information systems (Hevner & Chatterjee, 2010). The methodology consists of five basic parts which include; Suggestion, Awareness of Problem, Development, Evaluation and Conclusion as can be seen in Figure 3.2. The following sections explain each of the stages with respective outcomes.

3.3 The Research Methodology Phases

As mentioned earlier, this study utilizes DSRM and applies ITM to deliver the artifact and achieve the outlined objectives. Generally, March and Smith (1995) affirm that the outcomes of DSRM can be a model, instantiation, construct, method, or better theory. Meanwhile, appropriate artifacts can be algorithms, working prototypes, user interfaces, techniques, processes, methodologies, or frameworks (Norshuhada & Shahizan, 2013). Each phase in DSRM has several steps and activities (Figure 3.3), which interact with each other within the same phase or with other activities in other phases. In addition, the phases may iterate as well as steps and activities when it is necessary.

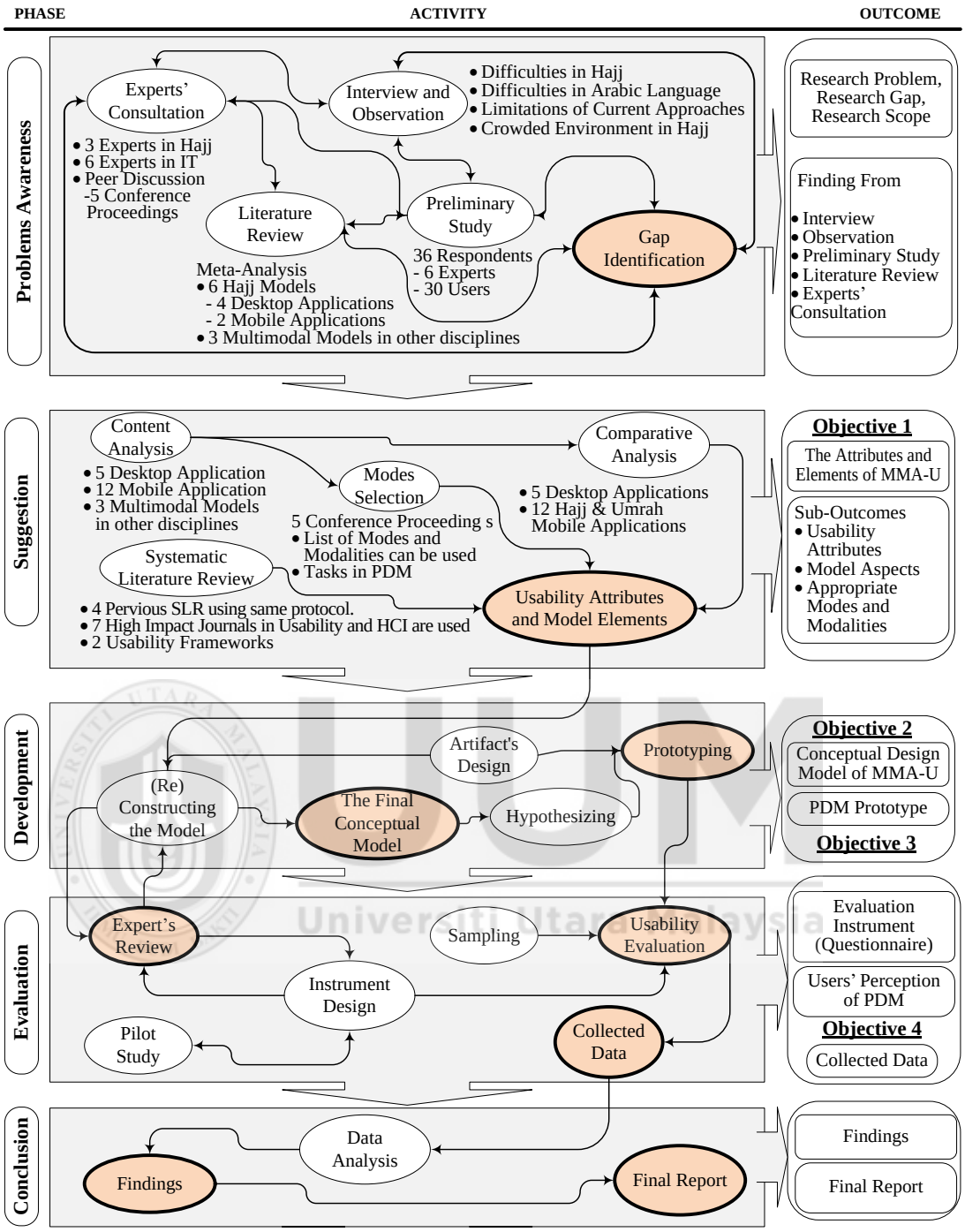


Figure 3.3. The Research Methodology phases

3.4 The First Phase: Problems Awareness

The awareness of problems refers to finding the latest reference discipline or development in the same field or relevant industry (Norshuhada & Shahizan, 2013) towards gathering the relevant information and having the knowledge to understand

the phenomena in the field and looking for the current issues, problems, or limitations. Also, it refers to understanding the relevant fields to discover the ability of extending the current technologies to another field or bringing new technologies to the field (Offermann, Levina, Schönherr, & Bub, 2009). Accordingly, various sources including books, articles in proceedings and journal, and expert opinions (Alzaza, 2012) were utilized after considering the recommendations by Vaishnavi and Kuechler (2008). In fact, Venable (2006) has reminded that different stakeholders might have dissimilar perceptions of the problem, in addition to many disagreements about the problem's nature (Dhillon, Stahl, & Baskerville, 2009). Based on the above arguments this study involves activities shown in Figure 3.4 for understanding the problem.

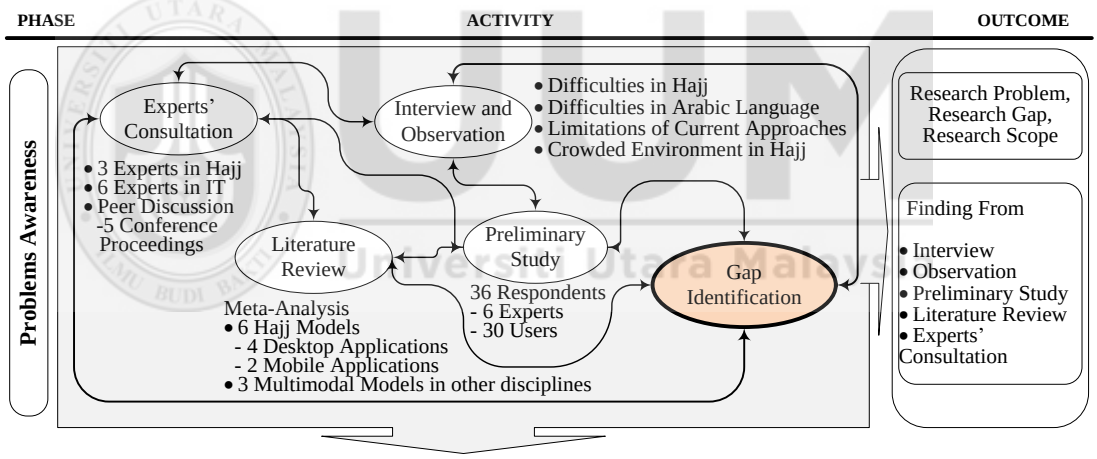


Figure 3.4. The First Phase in Methodology (Problems Awareness)

The outcome of this phase outlines the intention of the study, in which the research gap were identified, the problem statement were formed as well as the clarification of other aspects to ensure the research is scientific. This is visualized in Figure 3.5. According to Hoffer, George, and Valacich (2013), gathering the relevant and required information can be conducting via many techniques or methods such as direct interview, literature survey, observations, or focus group discussions. Accordingly, the

following subsections explain the activities in this phase in detail.

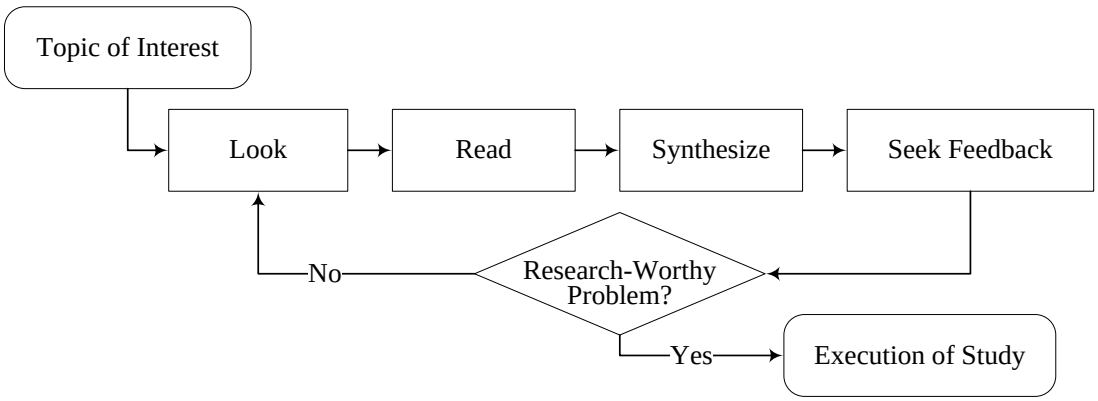


Figure 3.5. The Procedure of Formulating a Worthy Problem Statement
Source: (Ellis & Levy, 2008)

3.4.1 The Research Gap Identification

The vital and most important think in any scientific research is identifying the gap and formulating the problem statement (Uyangoda, 2011; Dissanayake, 2013). This activity is the most important in the first phase and other activities are carried out after this activity. In fact, the problem to be researched was associated with and relevant to the issues (Ellis & Levy, 2008; Klischewski, 2012). In addition, Norshuhada and Shahizan (2013) suggest a set of criteria that must be taken into account while identifying a worthy research gap such as justifying the research, the rationale and foundation of the research, showing main flaws in earlier studies, and outlining problem statements, questions and future work.

This research is competent to assist pilgrims during Hajj and Umrah journey. So the result of this phase (especially problem statement, research questions and objectives) is debated in detail in Chapter 1. The dominant techniques used was observation (Kerlinger & Lee, 2000; Kawulich, 2005), direct interview (Offermann et al., 2009) and literature review (Hoffer et al., 2013), beyond the experts consultation (Ellis &

Levy, 2008) in Information Technology and Shariah and Islamic Sciences fields. The following subsections debating the other activities in this phase and how the above-mentioned have been used.

3.4.2 Interview and Observation

Kerlinger and Lee (2000) found, that majority of beginner researchers believe that the 'gut feelings', personal interests, and hunches are the most realistic starting point for identifying a worthy research problems. Kerlinger and Lee (2000) also believe, that the inner desire of scientists lead them to keep trying to know "why something is as it is" (p. 15) and they will never rest until the phenomenon is well-explained. As it is known, Hajj involves several rituals that among others include Ihram, Tawaf, Saie, staying in Mina, staying in Muzdalifah, Wuquf, and stoning of the Jamarat. Through the first experience in Hajj, this study observed that generally pilgrims face many difficulties in Hajj as well as Umrah. Besides, informal conversation (informal interview) with the pilgrims strengthened the data from the observation. The pilgrims addressed that since there are many rituals in Hajj and Umrah, these rituals are accompanied with many duas that have to be recited by the pilgrims in different times and places, it is impossible for most pilgrims to memorize all of them. The pilgrims address their positive preferences as detailed in Table 1.3. Consequently, the research started reviewing the literature to understand the phenomenon, finding relevant issues, current approaches, and appropriate technologies and techniques to facilitating these difficulties, and proposing the solution.

3.4.3 Literature Review

Many scientific and non- scientific sources have been read to understand the

phenomenon. Briefly, the difficulties faced by all pilgrims especially Malaysian (and the pacific countries) pilgrims were investigated. The current approaches have been tracked to find the deficiencies and limitations. The technology penetration in the targeted countries has been studied to fine the appropriate techniques, services, device, platform, and modes. The required duas and zikr (for Hajj, Umrah and Ziarah including going to hajj and returning home) have been collected from trusted resources (such as books and booklets) according to the doctrine of the targeted countries (Shaafa'i madhhab). The usability issues related to mobile devices and mobile applications were also investigated. In short, the purpose of reviewing the related literatures (discussed in Chapter 2), which have been detailed in a meta-analysis (Table 2.1) is to understand environment, platforms, and modes as well as to fine the deficiencies, limitations, gaps, similar patterns, techniques, services, differences, and contents, which clearly contributes to the improvement.

3.4.4 Experts' Consultation

Communicating with experts in different fields related to this study comes to ensure the interdependence of the problems that have been identified and its cohesiveness as well as the legitimacy and validity of the contents and its translation. A number of interviews and expanded discussions with experts have been carried out to review the research materials as well as a number of participations in workshops and conference proceeding which included sharing and exchanges of ideas. In fact, this study involved two types of expert's consultation and each type has a certain criteria which assured their expertise. The first type of expert's consultation was related to the contents, which must be 100% valid and legitimate. Therefore, this type of consultation aims to gain valid and legitimate contents, since it is relating to Umrah or Hajj, the pillar fifth of Islam. Three

well-known experts who are qualified in Hajj were referred to in this phase and further.

The first expert ranks 25 in the world's 500 most influential Muslims in 2016/17 (Ahmed et al., 2017). He is the director of Dar Al-Mustafa (one of the foremost centers for Islamic education in the world located in Tarim-Yemen and has many branches worldwide including Malaysia, Indonesia, Kenya, and UK). The consultation has been conducted face to face while he was in Malaysia during his annual journey in the world for da'wah and humanitarian efforts plus many times in Dar Al-Mustafa in Tarim.

The second expert is an associate professor at School of Multimedia Technology and Communication SMMTC in Universiti Utara Malaysia UUM and he has published and supervised many research works related to Hajj such as V-Hajj (Mohd Fitri et al., 2011). The consultation has been conducted face to face to matching the gathered contents with the contents of his studies as well as adding the omitted contents in other studies.

The last expert in this type of consultation is a lecturer at the UUM College of Arts and Sciences, school of Islamic Studies. He is one of the qualified Hajj trainers for the Lembaga Tabung Haji of Malaysia. The consultation has been conducted via the Islamic center in UUM to validate the contents and the translation.

Meanwhile, the second type of experts' consultation is related to the technical part of the study, and it is aimed at defining the functional and non-functional requirements of PDM. Six senior lecturers at School of Computing SOC and SMMTC in UUM have been interviewed face to face before and after the preliminary study of this research. The technical issues such as the usability issues and mobile assistance's specifications, modes, features, and design have been discussed with them. The criteria for selecting them are listed below.

- PhD or master holder in Software Engineering (SE) or Computer Science (CS) or Information Systems (IS) or Information Technology (IT) or Human Computer Interaction (HCI) or Mobile Applications or any related areas.
- Teaching background for five years or above in the above mentioned areas or any relevant area.
- At least five years studying or researching in the above mentioned areas or any relevant area.
- Mother tongue is Malay.
- Have been to Makkah for Hajj or Umrah.

The experts' consultation involved reviewing their experience in Umrah or Hajj and the difficulties or problems that they faced, besides listening to their imagination and aspirations about the solution which would overcome these difficulties and problems.

3.4.5 Preliminary Study

The preliminary study has been conducted to obtain the user's opinion on the mobile assistance for Hajj or Umrah. It utilized a questionnaire that took two weeks to distribute and collect the questionnaire from 30 participants. The questionnaire (Appendix B) consists of 23 structured questions clustered into 4 parts. Each parts contains a number of questions to gather certain data about the following: part (1) contains 6 questions related to demographical information, part (2) contains 6 questions related to the usefulness of initial prototype, part (3) contains 6 questions related to the ease of use of initial prototype, and part (4) contains 5 questions related to the outcome and future use of initial prototype.

The participants were divided into two groups, used users-15 participants who have been to Makkah to perform Hajj or Umrah and new users-15 participants who have not been

to Makkah to perform Hajj or Umrah. Meanwhile, the basic statistical analysis techniques in SPSS version 18 (such as T-test and Descriptive Statistics) have been used in analyzing the users' responses (data obtained via the questionnaires). The results of the data analysis have been discussed in the Chapter 1 (Section 1.4.3). Briefly, the results show that MDZ4H won the users' acceptance and satisfaction.

3.5 The Second Phase: Suggestion

Based on the outcomes of the first phase, this phase aims at determining the appropriate modes, services, and technologies that can be used to assist pilgrims while performing Hajj or Umrah. However, the usability attributes related to those modes, services, and technologies that must be considered in designing and evaluating the pilgrims' assistance proposed in this study were reviewed systematically in SLR, because omission of one of these attributes may lead to the assistance failure, or at least will influencing its success. Therefore, this phase accelerated some activities eventually leading to the selection of usability attributes and modes which should be used in the proposed conceptual model of the multi-modal mobile assistance during Hajj or Umrah. As a result of this phase, a list of the usability attributes and modes that can be used in the pilgrims' assistance were obtained through activities outlined in Figure 3.6. It serves the achievement of Objective1.

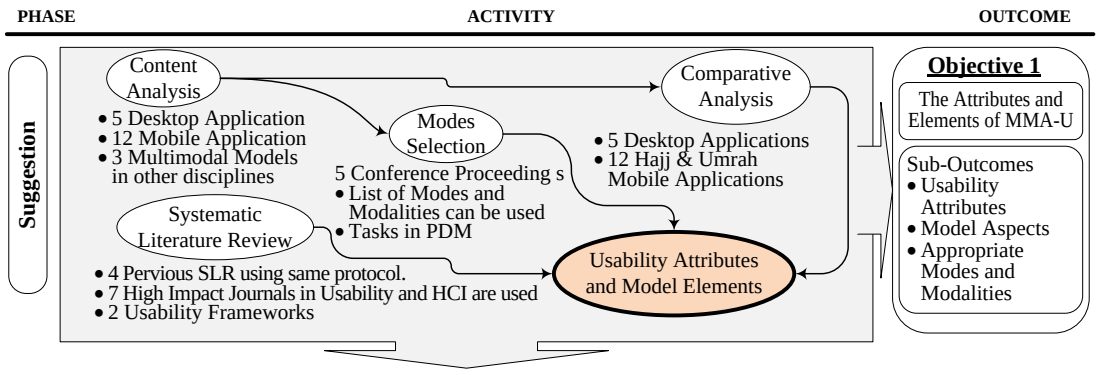


Figure 3.6. The Second Phase of Methodology (Suggestion)

3.5.1 Modes and Modals Selection

Results of the preliminary study have been discussed with peers and experts through international conferences, in which different versions of MDZ4H have been developed and shared. In every session, deep critical and important suggestions regarding the usability of MDZ4H were gathered. The suggestions gathered in the feedback gathering sessions include addition of new modes or modals to the current version for the purpose of supporting accessibility. Table 3.1 lists the papers presented in the conferences.

Table 3.1

The Findings of Peers and Experts Discussion in Conferences

Paper Title	Conference Name\Year	What was used		What is Suggested	
		Modalities	Modes	Modalities	Modes
Development of Mobile Dua and Zikir For Hajj (MDZ4H)	International Conference on Interactive Digital Media (ICIDM 2012)	• Tests • Icons • Audios	• Touch Screen (long menu)	• Images • Animation	• Divided the menu to sub menus based on rituals • GPS
Users' Perceptions and Usability of Mobile Dua and Zikr For Hajj (MDZ4H)	The First International Conference on Applied Sciences (ICAS 2013)	• Tests • Icons • Audios	• Touch Screen (Sub menus based on rituals)	• Images • Animation • Expressive images in menus	• GPS • Embedded mobile sensors
Study of Users' Perceptions Toward Mobile Dua and Zikr For Hajj (MDZ4H) Usability	The International Conference on Advances in Information Technology for the Holy Quran and Its Sciences (NOORIC 2013)	• Tests • Icons • Images • Audios	• Touch Screen (short menus with expressive images)	• Voices • Animation • Videos	• GPS • Embedded mobile sensors • Voice commands.
Multiple Input Modality Mobile Application for Pilgrims	7th Knowledge Management International Conference (KMICe) 2014	• Tests • Images • Icons • Audios • Voice	• Touch Screen (menus with expressive images) • Voice commands	• Animation	• GPS
Speech Recognition and GPS Incorporation in a Multiple Input Modality Mobile Application for Pilgrims (MDZ4H)	2nd International Conference on Islamic Applications in Computer Science And Technology (IMAN 2014)	• Tests • Images • Icons • Audios • Voice	• Touch Screen (menus with expressive images) • Voice commands • GPS	• Animation	

In the conferences many ideas have been discussed deeply and the ability of applying them have been studied carefully. After that, the comments were applied in the next version of MDZ4H, for further discussions in another conference proceeding and so on. Therefore, some of those suggestions have been excluded because of the impossibility of implementing it practically, at least at the present time (a justification will be given when discussing the finding in Chapter 4 of why these suggestions have been ruled out). Nevertheless, the excluded suggestions have been taken into account as an outline for future studies complementary to this study.

3.5.2 Systematic Literature Review

Systematic literature review (SLR), systematic review (SR), or structured literature review are defined as a formal literature review of high quality studies related to a specific research matter in order to identify, select and synthesize evidences relevant to the matter (Kitchenham, 2004). SLR as well as meta-analysis were originally used in medicine (Adèr & Mellenbergh, 2008). Also, it is considered as a key element of evidence-based studies in healthcare (Navas-Acien, 2015), but it is used in other fields too such as nutrition (Lichtenstein, 2015), business, and management (Denyer & Tranfield, 2015), software engineering (Mian, Conte, Natali, Biolchini, & Travassos, 2005) as well as information systems (Nguyen-Duc, Cruzes, & Conradi, 2015). Kitchenham (2004), has underlined many reasons for conducting SLR including:

- To summarize the available empirical evidences of a specific treatment, subject, phenomena, technology, or method to identifying the limitations and benefits.
- To discover the gaps in the existing researches to cover the current gaps or suggest further researches.

- To present a background, model, method, or framework to set an appropriate base for fresh investigation activities.

This study aims at developing a conceptual model concerning the usability of multimodal mobile assistance for pilgrims during Umrah. Accordingly, this study employed SLR in order to acquire the usability attributes of mobile applications in general and selecting only appropriate attributes to this study. Referring to Kitchenham (2004), SLR consists of three main steps, which are planning, conducting, and reporting the review (as seen in Figure 3.7).

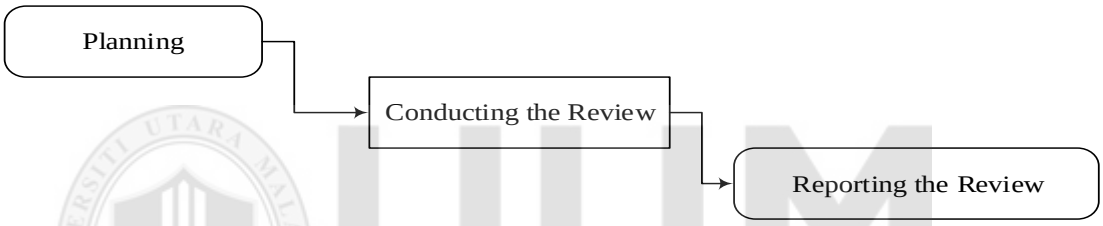


Figure 3.7. The Steps of SLR
Source: Kitchenham (2004)

3.5.2.1 Planning

The first step in SLR is planning, in which (1) the research question is formulated and (2) the research protocol is developed (Mian et al., 2005). In this study, SLR has been conducted to address the usability attributes of mobile applications. Therefore, the keywords "Usability", "Evaluation", and "Mobile" have been used to retrieve relevant studies. Four criteria as the basis of selecting references are: (1) the study has been published in a high impact journal in HCI or Usability Studies (2) published not earlier than 2000, (3) empirical study, and (4) on mobile technology. Based on the criteria, the journals listed in Table 3.2 are the results.

Table 3.2

The List of Selected Journals in HCI and Usability

Journal Title	ISI Short Title	Publisher	ISSN	Publication Frequency
Computers in Human Behavior	CHB	Elsevier	0747-5632	12
Human-Computer Interaction	HCI	Taylor & Francis	0737-0024	4
Interacting With Computers	IWC	Oxford	0953-5438	6
International Journal Of Human-Computer Interaction	IJHCI	Taylor & Francis	1044-7318	4
International Journal of Mobile Human Computer Interaction	IJMHCI	IGI Global	1942-390X	4
Journal of Usability Studies	JUS	Usability Professionals' Association	1931-3357	4
Transactions on Computer - Human Interaction	TOCHI	ACM	1073-0516	4

3.5.2.2 Conducting the Review

This phase involves identifying, selecting, and evaluating the primary studies based on the research question formulated in the first step, while the exclusion and inclusion of the studies was conducted subjected to the criteria of the review protocol that is developed in the planning phase. The research strategy helped in assessing the size of relevant studies and identifying the similar pervious work (Mian et al., 2005), thereby contributing to renovating the existing SLR studies. In addition, based on Shojania et al. (2007). Before identifying primary studies, there is a need to make sure that this work has not been done previously in order to avoid repetitions and waste time. Therefore, in this study a quick search about the previous meta-analysis and systematic reviews that addressed the same research question "the usability evaluation in mobile" by using the same protocol has been performed. In fact, four studies have been founded in which the same research question has been addressed by using the same research protocol (Coursaris & Kim, 2006; Azham & Kutar, 2009;

Coursaris & Kim, 2011; Rosnita et al., 2013). Accordingly, the research protocol time limit has been changed to retrieve the studies published between 2013 and 2016, while the previous studies were used in the comparative analysis described in Chapter 4. The selected papers in the final list were read deeply and passed to the next step of SLR for reporting.

3.5.2.3 Reporting the Review

When the final list is ready, the contents of the selected studies were carefully analyzed and summarized in such manner that makes it understandable. The retrieved data from all the studies in the final list were presented narratively or\and statically using figures, tables, or so on. In this study the SLR aims to address the usability attributes to evaluate the mobile applications. Therefore, the results summarized the context, terms and definition, the methodology, number of respondents, the key usability attributes and the key findings of each study in the final list. Finally the results of SLR were first summarized, and then combined with the findings of the existing systematic reviews. The process of conducting and reporting the review were discussed deeply in Chapter 4.

3.6 The Third Phase: Development

At the end of the previous stage (suggestions phase), the usability attributes have been ready to be incorporated in the artifacts of this study. In fact, this study has two artifacts (Figure 3.8) which are (1) the conceptual model for MMA-U and (2) a prototype of PDM. Those artifacts are the outcomes of this phase, which are preceded to the next phase for evaluation. Therefore, this phase includes iteration with the next phase until the flow of experts' feedbacks stopped.

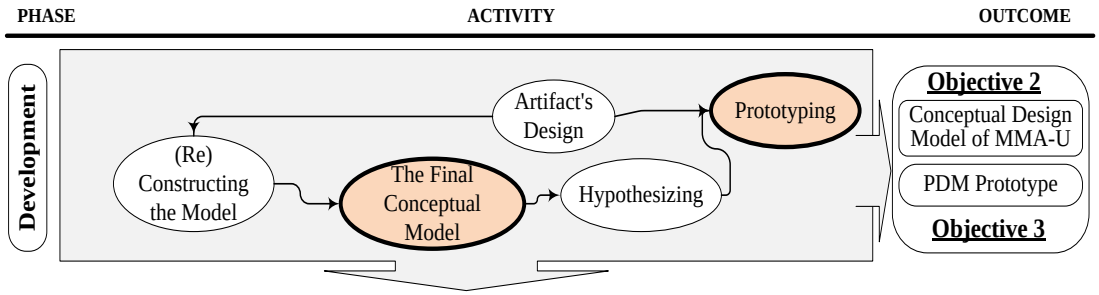


Figure 3.8. The Third Phase of Methodology (Development)

3.6.1 Artifacts' Designing

Designing artifacts is considered as a creative engineering procedure in which the available solutions must be considered (Siti Mahfuzah, 2011). A wide variety of methods can be used to design artifacts such as comparative analysis, literature analysis, case study, and prototyping (Ariffin, 2009; Siti Mahfuzah, 2011). This study employs the expert evaluation to design the artifacts, in which (1) the initial artifacts were designed, (2) then sent to experts for evaluation, (3) after that the results of experts' evaluation were implemented to enhance the artifacts.

3.6.2 Constructing the Model

As mentioned earlier in Chapter 2, there are many definitions of conceptual model. For example, Johnson and Henderson (2002) define conceptual model as a clever depiction of the way of organizing and operating the system. Thus, conceptual model refers to the representation of the system entities (concepts) and the relationships among them (Hendriks et al., 2011; Rad & Jabbari, 2012). Besides, Jomalis Joy (2013) define conceptual models as a graphical description "that shows the key elements in the system of interest and the hypothesized relationships between them". This means conceptual model is a graphical application's representation that can be supported by diagrams, tables and grammar notations. It enables developers to have a full understanding of unimagined systems (Ariffin & Norshuhada, 2009). Also, it can be defined as formal

model, in which every entity being modeled in the real world has a transparent and one-to-one correspondence to an object in the model. Therefore, Ariffin (2009) affirm that conceptual models of dissimilar applications with special requirements are definitely not same, because different applications employ diverse technologies in diverse contexts and perhaps used by dissimilar users. It is very important to distinguish between the conceptual model and the user interface description because conceptual model is only a structure outlining the general concepts of the application and their interrelations that is used to design and develop the product. Based on Sharp et al (2011) and Johnson and Henderson (2002), the conceptual model consists of the following components:

- The key analogies and metaphors (such as bookmarking and browsing) that help people in understanding what an application for and how to use the application for an activity.
- The concepts that will encounter the people through the application, including the created and manipulated task-domain objects, their characteristics as well as the operations that may be carried out on them.
- The interrelations and links between these concepts, for example whether an object is contained or part of another object as well as the relative importance of actions to others.
- The relationships between those concepts, such as whether one object contains another, the relative importance of actions to others, and whether an object is part of another.
- The mappings between the concepts and the user experience the product is designed to support or invoke.

Actually the conceptual model proposed by this study is constructed based on those definitions and taking into account the components of conceptual model introduced

by Sharp et al. (2011) and Johnson and Henderson (2002). Meanwhile, techniques such as hypothesizing (see next subsection) and expert reviewing (see subsection 3.7.1 in the fourth phase) are used to evaluate the constructed model. Therefore, the model construction process went through an iteration loop as seen in Figure 3.9 before delivering the final model. The iteration loop is between the constricting activity in the development phase and the experts reviewing in the evaluation phase until achieving the experts' satisfaction.

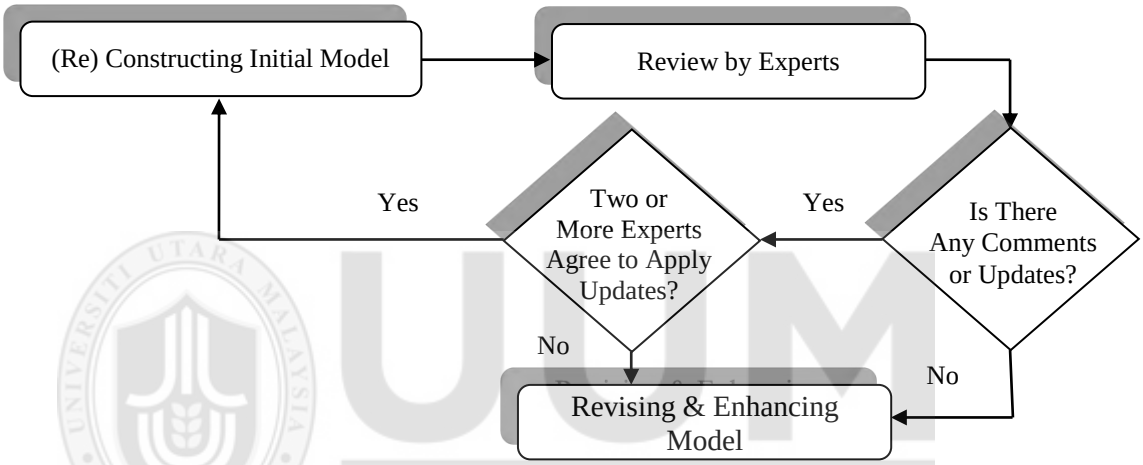


Figure 3.9. The Iteration Loop in the Model Construction Process

In fact, the proposed conceptual model aims to provide appropriate guidelines to design and develop a usable PDM during Umrah. In other words, it draws a roadmap to help anybody wanting to put efforts in designing and developing the PDM and fulfilling its requirements. Therefore, the conceptual model is engineered as a result of concatenation of formal and authoritative investigation related to multi-modality and usability in mobile applications. Scientifically, various methods (such as literature review, experts' consultation, preliminary study, SLR, as well as observing and interviewing users) have been employed to identify the usability attributes and aspects, validating and presenting the contents, and selecting the appropriate interaction modes.

3.6.3 Hypothesizing

As mentioned previously, ISO 9241 (1998) defines the usability as "the capability of a product to be understood, learned, operated and be attractive to users when used to achieve certain goals effectively and efficiently in specific environments". Attributes such as efficiency and effectiveness are clearly mentioned in the usability definition, while satisfaction has been implicitly mentioned by using the word "attractive" (Sauro & Kindlund, 2005; Bertoa et al., 2006). In addition, this study concerned about the usability of PDM that will assist pilgrims during Umrah and Hajj towards achieving accepted Umrah and Hajj Mabrur. On the other hand, the user's previous experience is one of the characteristics which can affect the product usability. Consequently, this study divided the pilgrims into two groups used users and new users based on their previous experience in Hajj and Umrah. Hence, satisfaction refers to attitude (Li et al., 2013) and acceptability (Choe & Schumacher, 2015). Therefore, according to the above discussion this study hypothesizes following hypotheses:

H_1: There is a significant difference between positive attitude of new users and used users of PDM.

H_2: There is a significant difference between the levels of acceptance between new users and used users of PDM.

H_3: There is a positive relationship between the effectiveness of PDM and the users' satisfaction.

H_4: There is a positive relationship between the efficiency of PDM and the users' satisfaction.

H_5: The mean score of overall effectiveness of PDM is high.

H_6: The mean score of overall efficiency of PDM is high.

H_7: The mean score of overall users' satisfaction of PDM is high.

3.6.4 Prototyping

Having a valid conceptual model needs to be translated into tangible artifact in order to validate its functionality and concepts. Therefore, prototyping approach has been employed. It can be defined as a procedure of converting the system's specification in the constructed conceptual design model into a tangible masterpiece (Dix et al., 2003; Sharp, Rogers, & Preece, 2007). In fact, prototyping has variety of methods and approaches. Obviously, the evolutionary prototyping and throwaway prototyping are considered the main bases of all methods and approaches (Dix et al., 2003). Based on Crinnion (1992), the evolutionary prototyping refers to the erection of a quite strong prototype in a systematic manner and improving it constantly. Whereas, the throwaway prototyping means building a prototype that would be ignored ultimately rather than fetching it as a part of the final application.

Here in this study a semi-working prototype simulates the final product that was developed along the line of the previous prototypes discussed in various conferences. It was developed following the approach by Laudon and Laudon (2015). According to Siti Mahfuzah (2011), using such kind of prototype enables users to test the functionality of final product and its flow. Also, the prototype provides them with a comprehensive view of the final version of the product, which would make them frankly and honestly casting their comments and impressions about the final product. On the other hand, implementing the prototype will enable the developers to test the proposed model's applicability and suitability.

3.7 The Fourth Phase: Evaluation

By the end of the development phase, the final PDM prototype was ready to be evaluated by users. Therefore, this phase describes how the evaluation instrument was

developed and how the usability test was conducted. Also, the process of constructing conceptual model the initial model was constantly reviewed by experts and being improved in an iteration loop with the development phase until obtaining the final model as stated previously. Figure 3.11 depicts the fourth phase and its sub-activities.

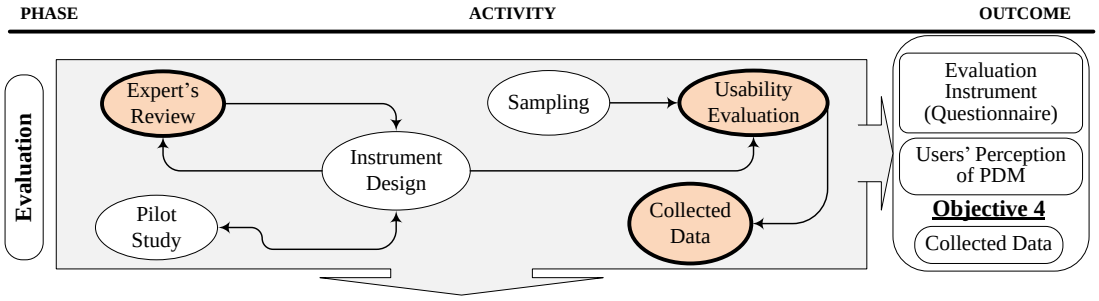


Figure 3.10. The Fourth Phase of Methodology (Evaluation)

3.7.1 Experts' Review

An expert review can be defined as a simple and swift evaluation method (Wiegers, 2001) and it does not involve actual users. However, according to Radice (2002) and Wiegers (2002), expert review is accepted and adopted as one of the significant techniques for product quality improvement and complementary to other types of product tests. Consequently, many studies adopt the expert review to evaluate the developed conceptual design model during the model construction process (Ariffin, 2009; Siti Mahfuzah, 2011; Syamsul Bahrin, 2011). Therefore, this study employs expert review to evaluate and enhance the conceptual design model for MMA-U during the model construction process as shown in Figure 3.6 as well as to validate the test instrument. Meanwhile, the same criteria listed in expert's consultation (Section 3.4.4) have been used to confirm the expert's expertise.

Shneiderman et al. (2010) asserts that in order to obtain a good and strong conceptual design model, there or five experts should be engaged. Therefore, in this study 15 experts have been involved in the experts' review. This study purposely considered

an odd number to obtain the most voted opinion in case of divergence of views. This implies that in the case whereby eight experts vote for opinion A and seven experts vote for opinion B, this study has the right to follow opinion A to enhance the model and ignores opinion B.

3.7.2 Usability Evaluation

In User-Centered Design and Interaction Design or such related fields, users are given the most attention and focus over technology (Barnum, 2002; Dix et al., 2003; Sharp et al., 2007; Barnum, 2011; Sharp et al., 2011; Wickens, Lee, Gordon, & Liu, 2011). Therefore, when a new technology is developed to serve users, the feedbacks obtained from users about their perceptions are adequate to judge on whether the technology meets the users' desires and won their satisfaction or not. However, according to Barnum (2002, 2011), usability is not just about (A) quality guarantee, (B) utility to design features, (C) nil defects, and (D) built-in in products, but it is saying slightly about usability of the product even though existence of such virtues in a product are assurance of its utility. Since usability focuses on users, consequently the product's usability evaluation process must be performed via users themselves by expressing their perception of certain issues such as ease of use, efficiency, learnability, intuitively, simplicity, usefulness and finally whether the product achieves their satisfaction or not (Nielsen, 1993; Dix et al., 2003; Sharp et al., 2007; George, 2008; Sharp et al., 2011; Albert & Tullis, 2013; Cockton, 2013; Dwivedi & Dubey, 2014).

Usability testing can be conducted in a lab, field, or remotely (Barnum, 2011). Nevertheless, the findings of many comparative studies show that each one of the environments can provide benefits as well as it has some limitations (Kaikkonen et al., 2005; Duh et al., 2006; Barnum, 2011; Ma et al., 2013) as discussed in Chapter 2 (Section 2.11.3). Therefore, the application's nature and the targeted audience play a

vital role in determining the appropriate place (environment) of conducting the usability testing (Duh et al., 2006; Barnum, 2011). Meanwhile, Ariffin (2009) affirm that carrying out a field study aims to witness how and what users do naturally as well as how the product mediates the user's activities in their original locations. Therefore, an empirical field study evaluation method named Trial-run was used to evaluate the prototype of this study, because it aims to develop a mobile application that assists Malay pilgrims while performing Umrah and the environment of Hajj and Umrah is extremely crowded and difficult to simulate. According to Sharp et al. (2007, 2011) Trial-run is a usability testing method in which the users are asked to perform the whole range of tasks and activities in the real environment (Appendix C provides a brief overview about each method). This method is powerful, provides valid data, reliable, high ecological validity, and it is aimed to reveal problem and improve usability of the product before release. Techniques such as observation (Ariffin, 2009), questionnaires, interviews, performance measures, and logging of activities can be used in data generation and collection in this method (Sharp et al., 2007, 2011). Meanwhile, questionnaire has been widely utilized by several studies as a trusty instrument of data collection (Offermann et al., 2009; Siti Mahfuzah, 2011). Therefore, questionnaire has been utilized in this study as an instrument for collecting data and the following sub-section describes how the instrument has been designed.

3.7.3 Instrument Design

This study concerns about the usability of PDM and earlier the usability attributes have been identified as a result of SLR in the second phase (suggestion). Therefore, the instrument should be able to measure all the selected usability attributes form the SLR. However, referring to most of usability evaluation models and frameworks, the

evaluation instrument must measure attributes such as usefulness and ease of use (Nielsen, 1993; Coursaris & Kim, 2006; Azham & Kutar, 2009; Shneiderman et al., 2010; Coursaris & Kim, 2011; Ma et al., 2013; Rosnita et al., 2013; Dwivedi & Dubey, 2014). Meanwhile, standard questionnaires such as Software Usability Measurement Inventory (SUMI) (Porteous, Kirakowski, & Corbett, 1993; Kirakowski, 1996; Kirakowski & Cierlik, 1998; Kirakowski, 2000) and the Post-Study System Usability Questionnaire (PSSUQ) (Davis, 1989; Lewis, 1995) have been widely adapted in many researches for preserving attributes such as usefulness, ease of use and outcome/future use. Furthermore, satisfaction is a critical criterion of product acceptance that cannot be numerically expressed or scaled through any quality test (Barnum, 2002, 2011), but many studies have attempted to develop an instrument for measuring user satisfaction such as the Questionnaire for User Interaction Satisfaction (QUIS) (Bailey & Pearson, 1983; Chin, Diehl, & Norman, 1988; Harper & Norman, 1993; Wang, Tang, & Tang, 2001; Ong & Lai, 2004; Shneiderman et al., 2010; Elias, Ghani, & Mohd, 2014). Consequently, all the above-mentioned instruments are adoptable to develop a questionnaire that is capable for measuring efficiency, usefulness, and satisfaction.

For the purpose of this study, the evaluation instrument is shaped as a series of questions that can be answered by using predefined multiple choice answers. It consists of two sections. The first section contains questions asking about the demographic data and the classification of the study sample. The second section involves questions asking the participants about their perception relating to the application in terms of the usability attributes. Therefore, in the second section, a five-point Likert scale answers (listed in Table 3.3) anchored by "Strongly Disagree" (1) and Strongly Agree (5), Very Difficult (1) and Very Easy (5) is used.

Table 3.3

Five-Point Likert Scale Format

Agreement Scale (Score)	Point of Agreement (Category)	
1	Strongly Disagree	Very Difficult
2	Disagree	Difficult
3	Neutral	Neutral
4	Agree	Easy
5	Strongly Agree	Very Easy

As previously stated, by the end of the SLR, the usability attributes to be measured are identified, thus determining the instrument's items depends on the outcomes of the SLR. Furthermore, according to Hussain and Ferneley (2008), each attribute is considered as a goal in the evaluation process. Meanwhile, each attribute has its own usability metric. Therefore, developing the evaluation instrument is depending on the attributes' usability metrics. On the other hand, Solingen and Berghout (1999), discovered that the Goal Question Metric (GQM), which is one of the accepted measurement approaches introduced by Weiss and Basili (1985) becomes popular and standard for the definition of measurement in many studies (Caldiera & Rombach, 1994; Solingen, Basili, Caldiera, & Rombach, 2002; Azham & Ferneley, 2008). It is adaptable to various environments and organizations. It has been employed by many companies such as NASA, Siemens, and Philips (Henry & Kafura, 1981). Therefore, this study employed GQM to develop the usability metrics and identify the items of the evaluation instrument. Then, the designed instrument was piloted to verify its reliability and validity before using it to measure the usability of the PDM (Bordens & Abbott, 2013).

3.7.3.1 Goal Question Metric Approach (GQM)

According to Weiss and Basili (1985), GQM is an approach used to create usability metric and guideline as well as usability measurement instrument. GQM is a hierarchical structure forming two steps beginning with goals and ends with a set of questions that

measure those goals (as illustrated in Figure 3.12). Therefore, the first step is refining each goal into several questions, while the second step is creating the metrics of each question. Thus, for the efficiency, the process is as the following:

G1: Efficiency

Q1: How quickly users can perform tasks?

M1: The time to complete task

M2: The consumed time to fulfil a given exercise

M3: The period used up on each screen

Q2: .....

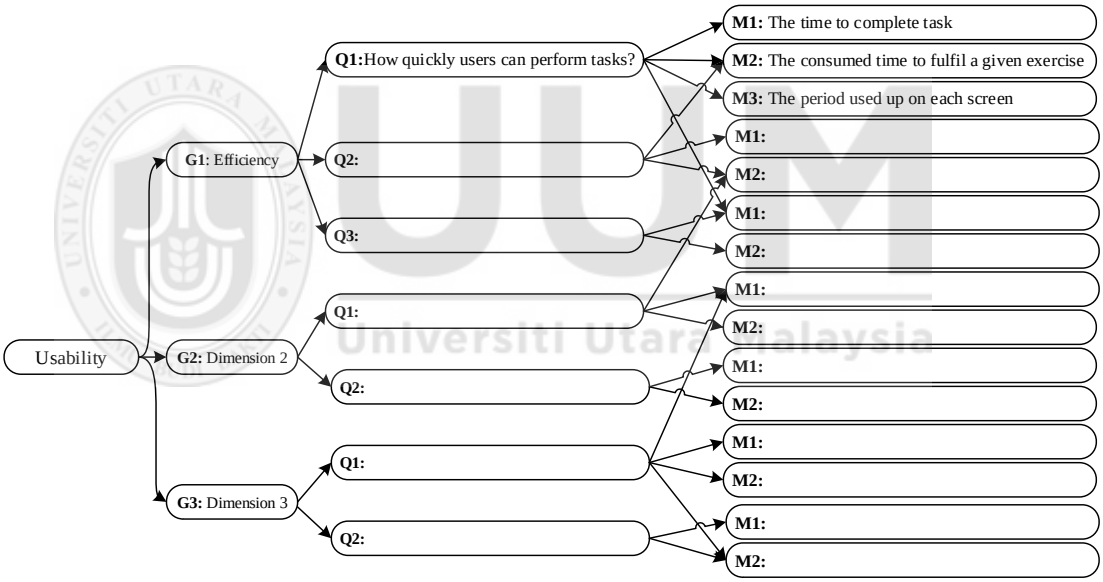


Figure 3.11. The Goal Question Metric Approach Introduced by
Source: (Weiss & Basili, 1985)

3.7.4 The Instrument Goodness Testing: Pilot Study

Pilot study can be defined as a miniature scale trial version of the study, which can be used to check the instrument goodness and the experimental procedures validity (Sekaran & Bougie, 2013). Therefore pilot study has been used widely to guarantee that instrument elements are really scaling the variables that are supposed to be

measured (construct validity) and the instrument reliability (Bordens & Abbott, 2013). However, Van Teijlingen and Hundley (2002) remind, that the success of pilot study does not mean a success of the original study, but it helps to increase the possibilities and chances of success.

In the same context, the Islamic Centre in University Utara Malaysia (UUM Pusat Islam) in collaboration with Lembaga Tabung Haji of Malaysia offers a regular practical training for the rituals of Hajj and Umrah for Malaysian pilgrims in Kedah. It is good opportunity to conduct the pilot study. Therefore, a small sample of those trainees and trainers were asked to experiences and use the prototype first. Then they were asked to use the instrument to evaluate the prototype. The findings of the pilot study are discussed in detail in Chapter 6.

3.7.5 Sampling

Generally, conducting any study aims to understand and solve the problems of the a targeted group of things (which could be for example items, organizations, people, companies, etc.) have specific characteristics which are called the population. It is very rare (almost impossible) owning an adequate amount of money and time to collect data from every member in the population. Therefore according to Sekaran and Bougie (2013), when the population is very large and dispersed in a geographic locations, a sample (selected subset) can be used by researchers in representing the whole targeted population. Sampling refers to the procedure of selecting random units, representatives or subset from the whole population targeted by the study, whereby the researcher can study the targeted population and fairly generalize the results and disseminate them (Marshall, 1996; Gaber, Zaslavsky, & Krishnaswamy, 2005; Sewdass & Du Toit, 2014). Accordingly, the sample must be appointed

carefully. Furthermore, this selected sample would accurately represent the targeted population via estimation and reflect all its characteristics, because an accurate and correct selection of the sample will definitely lead to obtain an accurate and correct data. Therefore, it means obtaining accurate and trusted results that can be generalized on the rest of the targeted population (Marshall, 1996). There are many practical techniques of sampling for representing the targeted population, but probability and non-probability sampling are the major sampling types. In the subsequent paragraphs, both types of sampling techniques are explained.

In probability sampling, every element in the targeted population has the opportunity to become one of the elected sample members. In contrast in non-probability sampling, the representativeness of sample is not critical to the study (Ariffin, 2009). Therefore, in non-probability sampling, not every member has a predetermined chance to being elected in the sample. Meanwhile, techniques such as systematic, random, cluster, area, stratified, and double are practicable in designing the probability sampling, whereas techniques such as judgment, convenience, and quota are practicable for designing the non-probability sampling (Cooper, Emory, & Schindler, 2003; Zikmund, Babin, Carr, & Griffin, 2012; Sekaran & Bougie, 2013).

On the other hand, the composition of the targeted population may be homogeneous or heterogeneous. The population homogeneity refers to that all the relevant characteristics somewhat evenly distributed among the population members. Bouma and Atkinson (1996) agree, that a small sample is sufficient and reliable if the targeted population is homogeneous, but it may not be sufficient and reliable in case of a heterogeneous and considerably variable population. In regards to this, Nielsen (2012a) and Burgess (2001) suggested that participation of five users in usability testing is sufficient statistically, while developers need to test at least 20 users in the statistics quantitative studies (not

insights) to obtain sufficient and reliable data. However, if the confidence intervals are strict they need more users to test.

As mentioned earlier, this study aims to help the pilgrims to perform Umrah rituals, and it is well known that Umrah and Hajj must be carried out at least once in a lifetime by every able bodied Muslim. Therefore, the term pilgrims includes all Muslims from both genders (male and female) who come from various backgrounds, nationalities, languages, ages, cultures, races, capabilities, skills, and educational levels as well as different levels of mobile application experience. Furthermore, Malaysia is the place of holding this study. Therefore, this study targets every Muslims who speak Malay or Indonesian languages, but it is still beneficial for pilgrims who speak Arabic language or any other languages on condition the ability to read the Arabic text.

In conjunction to the above-mentioned population, sampling, and the audience of this study, it clearly seems that the population in this study is homogeneous. Since the population of this study comes from several countries geographically contiguous having a converged cultures and languages, therefore factors such as nationality, language, culture, and race do not affect the population homogeneity. Furthermore, differences in gender, age, and skills will not have a significant impact on the population homogeneity as well. However, data must be collected from different genders, races nationalities, and educational level to prove the population homogeneity. On the other hand, characteristics such as age, ability to read Arabic text, experience in Hajj and Umrah, and experience in mobile application could have a significant influence on the authenticity and reliability of data if they are not represented in the sample.

The targeted population in this study is more than 250 thousand persons live in different countries in Malaysia, Indonesia, Singapore, Brunei, and Thailand. However persons in

this population have differences the major characteristics described in the previous paragraph such as age and experience in Hajj and Umrah. It has also been discussed that experts recommend to employ 20 subjects in qualitative study. Therefore, this study employs 129 participants (more than 20 for qualitative study). In detail, it consists of at least five persons from each category listed in Figure 3.12 (eight categories * five persons = at least 40 persons in the sample) identified using simple random sampling technique.

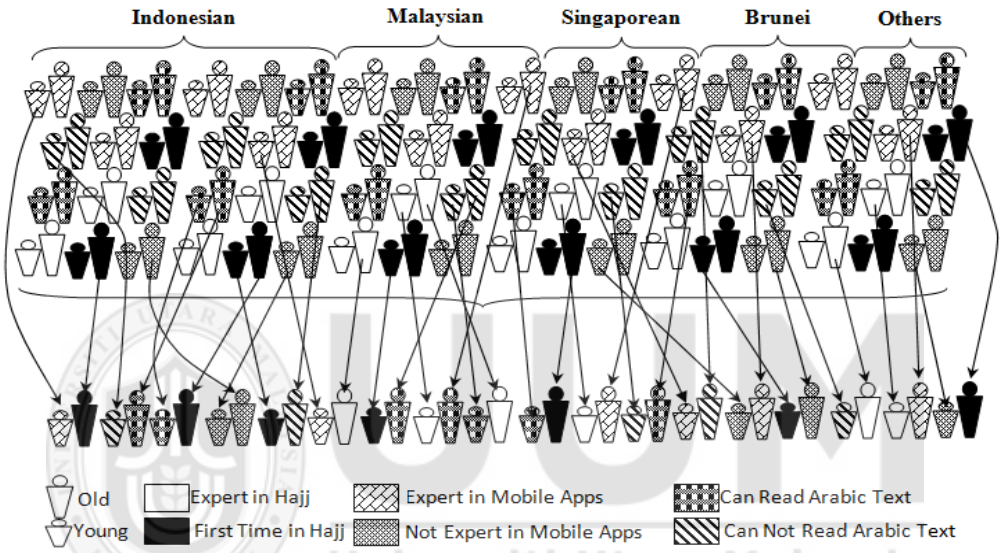


Figure 3.12. A Visual Representation of Selecting the Simple Random Sample in This Study

3.7.6 Data Collection

As earlier mentioned, the evaluation method named trial-run was been used to evaluate the developed prototype. According to Sharp et al. (2007, 2011), in trial-run method users are asked to perform the whole range of tasks and activities in the real environment. Questionnaire was used as the instrument to collecting data. On top of that, observation and interview were used to collect additional data such as admiration, facial expressions, happiness and acquisitions. All the techniques were used to collect data in the field during Umrah or Hajj season. The following steps were gone through:

1- Users were asked to perform one ritual such as Tawaf, Saie, or stoning of the Jamarat by using the conventional approach without the prototype assistance.
2- The users were allowed to navigate and operate the prototype.
3- The users were asked to perform the same rituals in Step 1 but with the prototype assistance.
4- The users were asked to answer the questionnaire.

The above-mentioned steps are considered as the procedure of data collection as seen in Figure 3.13. In steps 2 and 4, observation and informal interview took place. Particularly data such as the user's faults, facial expressions, performance speed, and difficulties faced while using the prototype were obtained through observation in step 2. While in step 4, an informal interview was used to obtain data such as the user's impression, admiration, happiness and acquisitions by asking some direct questions.

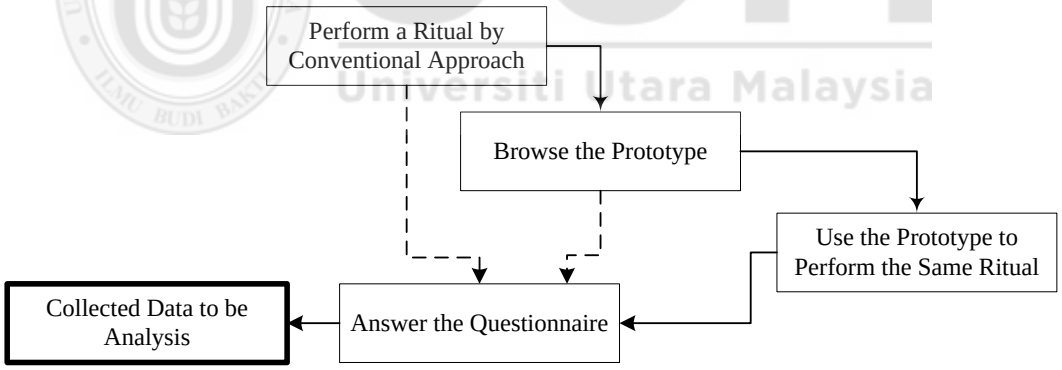


Figure 3.13. The Steps of Data Collection

3.8 The Fifth Phase: Conclusion

The last phase is conclusion, in which the collected data in the evaluation phase were analyzed. The results enable this study to generalize the findings (Figure 3.14). Therefore, this phase comprises two activities: (1) analyzing data and (2) concluding and reporting findings.

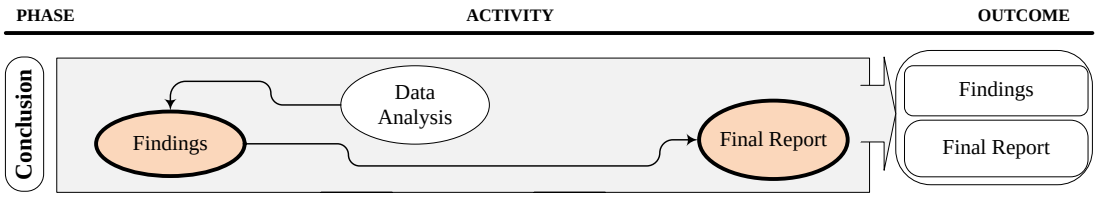


Figure 3.14. The Fourth Phase of Methodology (Evaluation)

3.8.1 Data Analysis

IBM SPSS version 18 was used to analysis the data collected through the questionnaires. As mentioned earlier, the Cronbach's Alpha Coefficient was used in the evaluation phase to test the instrument reliability. This means the data analysis took place in evaluation and conclusion phases. T-test and Descriptive Statistics were used in analyzing the data collected through questionnaires. The independent samples T-test was used to perform the comparison between the two groups. The significant value of T-test should be less than 0.05 to prove that there is a significant difference between the two groups (Coakes & Steed, 2009). Therefore, to prove that the population of this study is homogeneous, the significant value of T-test should be greater than 0.05, which implies no significant difference between pilgrims from different nationalities, cultures, and races, as hypothesised earlier. Since, this study hypothesizes that major characteristics of pilgrims such as age, experience in Hajj or Umrah, experience in mobile applications, and ability to read Arabic text will influence the evaluation of the prototype. Thus, the significant value of T-test should be less than 0.05 to show that there is a significant difference between these groups.

In descriptive statistics, a demographic description of the sample is discovered besides some descriptions on every attribute in the instrument. The mean value indicates the respondent's satisfaction. If the item score is below 3, it indicates that the respondent's satisfaction is very low and if the score is between 3 and 4, it indicates that the

respondents are not sure but if the score is 4 and greater, it shows a high satisfaction of the respondents. The results are discussed in Chapter 6.

3.9 Summary

This chapter elaborates the research design and all approaches, methods and techniques used in this study. This research takes the advantages of one of the widely prevalent research methodologies, which is DSRM by Vaishnavi and Kuechler (2008). It consists of five parts (1) awareness of problem, (2) suggestion, (3) development, (4) evaluation and (5) conclusion. Those five steps have been gone through and the outcomes have answered the research questions and achieved the research objectives.

CHAPTER FOUR
CONCEPTUAL DESIGN MODEL OF MMA-U

4.1 Overview

Previously, in Chapter 1 the research objectives of this study have been listed as well as the research questions to be answered. Then, Chapter 3 explains the methodological approaches, processes, and techniques used to achieve the objectives. Consequently, this chapter explains the construction procedure of the conceptual model for MMA-U. Meanwhile, in Chapter 2 describes a simple meta-analysis of related studies on multimodality and interactive multimedia which results in appropriate modalities and interaction modes to be incorporated in MMA-U. Figure 4.1 summarizes the construction activities as well as the methods used in each activity and their objectives.

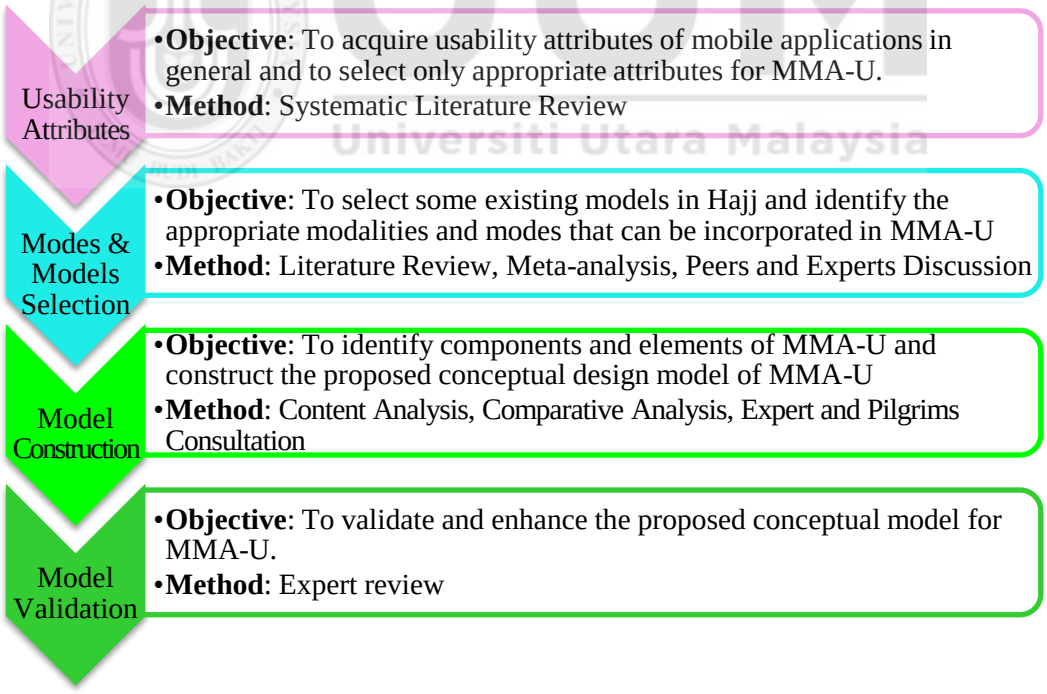


Figure 4.1. Summary of activities in constructing the conceptual model of MMA-U

As illustrated in Figure 4.1, prior to proposing the model for MMA-U, the most appropriate usability attributes for MMA-U need to be identified, this serves to achieve

the first objective of this study. Afterward, the existing models for Hajj and Umrah have been reviewed as well as some multimodal mobile applications in other fields. Meanwhile, the appropriate interaction modes that can be exploited MMA-U in to enhance its usability of PDM need to be selected carefully. In addition, different techniques such as content analysis, comparative analysis, as well as expert and pilgrims consultation have been utilized in constructing the proposed conceptual model for MMA-U. Nevertheless, expert review method has been utilized in validating the model.

The proposed conceptual model of MMA-U inherits the ideas of the existing conceptual models for Hajj and Umrah. Based on the idea, sufficient adaptation was made to suit the purpose of MMA-U which is to assist the pilgrims while performing their rituals during Hajj and Umrah. It is different than existing models which focus on acquiring initial perspective and background knowledge about Hajj and Umrah before going to Makkah as stressed in Chapter 1.

Based on the principles and theories of multimodality, IA, user interface architecture, user-centred design and user experience as well as usability guidelines, principles and theories that have been debated in Chapter 2, the appropriate elements and components of the proposed conceptual model for MMA-U have been discovered. Meanwhile, the elements have been identified through content analysis and comparative analysis and consultation with pilgrims and experts through UCD. Figure 4.2 illustrates the characteristics of the participants in constructing the proposed model, who have identified based on the criteria outlined in Table 4.1.

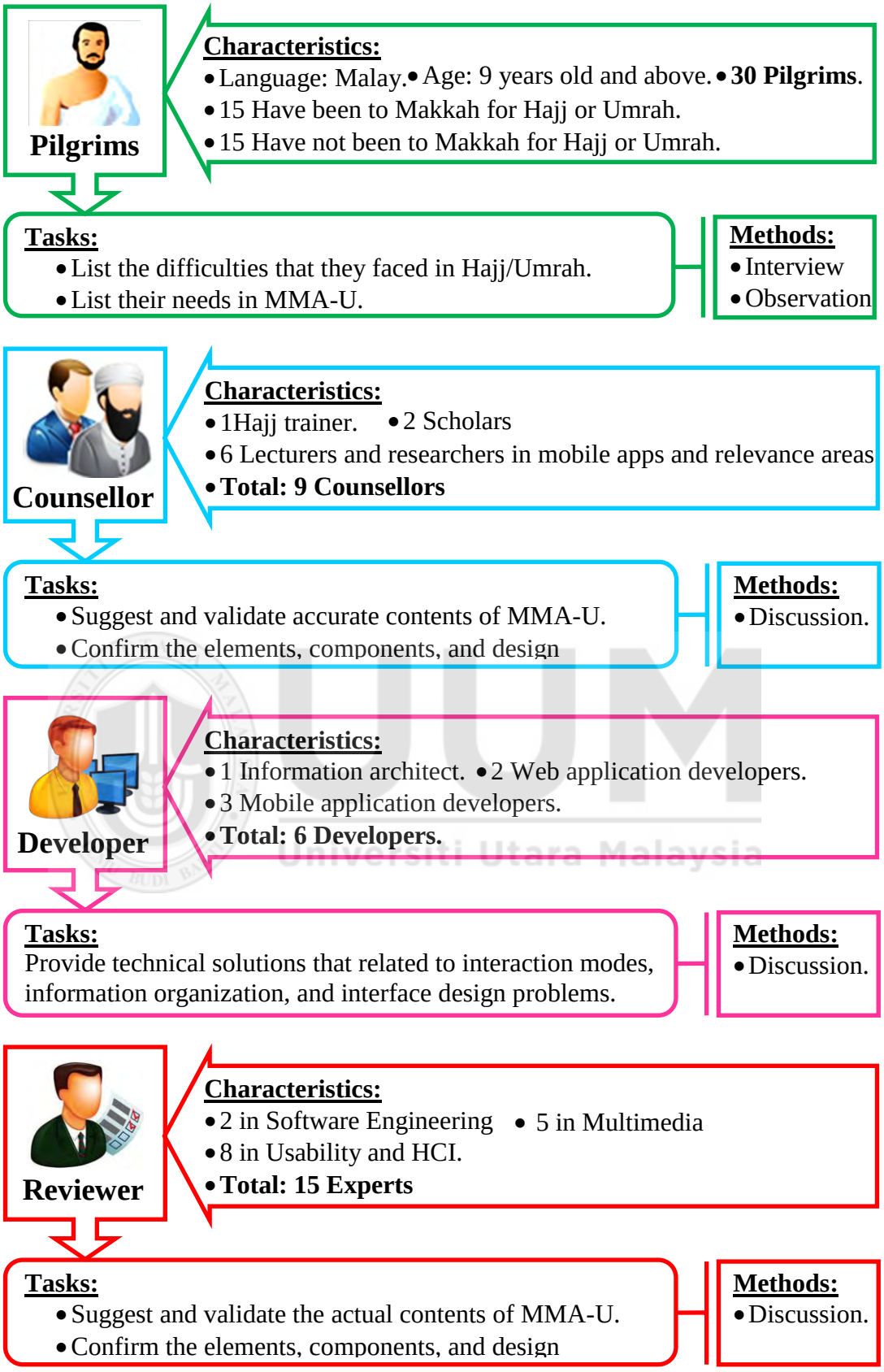


Figure 4.2. Summary of Participants in Construction Process of the Proposed Model

Table 4.1

The Criteria of Human Participants in UCD Cycles in the Construction Process of the Conceptual Model for MMA-U

Participant	Criteria	Justification
Pilgrims	1. Malay or Malay language speakers. 2. Their age over 9 years old.	Malaysian pilgrims are the targeted users of PDM. Whereas, the age of puberty (adulthood) in Islam is 9 years old. Therefore, involving them in the construction process of the proposed model is very important to identify the model's elements and design principles that can meet their needs during Hajj and Umrah.
Counsellors and Experts	Their criteria are as discussed in Section 3.4.4.	PDM is relating to Hajj and Umrah, the fifth pillar of Islam, so the contents of PDM must be hundred percent valid and legitimate. Therefore, participation of experts in Hajj (coaches and scholars) is necessary to gain valid legitimate contents. Meanwhile, participation of technical experts (lecturer or researcher in mobile application or relevant areas who have been in Makkah for Hajj or Umrah) is important to define the design specification, functional, and non-functional requirements of PDM.
Developers	Have experience in developing mobile apps for at least 3 years.	Involving mobile apps developers in the construction process of the proposed model is significant to confirm the technical part of the proposed model.
Reviewers	Their criteria are as discussed in Section 3.4.4.	Their participation is to review, comment, and validate the proposed model.

Briefly, MMA-U focuses on delivering contents to the pilgrim during Umrah on time based on their locations. Therefore, the proposed conceptual model of MMA-U gives particular attention to supporting the information accessibility, understandability, and navigation ability in ensuring that PDM delivers the right information at the right place and time. This information is called assistive contents. In the remaining sections of this chapter, the construction activities of the proposed Conceptual Design Model for MMA-U are detailed deeply.

4.2 Usability Attributes

As mentioned in Chapter 1, the first objective of this study is to identify the most appropriate usability attributes for MMA-U. To fulfill this objective, the research question "What are the most appropriate usability attributes MMA-U?" must be

answered. Therefore, an SLR has been conducted to identify the usability attributes of the mobile applications by using the "Usability", "Evaluation", and "Mobile" keywords. In this Chapter, the results of the SLR are reported. The first two steps of SLR (planning and conducting) have been elaborated deeply in Section 3.5.2.

Consequently, decision the exclusion and inclusion of the studies was subjected to the criteria of the review protocol that is developed in the planning phase (see Section 3.5.2.1). However, before identifying the primary studies, this study performed a quick search about the previous meta-analysis and systematic reviews that address the same research question "the usability evaluation in mobile" by using the same protocol to avoid repetitions and waste time. In fact, four studies (listed in Table 4.2) have been found in which the same research question has been addressed by using the same research protocol. Accordingly, the research protocol time limit has been changed to retrieve the studies that have been published between 2013 and 2016.

Table 4.2

The Previous SLRs that Addressed the Same Research Question by Using the Same Research Protocol

Year	Author	Title
2006	Coursaris and Kim	A Qualitative Review of Empirical Mobile Usability Studies
2009	Hussain and Kutar	Usability Metric Framework for Mobile Phone Application
2011	Coursaris and Kim	A Meta-Analytical Review of Empirical Mobile Usability Studies
2013	Rosnita, Dalbir, and Rozilawati	Usability Attributes for Mobile Applications-A Review

In order to minimize the omission of relevant studies, the reviews were performed based on multiple databases. As a result 261 journal articles have been downloaded (sparing years are detailed in Table 4.3). These articles were reviewed and 18 articles were selected based on the criteria defined in the planning phase (Section 3.5.2.1).

Table 4.3

The List of Selected Journals Titles in HCI and Usability and Number of Candidates and Selected Papers

Journal Title	Publishing Year			Total Number of Journals	
	2013	2014	2015	Candidate	Selected
Computers in Human Behavior	11	21	20	52	6
Human-Computer Interaction	6	12	7	25	0
Interacting With Computers	24	9	11	44	2
International Journal Of Human-Computer Interaction	32	31	19	82	5
International Journal of Mobile Human Computer Interaction	2	12	1	15	1
Journal of Usability Studies	5	10	2	17	2
Transactions on Computer - Human Interaction	10	9	7	26	2
Total	90	104	67	**261**	**18**

4.2.1 Reporting the Review

In this step, the 18 selected papers and the previous SLRs have been analyzed carefully and summarized. This study focused on the measures that have been addressed in selected studies in measuring and evaluating usability. The Analysis reveals that there are 27 measures commonly appear in the existing models. They are summarized in Table 4.4.

Table 4.4

The Original List of Usability Measures in the Previous SLRs

No	Measures	2006	2009	2011	2013	Freq.	Decision
1.	Effectiveness	√	√	√	√	4	Become main usability attribute
2.	Efficiency	√	√	√	√	4	Become main usability attribute
3.	Satisfaction	√	√	√	√	4	Become main usability attribute
4.	Errors	√		√		2	Become sub usability attribute
5.	Attitude	√		√		2	Become sub usability attribute
6.	Learnability	√		√	√	3	Combined to attribute (Ease of use)
7.	Accessibility	√		√	√	3	Become sub usability attribute
8.	Operability	√		√	√	3	Combined to attribute (Acceptability)
9.	Accuracy		√	√		2	Combined to attribute (Reliability)
10.	Acceptability	√		√	√	3	Become sub usability attribute
11.	Flexibility	√		√	√	3	Become sub usability attribute
12.	Memorability	√		√	√	3	Combined to attribute (Ease of use)
13.	Ease of use			√	√	2	Become sub usability attribute
14.	Usefulness			√	√	2	Become sub usability attribute
15.	Utility			√		1	Combined to attribute (Usefulness)
16.	Playfulness			√		1	Combined to attribute (Acceptability)
17.	Simplicity		√		√	2	Become sub usability attribute

Table 4.4 Continued

18.	Attractiveness	√		√		2	Combined to attribute (Acceptability)
19.	Safety		√		√	2	Become sub usability attribute
20.	Intuitiveness				√	1	Combined to attribute (Simplicity)
21.	Aesthetic				√	1	Combined to attribute (Attitude)
22.	Consistency				√	1	Combined to attribute (Flexibility)
23.	Adaptability				√	1	Combined to attribute (Flexibility)
24.	Reliability				√	1	Become sub usability attribute
25.	Understandable				√	1	Combined to attribute (Simplicity)
26.	Compatibility	√					Combined to attribute (Flexibility)
27.	Enjoyability	√					Combined to attribute (Attitude)

Table 4.4 exhibits that the studies focus clearly on the usability measurements defined by ISO 9241-11 (1998) which are effectiveness, efficiency, and satisfaction. Meanwhile, the other measures appear independently or listed under these three measurements subjected to the nature of study. Some of these measurements are synonymous or a part of other measures. Therefore, the original list has been collapsed by combining the synonymous measures to each other under one name as well as incorporating the sub measures under the main measures. Table 4.5 shows the collapsed list of the usability measures. Then, the next paragraph explains how the 27 measures are collapsed into ten sub-measures under the main three measures.

Table 4.5

The Collapsed List of Usability Measures

ISO Measures	No.	Sub- Measures	Combining to\ Incorporating with
Effectiveness	1.	Usefulness	Utility
	2.	Errors	Accuracy
	3.	Simplicity	Intuitiveness, Understandability.
	4.	Reliability	Accuracy
Efficiency	5.	Ease of use	Learnability, Memorability.
	6.	Safety	
	7.	Flexibility	Compatibility, Adaptability, Consistency.
	8.	Accessibility	Operability
Satisfaction	9.	Attitude	Enjoyability, Playfulness
	10.	Acceptability	Attractiveness, Aesthetic.

From 18 selected studies, 88.9% of them use the effectiveness as one of the measures in the usability evaluation instrument, whereas efficiency and satisfaction appear in 77.8% of the studies. Other measures appear as follow: usefulness 83.3%, errors 44.4%, simplicity 94.4%, reliability 38.8%, ease of use 77.8%, safety 16.6%, flexibility 27.8%, accessibility 22.2%, attitude 66.6%, and acceptability 50%.

According to Mohammadi (2015), errors, usefulness, reliability, and simplicity can be grouped as effectiveness. Similarly, Molina et al. (2014) group utility, accuracy, and intuitiveness as effectiveness. A system is simple when it is learnable, understandable, memorable, and intuitive (Negahban & Chung, 2014), whereas, reliability means accuracy (Shuib, Shamshirband, & Ismail, 2015), and efficiency means ease of use (Salazar, Lacerda, Nunes, & von Wangenheim, 2013).

Meanwhile safety, flexibility, and accessibility can be grouped as efficiency. Further, flexibility means consistency, adaptability, and compatibility (Motamedi & Choe, 2015), while accessibility means operability (Youngblood & Youngblood, 2013). Then, Li et al. (2013) refers satisfaction to attitude, which particularly refers to user's comfortable feeling level when using a product. It also means acceptability, which implies users' acceptance of a product in terms of achieving their goals (Choe & Schumacher, 2015). Further, enjoyability, attractiveness, playfulness, and aesthetic are part of satisfaction and refer to the degree of user's comfortable feeling when using a product (Silvennoinen, Vogel, & Kujala, 2014). This clusterization is schematically illustrated in Figure 4.3.

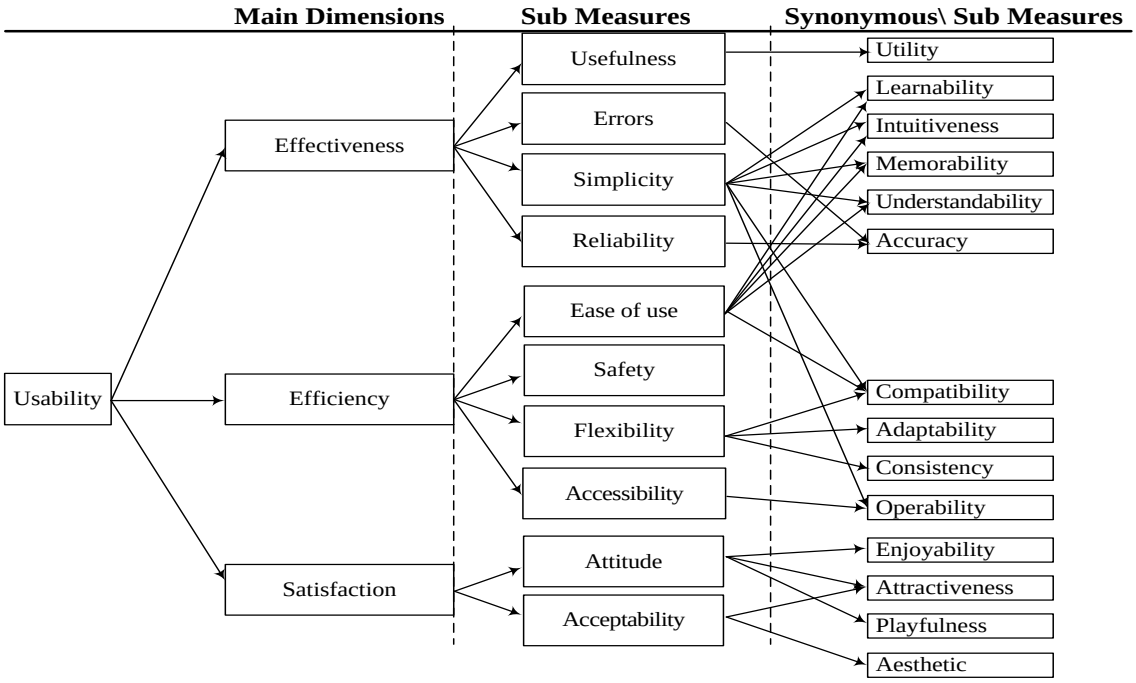


Figure 4.3. Summary of How the 27 Usability Measures collapsed to ten only

4.3 Mode and Models Selection

As mentioned in Chapter 1, many efforts have been initiated to facilitate the difficulties faced by pilgrims. Unfortunately, those studies focus on acquiring initial perspective and background knowledge about Hajj and Umrah before going to Makkah. Therefore, as a response to that, this study focuses on designing an assistant for pilgrims during Umrah. The proposed assistant must be portable (on mobile phone) as well as usable in the extremely crowded environment (environment of Hajj and Umrah). Therefore, a preliminary study has been conducted to understand the needs of the pilgrims (see Section 1.3), in which various versions of MDZ4H have been developed.

4.3.1 Interaction Modes

Results of the preliminary study have been discussed in various intentional conferences. Through the discussions, critical and important suggestion that enhance the usability of MDZ4H (Table 3.1 in Section 3.5.1 provides the findings were gathered). In short, that suggestions include to add new interaction modes to the

current version besides the manual mode (touch screen with menus and buttons) to increase the accessibility. Also, peers and experts recommended to embed three new interaction modes in MMA-U: embedded sensor mode, Voice command mode, and GPS mode. In contrast, the developers recommended to exclude the embedded sensor mode because it needs a special infrastructure in the holly places, which requires the KSA government's permission to install. The next sub-sections discuss the newly-recommended interaction modes in MMA-U.

4.3.1.1 GPS Mode

Location-Based Services (LBS) can be defined as an applications that takes advantage of the information of the physical location of a mobile device for the purpose of providing services based on available information (Mahmoud, 2004; Singhal & Shukla, 2012). Recently, LBS application has become very popular. Those kind of mobile applications can easily track user location and may offer additional services such as locating amenities nearby, as well as offering suggestions for route planning. One of the key ingredients in an LBS application is map, which represents a visual representation of certain locations (Lee, 2012). It can be classified into many categories depending on the purpose of use and the service. Therefore, LBS can be utilized in MMA-U as an automatic interaction mode through which the right and necessary instructions will be given automatically to the pilgrims at the right time and please based on their current location (Ververidis & Polyzos, 2006). Based on the literature, this mode has not been used in the existing models for Hajj and Umrah or in the current Hajj and Umrah Apps in google play. Therefore, incorporating such mode in such assistance can be considered as one of the contributions of this study.

4.3.1.2 Voice Commands Mode

Speech recognition (SR) in Electrical Engineering and Computer Science refers to the process of spelling the spoken words to written words or text (Konno et al., 2013). It is part of voice recognition, which concerns about distinctive voices to determine either speaker's identity (speaker recognition: who the speaker is) or the spoken words (speech recognition: what the speaker says) (Sandilyan & Darley, 2013). Nowadays, voice recognition is used in many daily life fields such as education (Jones, 2005), car systems (Graham & Carter, 2000), healthcare (Sandilyan & Darley, 2013), telephony (Balentine & Morgan, 1999), and military aircraft (Wurgler, 1987). It is used in many forms such as speech-to-text (e.g., emails, SMS, or word processors), aircraft (usually called direct voice input), data entry (e.g., entering a dates or credit card number), and voice dialling (e.g. "Call home").

There are two mechanisms used to realize and detect the spoken words, which are Speaker Independent Speech Recognition (SISR) and Speaker Dependent Speech Recognition (SDSR) (Mehla & Aggarwal, 2014). In the SDSR mechanism, each new user of the system is required to read a specific text, in order to train the system to recognize the user's voice. The system analyses the user's voice into tones, which is used to adjust the voice recognition of that user in order to get the best accurate transcription (Merrow et al., 2013). In contrast, SISR does not require and training (Sinha, Agrawal, & Jain, 2013).

With regards to the discussions in the previous paragraphs, this study attempts to incorporate the voice activated function in the MMA-U as an interaction mode. For that, the app by Google is utilized.

4.3.2 Models Selection

Since MMA-U stretches the ideas of the existing conceptual models, the existing models

and applications of Hajj or Umrah have been used as the basis in constructing MMA-U. Therefore, to get the generic components of MMA-U; the existing applications, and models have been compared. The samples that have been included in the comparison are collected from various outlets including in Google Play and are divided into two types: (1) Desktop Models (DT) and (2) Mobile Applications (MA) for Hajj and Umrah. This section was made based on the arguments detailed in Table 4.6.

Table 4.6

Justification of Selecting Desktop Models for Hajj and Umrah (DT)

No.	Name and Author	Justification
DT1	Web Services-Based Hajj Information System (Harmain, et al. 2004).	This model builds background knowledge about Hajj by giving the latest information on Hajj and guiding people during the Hajj season
DT2	Web-based Hajj simulation (Fathnan et al., 2010)	This model have been selected because it enhances the Hajj performance's usefulness by delivering a new media in the education of Hajj for pilgrims
DT3	V-Hajj (Mohd-Fitri, et al. 2011).	This model enhances the user experience in performing Hajj and Umrah.
DT4	Virtual Umrah (Normala, et al. 2013).	This model provides a realistic experience for Muslims in performing Umrah
DT5	Manasek AR (Taileb et al., 2014)	This model is a location-based augmented reality application for Hajj and Umrah.

Further, Table 4.7 describes the criteria for each selected mobile application from Google play. They were selected based on the following criteria:

- The application must be published not earlier than 2015 and are rated by 4 points or above.
- The application must have been installed over than 10000 times.
- If any developer has more than one application the highest rated application will be selected. Also if the application has many versions the latest version will be selected.

Table 4.7

List of the Selected MA from Google Paly with Justification

No.	Name	Developer	Publishing Date	Rate	Installation Times **	Justification
MA1	Salam: Hajj & Umrah Guide	Hajj Net	25\09\2015	4.6	100-500	This application saves time and makes it easier to pray, perform Hajj and Umrah. It has ranked in the top 10 in Apple's Travel category in 59 countries. According to Sky News Arabia, this application is "the first smartphone application to serve millions of Hajj pilgrims"
MA2	Al-Mutawif for Hajj, Umrah and Ziarah (المطوف الحج والعمرة والزيارة)	Madar Software	18\09\2015	4.6	100-500	This application provides comprehensive information related to Hajj, Umrah and Ziarah in one compact package in Arabic language. It's easy to navigate interface provides a step-by-step description of all Hajj, Umrah and Ziarah related matters and takes away the agony of flipping through various pages to get you through directly to the information that you really want.
MA3	Hajj and Umrah Guide	Darussalam Publishers and Distributors	02\09\2015	4.7	10-50	This application provides comprehensive and easy-to-understand Guide about the Holy Pilgrimage to Mecca. Pilgrims can learn rituals alongside their respective places; like, what to perform/recite at the Holy places.
MA4	Hajj and Umrah	I.T. Department of DawateIslami	28\08\2015	4.7	10-50	This application designed to provide the Pilgrims with thorough knowledge and essential information about Hajj and Umrah, this application contains a detailed account on how to perform Hajj and Umrah correctly including the method and types of Hajjas well as different Dua's (supplications). It also consists of a detailed account about Shariah rulings in the form of questions and answers.
MA5	Umrah & Hajj Guide	Quran Reading	08\09\2015	4.4	10-50	This application helps Muslims all over the world to know about every aspect of performance of religious rituals of Umrah and Hajj in the most effective way.
MA6	Haji Pintar	Kementerian Agama Ri Indonesia	18\09\2015	4.5	10-50	This application is an easy and comprehensive guide to know all the information related to Hajj in the Holy Land in Makkah as well as in Madinah.

Table 4.7 Continued

MA7	Manasik Haji dan Umrah	Pusat Kajian Hadis Indonesia	21\08\2015	4.5	10-50	This application is an easy and comprehensive guide to know all the information related to Hajj and Umrah.
MA8	Hajj & Umrah Guide	Yuumedia	30\09\2015	4.4	10-50	This application educates and trains the congregation of Hajj and Umrah in the process of teaching and learning. It also provides guidance and procedures to implement the complete Hajj and Umrah according to sunnah wal jamaah experts to get Hajj and Umrah accepted.
MA9	Lovers' Hajj (حج العاشقين)	Mohib Group for Production and Creativity	14\09\2015	4.4	10-50	This application explains the rituals of Hajj step by step in Arabic language. It contains a 3D animation shows and explains everything with regard to the Hajj.
MA10	Telkomsel Ibadah	Telkomsel	31\08\2015	4.4	10-50	This application contains complete and comprehensive information about prayers and locations that should be visited during Umrah and Hajj.
MA11	Hajj and Umrah Guide English	As-Sirat Zoxcell's Islamic Apps	17\09\2015	4.4	10-50	This application is a complete offline Hajj and Umrah guide in English language to learn how to perform Hajj and Umrah. This app explains each Hajj and Umrah steps in detail. Arabic supplications during each step with their translation. With audio of supplications and Image gallery. It is good featured app, can customize the text colour, font, size and background colour.
MA12	Hajj aur Umrah in Urdu	Oracle Developers	03\07\2015	4.4	10-50	This application is a humble effort to spread the knowledge of Performing Hajj and Umrah according to Islam in Urdu Language. It contains dua's and lafadz that will facilitate while performing Hajj and Umrah in the Holy Land.
MA13*	Hajj Amharic	Bilal Apps	02\06\2015	4.2	10-50	Hajj Amharic is a hajj full guide in Amharic for Ethiopian Muslim

*Model No. 13 is an application in Ethiopian language, therefore it were excluded from this study because the researcher can't got assistance to understand the contents and structure of that application. Meanwhile, the researcher got his colleagues assistance to understand the contents and structure of the applications in English, Malay, Urdu, and Arabic.

** In the Table every one installation time is equal 1000 times to be read (Exp. 10-50 = 10000-50000).

Generally, each model (DT or MA) selected in this study has been selected based on a set of criteria and reasons, which is seen unique according to interest. Some models interest this research via the interaction modes, while some with the contents as well as their content basis. Therefore, it has been emphasized in advance that the selected models have been selected in order to produce generic components of MMA-U. The process of constructing the proposed conceptual model of MMA-U is elaborated deeply in the next section.

4.4 Model Construction

This section describes the generic components that form the proposed conceptual model of MMA-U. The components are defined separately in terms of Structural Components (SCs), Content Composition Components (CCCs), design principles, technology, and the development approach.

4.4.1 Structural Components (SCs)

The proposed MMA-U must be organized properly in order to ensure that pilgrims are getting the appropriate assistance effectively and properly during the performance of their rituals at the right time by the right way in the right place. Therefore, MMA-U must be structured in a coherent and consistent manner starting from the beginning until the end (Efendioğlu, 2012; Nurulnadwan, 2015). Briefly, the way of presenting the contents should make sense to the pilgrims.

Accordingly, content analysis and comparative analysis techniques were utilized in determining the components of MMA-U. This study takes the advantages of the existing applications in Google play to determine the structural component segments of MMA-U. Previously, Ariffin (2009) and Nurulnadwan (2015) discovered that the SC comprises

three segments. They are (i) opening segment that contains not the actual content about an overview the application, (ii) content segment that contains the application's actual contents, and (iii) closing segment to indicate that the content is about to end. Table 4.8 outlines the details of those segments.

Table 4.8

Details of the Structural Components

Section	Component	Details
Opening	Title	The Name of the product.
	Logo	A graphic symbol, sign, emblem, or design represents and symbolizing to the product.
	Developers	List of persons or/and establishments whom participated in the making of the product.
	Sponsors	List of the official establishments who supported the making of the product.
	Introduction	An overview about Umrah and Hajj such as types of Hajj, duties and pillars of Umrah and Hajj. Also how pilgrim prepares himself.
Content	Instructions	The instructions of how to preparing, starting, doing and finishing all the rituals of Umrah and Hajj.
	Supplications	The prayers and supplications that must be recited during the rituals of Umrah and Hajj.
	Separators	Spacers between the various rituals of Umrah and Hajj or between the steps of the rite itself.
Closing	Assistance and Support	General tips, maps, and guidance on the pilgrimage and sacred places in Makkah and Medina.
	Thanking Remarks	Thanks and appreciation for participation in making and using of the product.
	Acknowledgement	Acknowledging the content contributors whom their contents are used in the product.

Source: (Ariffin, 2009; Nurulnadwan, 2015)

As mentioned earlier, MMA-U stretches the ideas of the existing models and applications of Hajj or Umrah. Therefore the SC of the selected models were analysed and compared. Meanwhile, snapshots of the existing applications (as illustrated in Appendix D) are highly beneficial to deduce the SC of MMA-U. The results of the analysis and comparison are tabulated in Table 4.10 and Table 4.11, while Table 4.12

summaries the results based on the regulations in Table 4.9.

Table 4.9

Components Categories Index

Index	Description	Condition
A	All models apply	**100%** models apply
M	Majority of models apply	There are **50% or more** models applying
F	Few models apply	There are **less than 50%** models applying
X	Not applied in any model	There is **no (0%)** model applying

Table 4.10

Structural Components for DTs

Section	Component	DT1	DT2	DT3	DT4	DT5	Rate	Index
Opening	Title	✓	✓	✓	✓		80%	**M**
	Logo			✓	✓	✓	60%	**M**
	Developers		✓		✓		40%	**F**
	Sponsors						0%	**X**
	Introduction	✓	✓	✓	✓	✓	100%	**A**
Content	Instructions	✓	✓	✓	✓	✓	100%	**A**
	Supplications	✓	✓	✓	✓	✓	100%	**A**
	Separators	✓	✓	✓	✓	✓	100%	**A**
Closing	Assistance and Support	✓					20%	**F**
	Thanking Remarks			✓			20%	**F**
	Acknowledgement						0%	**X**

Note: ✓ means contained in the model.

Table 4.11

Structural Components for MAs

Section	Component	MA1	MA2	MA3	MA4	MA5	MA6	MA7	MA8	MA9	MA10	MA11	MA12	Rate	Index
Opening	Title	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	92%	M
	Logo	✓	✓	✓	✓	✓	✓	✓		✓	✓			75%	M
	Developers		✓	✓		✓	✓		✓	✓		✓		58%	M
	Sponsors		✓				✓	✓		✓	✓		✓	58%	M
	Introduction	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	83%	M
Content	Instructions	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	83%	M
	Supplications	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	92%	M
	Separators	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100%	A
Closing	Assistance and Support	✓	✓	✓	✓	✓	✓	✓		✓	✓			75%	M
	Thanking Remarks	✓		✓										17%	F
	Acknowledgement		✓					✓		✓				25%	F

Note: ✓ means contained in the model.

Table 4.12

Summary of Structural Component of Existing Models

Section	Component	DTs	MAs
Opening	Title	**M**	**M**
	Logo	**M**	**M**
	Developers	**F**	**M**
	Sponsors	**X**	**M**
	Introduction	**A**	**M**
Content	Instructions	**A**	**M**
	Supplications	**A**	**M**
	Separators	**A**	**A**
Closing	Assistance and	**F**	**M**
	Thanking Remarks	**F**	**F**
	Acknowledgement	**X**	**F**

Description of symbols

A : **All** models applying

M : **50% or more** models applying

F : **less than 50%** models applying

X : **No** model applying

Based on the findings of the comparative analysis for the existing model that has been summarized in Table 4.12 the SCs of MMA-U have been derived and provided in Table 4.13. The basis of the conditions is laid down in Figure 4.4.

Condition 1: The component is compulsory (☻) when there is any **A** OR there is at least one **M** with no **X** in the row.

Condition 2: The component is recommended (☺) when there is only **F** and **X** in the row.

Figure 4.4. Classification Condition

Table 4.13

The Proposed Structural Component of MMA-U after Analysis

Section	Component	MMA-U
Opening	Title	☻
	Logo	☻
	Developers	☻
	Sponsors	☺
	Introduction	☻
Content	Instructions	☻
	Supplications	☻
	Separators	☻
Closing	Assistance and Support	☻
	Thanking Remarks	☺
	Acknowledgement	☺

Description of symbols

☻ : Compulsory to apply

☺ : Recommended to apply

The analysis results shows that the SCs listed in Table 4.12 were contained in the existing models and applications of Hajj and Umrah, but with different labels. Some SCs are contained in all models while some appear in at least one model. On the other hand, the reliability of contents one of the major effectiveness standards, that must be met in the proposed solution by this study to ensure the usability. With regard to this issue, adding the name or logo of the official sponsors in the opening section as well as the names of contents contributors in the acknowledgement sub-section is highly recommended by some experts (Nurulnadwan, 2015). They also stressed that the contents will be reliable and more acceptable by users whenever the contents contributors and sponsoring entity are experts, accredited, and famous.

Consequently, some of the recommended structural components listed in Table 4.13 such as acknowledgement and sponsors were changed to become structural components that compulsory to apply in the proposed model of MMA-U as shown in Table 2.14. And accordingly the model of MMA-U structure could be obtained and illustrated in Figure 4.5.

Table 4.14

The Proposed Structural Component of MMA-U after Experts Revision

Section	Component	MMA-U
Opening	Title	☻
	Logo	☻
	Developers	☻
	Sponsors	☻
	Introduction	☻
Content	Instructions	☻
	Supplications	☻
	Separators	☻
Closing	Assistance and Support	☻
	Thanking Remarks	☺
	Acknowledgement	☻

Description of symbols

☻ : Compulsory to apply

☺ : Recommended to apply

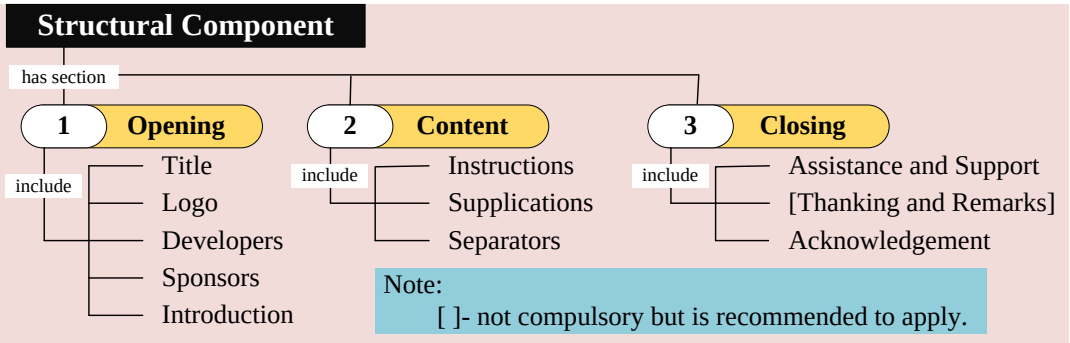


Figure 4.5. The Proposed Model for SC of MMA-U

4.4.2 Content Composition Components (CCCs)

As mentioned earlier, the purpose of designing MMA-U is to assist pilgrims during Umrah. This study focuses on the usability of PDM during Umrah; meanwhile it is known that the environment of Umrah and Hajj is extremely crowded. Consequently, composing content of MMA-U needs adequate efforts to ensure the contents are deliverable in appropriate manner as a personal assistance during ritual tasks. The contents that need to be delivered are called assistive contents. Therefore, composing contents in MMA-U must give particular attention to supporting the information usefulness, accuracy, accessibility, simplicity and understandability.

Earlier in Chapter 2, the usability issues as well as the theories and principles of multimodality, information architecture, and interactive design have been discussed deeply, and how they influence the process of constructing the content composition. According to Saffer (2010) and Sharp et al. (2011), PDM should have an interaction design that is able to support the human communication patterns similar to communication between the human mutawwif and the pilgrims. This means that PDM must have an interactive interface to facilitate the interaction between the pilgrims and the services provided by PDM. Therefore, this study believes that interaction design and human entities play a serious role in delivering assistive information. In overall, there are two categories

of components in this study which are: (1) interaction design, and (2) human entity.

On top of the discussions in the previous paragraphs, the same models and steps that have been used in identifying the structural components were also used to identifying content composition components of MMA-U. The process begins with analysing the existing models which designed for desktop followed with the mobile applications and finally the results of both types have been summarized. Next sub-sections list and elaborate all samples for CCCs for SCs in the context of this study.

4.4.2.1 Interaction Design

Goal-oriented design is one of the interaction design methodologies, which "concerns on satisfying the needs and desires of the people who will interact with a product or service" (Lal, 2013). Therefore, in this study the UCD approach has been employed in designing MMA-U. Multimodality has been involved in this study to enhancing the usability of PDM. Consequently, the interaction design in this study is divided into four sub-categories; (a) modalities, (b) presentation styles, (c) instruction strategies, and (d) flow styles.

I. Modalities

Mode can be defined as a socially and culturally shaped resource for making meaning. According to Kress and Bezemer (2009), images (such as icons or figures, and animations), speech, text, and layout, can be considered as examples of modes. However, each mode has dissimilar modal resource because each mode has different limitations and meaning (Kress, 2010). Besides, the existing models utilize and adapt the media elements to enhance the interaction between the product and users. Therefore, this study uses a mixture of media elements such as visual, textual, and

audio to give an effective meaning that is able to simplify the presented information and increase the audience absorption (Giberson & Moriarty, 2010; Lutkewitte, 2013). With regard to this study, the existing models generally contain the modalities (with their descriptions) as listed below:

1. **Audio:** The audible materials such as supplication, narration, and recitation.
2. **Visual:** The visible materials such as:
    a. **Texts:** Written words such as labels, titles, and content description.
    b. **Images:** Any optical form represent or counterpart of a real object.
    c. **Graphics:** Any diagram showing the structure, appearance, workings, or steps of something. It is helpful in representing the complex concepts.
    d. **Animations:** Any movable object used to clarify complex concepts.

The idea of proposing the above-mentioned modalities and included in a multimodal interactive design for MMA-U is inline with the theory of multi-modal interaction, which hypotheses that communication was facilitated by providing multiple channels and maximising bandwidth (Whittaker & Walker, 1991). This means more freedom in interacting with systems in a natural way via the input and output channels (Stivers & Sidnell, 2005) and provides an efficient, flexible and usable interaction environment (Sowa et al., 2001). Thus, those multimedia elements can be processed as follows:

1. **Fusion:** The process of recognizing the inputs through the various input channels and combining them in order interpreting them.
2. **Fission:** The process of dividing or selecting the output channels to distribute the information through the available outputs and according to the user profile and environmental context.

II. Presentation styles

It refers to the ways of knowledge transmission from the product to the audience. The existing models use two types of presentation styles: demonstration style and documentary style, but the findings of preliminary study shows that those types of presentation styles are not functional in the extremely crowded environment and it is one of the limitations in the exiting approaches. Thus, this study introduces to add the instruction-based style besides those two styles, as detailed in the next paragraph.

MMA-U presents the contents in three styles; instruction-based, demonstration, and documentary. When the pilgrim performs tasks according to orders received from a hidden actor[5], the instruction-base style is recommended. Meanwhile, the demonstration style is recommended when describing about things, while documentary style may help information conveying about living aspects effectively.

1. **Instruction-Base:** The pilgrims are performing their rituals based on the instructor commands.
2. **Demonstration:** Shows the rituals steps to enhance the pilgrims understanding.
3. **Documentary:** Similar to story-telling, in which the events of Hajj and Umrah journey, rituals steps and chronology must be visualized.

III. Instruction modes

In the existing models, the interaction mode is manual mode (touch screen with menus and buttons), which is not suitable for the extremely crowded environment. Referring to the results of the preliminary study, the pilgrims face difficulties finding the required Dua and Zikr especially while performing rituals such as Tawaf and

5 Hidden actor refers to an unseen actor who only speaks.

Saie, which are extremely crowded. Therefore, this study suggests adding new interaction modes besides the manual mode to increase the content accessibility, voice command mode, and GPS mode.

1. **Manual Mode:** The pilgrims interact with PDM manually using elements such as menus and buttons on a touch screen.
2. **Oral Mode:** The pilgrims use their voice to interact with PDM.
3. **Automatic Mode:** In this mode, PDM instructs the pilgrims automatically according to their location by using GPS.

The idea of proposing the above-mentioned modes and included in a multimodal interactive design for MMA-U is inline with the theory of multimodal human-computer interaction, which links the knowledge about human-human interaction to technological implementation (Hunyadi et al., 2011). On the other hand, multimodal interaction refers to more than one way to interact with the system and providing several distinct methods for inputting and outputting data (Wechsung, 2014). Therefore, this study believes that involving such modes can increase the accessibility and flexibility of contents.

IV. Flow patterns

Delivering the contents in MMA-U could be done in two different patterns. It could be delivered in separated or non-separated patterns. Non-separated pattern could be applied when the contents must present steadily from start to finish in a single screen or page without break. Therefore, the non-separated pattern is the most appropriate pattern for the rituals that consist of a single step such as the ritual of hair shaving or trimming. Alternatively, the separated pattern can be applied when a fragmented contents need to be presented sequentially in more than one screen or page. This type

of flow pattern is the best pattern for the rituals that consist of multi-steps such as Tawaf and Saie. In this case, the use of transition or navigation buttons is essential.

1. **Non-Separated Pattern:** Used when presenting the contents steadily from start to finish without breaks. Best pattern for the rituals which consist of a single step.
2. **Separated Pattern:** Used when fragmented contents need to be presented sequentially. It is the best pattern for the rituals that consist of a few steps. It requires:
    a. **Transition:** Audible or visible sign announces the end of the segment.
    b. **Navigation Buttons:** Buttons used for surfing the system, such as forward, back, and home.

4.4.2.2 Human Entities

The human entities refer to people (Actors) who act with MMA-U, where they could be either the instructor or the pilgrims. Pilgrims could be male or female, because some rituals such as wearing Ihram, Saie, and shaving or trimming have different performance ways according to the gender of the pilgrims. For example, male pilgrims are not allowed to wear stitched/sewn clothes (they are allowed to wear two towels), while female pilgrims are allowed to wear normal clothes (except gloves) that are not made of pure silk (Obaid, 2008). Meanwhile, instructor could be either seen or hidden instructor. The seen instructor could be a real human actor or an animated character, whereas hidden instructors are people using their voice to instruct without appearing in MMA-U.

1. **Instructor:** The person who gives instructions, and could be:
    a. **Seen Instructor:** Any actor appears in the screen and gives the instruction.
    b. **Hidden Instructor:** Any actor gives the instruction by his voice only.
2. **Pilgrims:** The person who uses the system, and could be make or female**.**

Having the terminologies described in the previous paragraphs allows conducting a comparative analysis to ensure that the contents are inline with the existing models. The results of the comparative analysis are portrayed in Table 4.15 and Table 4.16.

Table 4.15

Content Composition Components for DTs

Categories		Composition	DT1	DT2	DT3	DT4	DT5	Rate	Index
Interaction Design	Modalities	Audio		√	√	√	√	80%	**M**
		Visual							
		• Texts	√	√	√	√	√	100%	**A**
		• Images	√	√	√	√	√	100%	**A**
		• Graphics	√		√		√	60%	**M**
		• Animations		√	√	√	√	80%	**M**
	Presentation styles	Demonstration	√	√	√	√	√	100%	**A**
		Documentary	√	√	√	√	√	100%	**A**
	Instruction modes	Manual	√	√	√	√	√	100%	**A**
	Flow patterns	Non-Separated	√	√				40%	**F**
		Separated							
		• Transition			√	√	√	60%	**M**
		• Navigation Buttons	√	√	√	√	√	100%	**A**
Human Entities	Actors	Seen Instructor	√	√	√	√	√	100%	**A**
		Hidden Instructor			√	√	√	60%	**M**
		Pilgrim			√	√	√	60%	**M**

Note: √ mean contained in the model.

Description of symbols

A **All** models applying

M **50% or more** models applying

F **less than 50%** models applying

X **No** model applying

Table 4.16

Content Composition Component for MAs

	Categories	Composition	MA1	MA2	MA3	MA4	MA5	MA6	MA7	MA8	MA9	MA10	MA11	MA12	Rate	Index
Interaction Design	Modalities	Audio	√		√	√		√	√			√			50%	**M**
		Visual:														
		• Texts	√	√	√	√	√	√	√	√	√	√	√	√	100%	**A**
		• Images	√	√	√				√	√	√	√	√		66%	**M**
		• Graphics		√			√						√	√	33%	**F**
		• Animations	√							√					16%	**F**
	Presentation styles	Demonstration	√	√	√	√							√		41%	**F**
		Documentary	√	√	√	√	√	√	√	√	√	√	√	√	100%	**A**
	Instruction modes	Manual	√	√	√	√	√	√	√	√	√	√	√	√	100%	**A**
	Flow patterns	Non-Separated	√			√			√	√	√	√	√	√	66%	**M**
		Separated:														
		• Transition	√	√	√		√	√		√	√		√		66%	**M**
		• Navigation Buttons	√	√	√	√							√		41%	**F**
Human Entities	Actors	Seen Instructor	√	√	√										25%	**F**
		Hidden Instructor	√		√	√		√	√			√			50%	**M**
		Pilgrim	√	√	√	√	√	√	√	√	√	√	√	√	100%	**A**

Note: √ mean contained in the model.

Legend

A :**All** models applying **M** :**50% or more** models applying **F**:**less than 50%** models applying **X** **:No** model applying

Table 4.17 provides the summarized results of the comparative analysis of content composition component by using the classification rules that have been used in the structural components provided in Figure 4.4.

Table 4.17

MMA-U Content Composition Components Based Comparative Analysis

Categories		Composition	DTs	MAs	MMA-U
Interaction Design	Modalities	Audio	M	M	☻
		Visual			
		• Texts	A	A	☻
		• Images	A	M	☻
		• Graphics	M	F	☻
		• Animations	M	F	☻
	Presentation styles	Demonstration	A	F	☻
		Documentary	A	A	☻
	Instruction modes	Manual	A	A	☻
	Flow patterns	Non-Separated	F	M	☻
		Separated			
		• Transition	M	M	☻
		• Navigation Buttons	A	F	☻
Human Entities	Actors	Seen Instructor	A	F	☻
		Hidden Instructor	M	M	☻
		Pilgrim	M	A	☻

Legend

☻ : Compulsory to apply ☺ Recommended to apply

The results of analysis show that the CCCs listed in Table 4.17 are contained in the existing models and applications of Hajj and Umrah. Some elements in the CCCs are contained in all models while some appeared in at least one model. In this regards, the aim of this study is to propose a multimodal mobile assistance tool to assist pilgrims during Umrah. The motivation for this is the observation that all the existing models use the documentary style while some of these models used demonstration style to present the contents. The preliminary study findings show that pilgrims face difficulty in browsing the current approaches while performing rituals which involve large crowd. Therefore, the instruction-base style will be the major style in MMA-U

while documentary style and demonstration style are recommended.

Likewise, the existing models use manual mode (menus and buttons) to interact with pilgrims, which is not efficient in the extremely crowded environment. Therefore, this study suggests making the automatic mode (using GPS) and oral mode (using voice commands) while the manual mode is highly recommended as an alternative mode in case of any failure such as connectivity failure. Media elements such as graphics and animations are not compulsory in the context of this study because the pilgrims would not be able to attend to them, but they are highly recommended to clarify the complex concepts while the pilgrims are in their camps.

Based on the discussions in the previous paragraphs and the findings of the comparative analysis, Table 4.18 exhibits the content composition components of MMA-U. It is followed with an illustrative diagram in Figure 4.6.

Table 4.18

The Proposed Content Composition Components of MMA-U

Categories		Composition	Index
Interaction Design	Modalities	Audio	☻
		Visual	
		• Texts	☻
		• Images	☻
		• Graphics	☺
		• Animations	☺
		Fusion	☻
		Fission	☻
	Presentation styles	Instruction-Base	☻
		Demonstration	☺
		Documentary	☺
	Instruction modes	Manual	☻
		Oral	☻
		Automatic	☻
	Flow patterns	Non-Separated	☻
		Separated	
		• Transition	☻
		• Navigation Buttons	☻

Table 4.18 Continued

Human Entities	Instructor	Seen Instructor	☻
		Hidden Instructor	☻
	Pilgrim	Male	☻
		Female	☻

Legend
☻ : Compulsory to apply ☺ Recommended to apply

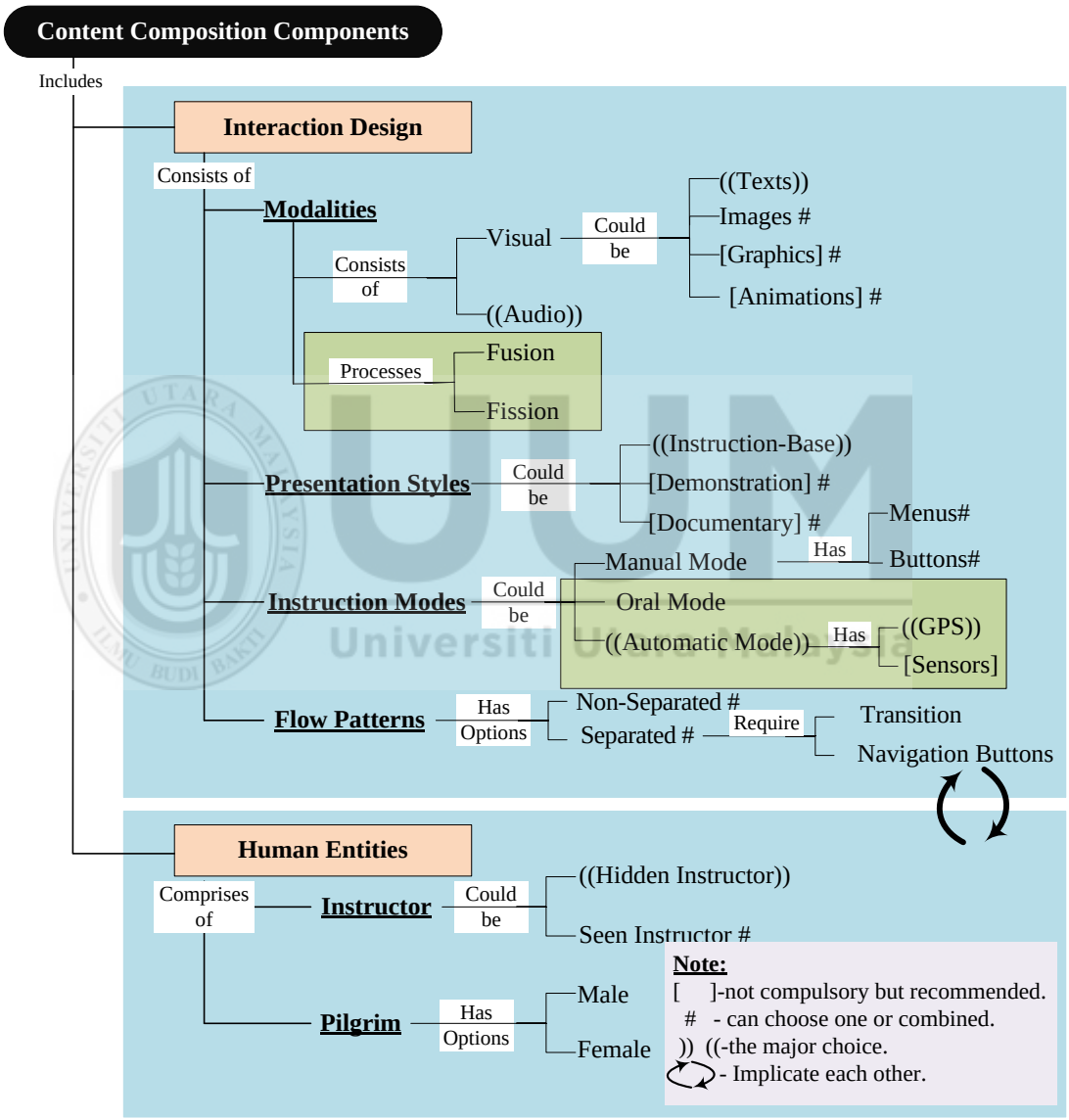


Figure 4.6. The Proposed Model for Content Composition Component of *MMA-U*

4.4.3 Principles of Usable Design

Users interact with any product through its interface. Therefore, the usability of the

product depends on the usability of its interface. The interface design should be usable in order to be intuitive, satisfied and competent. In this regards, many researches have been conducted to determine the design principles for effective user interface (Nielsen, 1994; Lidwell et al., 2010; Thimbleby, 2010; Niu et al., 2013; Eskridge et al., 2014). Those principles are constructed inline with the theories and principles of usability, multimodality, information architecture, and user interface architecture as well as the existing studies and usability guidelines, which are discussed deeply in Chapter 2. Accordingly, the proposed elements of MMA-U must be organized and designed based on those principles, in order to have a user interface design which is controllable, comprehensible, and assisting users to complete their tasks efficiently and successfully in the targeted context. In addition, all elements are driven by a set of design principles which have their own reasonable grounds, as exhibited in Table 4.19.

Table 4.19

The Proposed Design Principles of MMA-U

Modalities	Principles	Reasons
MULTIMODALITY PRINCIPLES AND THEORIES		
Texts	Use a font face similar to the Quran fonts	Generating of the Arabic font on the computer systems is a complex process (Abudena & Hameed, 2015). In addition, Muslims are familiar with Quran fonts. Therefore using the font faces of Quran or similar fonts will enhance the consistency and the understandability of the textual contents.
	Add morphology to the Arabic Texts	According to Su'aidi (1997), the Non-native Arabic speakers cannot read or recite the Arabic text correctly without morphology. Therefore, adding the morphology will facilitate the Arabic texts reading.
	Allowing change the font size	Pilgrims have different visibility vision. Therefore, providing a feature enables them to change the font size according to their ability to read the texts is highly recommended.
	Use consistent colors	The lack of colors consistency and contrast between background and foreground may cause problems in visibility and readability (Christine Roy, Dewit, & Aubert, 2001). Therefore, creating a pretty contrast color between the contents and background to make the contents clear and readable.
	Use easy terms	The instructions (textual or audible) should be short, clear, and understandable. Therefore, the words that used in the instruction as well as the translation of Duas should not be incomprehensible or blur.
	Highlighting the important contents	Use typeface such as bold, italic, and underline or even colors to highlight the important information that need more attention.
Images	Emulating or use real world objects	Using real-world images of an object or emulating the real-world objects is linking the descriptive information to the real world and is likely to be easily understood.

Table 4.19 Continued

	Use images with low size capacity	In mobile applications development process the resource constraints (small size of memory) must be taken into account (Giurgiu, Riva, Juric, Krivulev, & Alonso, 2009). Therefore, the images that will be used in PDM must have low size capacity with good quality.
	Avoid the pictorial explanations	Use images when necessary only, by replacing the pictorial explanations with the vocal or textual explanations.
	Use background images sparingly	Inappropriate backgrounds usage may cause confusion or overlap with the contents. For example, dark or bright backgrounds will cause a lack of vision. Therefore, users will face a difficulty to understand the information presented on such backgrounds.
Graphics	Provide meaningful graphics	Use graphics that having a clear meaning and easy to understand. At the same time, avoid adding non-necessary decoration and complex shapes. In addition, it must be able to deliver the desired meaning in a reliable and simple way.
	Use simple graphics	Use simple graphics that fitting and deliver the meaning easily, and avoid using complex graphics that need a mental effort to understand
	Use consistent colors.	Create a pretty contrast color between the graphics and background to differentiate between the graphic contents and background easily.
	Use graphics sparingly	Use graphics when necessary only, by replacing it with the vocal or textual discerption when it is possible.
Animations	Apply the same roles of graphics	Use animations when necessary only.
	Use appropriate movement.	Use slow movement of animation. Thus, the pilgrims can capture the information.
	Provide controllable animation	Add user-control elements that allow pilgrims to play, stop, replay, and pause the animations.
Audio	Providing acoustic instructions	In the crowded environments such as Hajj, reading the instructions seems very difficult. In addition, pilgrims face difficulties to find the exact page of the required Dua in crowd. Therefore, the acoustic instructions must be available when it is required, and must be well organized in a simple manner.
	Providing a pure vocalization.	The acoustic instructions must be clear and short to the pilgrims. Therefore, the delivered instruction should be pronounced clearly and purely word by word.
	Use small-sized audio files	The resource constraints such as the memory size must be taken into account when developing applications for mobile phone. Therefore, the audio files that will be used in PDM must be compressed to the lowest possible size while maintaining the purity and quality of sound.
	Use common audio coding formats (MP3)	MP3 extension has been chosen because it is supported by many types of mobile phones platforms. In addition, MP3 files can also be constructed at higher or lower bit rates, with higher or lower resulting quality (Heller, 2012).
	Provide controllable audios	Add user-control elements that allow pilgrims to play, stop, replay, and pause the sounds.
	Avoid the rapid recitation	The targeted users of PDM are non-native Arabic speakers, who are facing difficulties in reading or reciting the Arabic text correctly (Su'aidi, 1997; Abdul-Hamed, 2009). Therefore, the speed of recitation should be commensurate with the ability of the pilgrims.
	Providing an attractive recitation voices	Muslims prefer listening to the expert Qur'an readers who have beautiful voices. Because the intoned recitation perfectly with a beautiful voice increases the reverence. So pilgrims need something increases their reverence in such a faith environment.
	Omitting the background sound	Hajj is a crowded and noisy environment, in which pilgrims depend on the sound of the human mutawwif to reciting duas. Therefore, adding background audio to the acoustic instructions will increase the noise that would affect the purity sound and makes pilgrims confused.

Table 4.19 Continued

	Avoid using loud voices suddenly.	Pilgrims live in an environment filled by faith and reverence. Thus blasting them with loud voices suddenly will disturb this faith atmosphere.
	[Provide multiple speeds of recitation]	As suggested by experts, providing multiple speeds of recitation will enable the pilgrim to choose the appropriate recitation speed to him.
	[Provide multiple languages]	As suggested by experts, providing multiple languages of recitation will enable the pilgrim to choose the appropriate language to him.
Fusion / Fission	Use fusion\fission sparingly	Use fusion\fission when necessary only to process the modalities.
	Avoid ambiguity	Ambiguity can rise in the multimodal level when one modality provides an element with multi-interpretation (Caschera et al., 2013). Therefore, avoid using such kind of modalities.
Instruction -Base	Use simple instructions	The instructions must be easily understood and done, so the pilgrims will grasp the assistance information easily without difficulty.
	Use expressive instructions	The instructions must be conveying the assistance information effectively.
	Use succinct instructions	Use short and succinct sentences that can convey the assistance information briefly and clearly.
	Use explicit instructions	To avoid misunderstandings, clear instructions must be used that has a single and clear intent without any multi-interpretation.
INFORMATION ARCHITECTURE PRINCIPLES AND THEORIES		
Organization	Use a clear classification of the contents	The application's contents must be categorized depending on rituals. Therefore, every screen will be related to only one ritual. Because every ritual involved different Duas and steps.
	Using a narrow range of information as far as possible	Shows the lowest amount of contents in each screen. This can be done by fragmenting the large amount of information that can be placed in a single screen to multiple-sequential screens; each screen contains a narrow range of information.
Labelling	Using consistent labels	Use labels that can reflect the contents. In addition, labels should be descriptive, short, and to the point. Thus, users can expect the contents through the labels directly.
	Use specialized terms.	To have good labeling system labels must be specialized terms or organizational jargon that used by the field's specialists themselves not by audience only.
	Realizing the variations in perceptions and languages	Use terms that have a single meaning in the various languages. In addition, the users' culture must be taken in the consideration which helps in forecasting the perceptions of users.
Navigation Systems	Clickable	The navigation items must be well designed and look clickable in terms of shapes, colors, and etc. Therefore, pilgrims are able to recognize the navigation elements easily.
	Simple & shallow	The navigation system must be simple and shallow with clear conceptual model and no unnecessary levels, by placing many items on a menu rather than many menu levels.
	Distinct	The navigational elements must be visually separated, notable, and easy to find. Therefore, users can easily differentiate the navigational elements from the actual contents by using different font or color.
	Consistent	Use a consistent design in all screens by applying unified navigation model only. So the pilgrim can easily go about the application.
	Familiar	Avoid using unusual or strange navigation elements. Use the navigation elements that users already know how to deal with.
	Visual	Because in human brains textual information processed much slower than the visual information (Molchanov, 2014), but avoids using icons alone without description.
	Sticky	The navigational elements that stick in one place where it does not disappear when the user scrolls down. Therefore, users can easily access it and browse faster (Molchanov, 2014).

Table 4.19 Continued

	Provide repetition function	Providing a repetition function can allow pilgrims to iterate the desired instructions when they need.
	Provide next and back function	To allow pilgrims to browse the contents easily.
	Provide home function	To allow pilgrims to return back to the main menu any time.
	Provide exit function	To allow pilgrims to exit from the application any time.
	Use logical order for items	Navigation elements must be ordered in the most logical or task-oriented manner.
Transitions	Use clear transitions	Use clear and understandable transitions to inform the user that he complete one step or ritual successfully, and he is moving to the next step or ritual.
	Use spoken transitions	Basically PDM depends on the instruction-base style to present the contents through audio instructions. Therefore, spoken transitions must be used to signify the end of each step of the ritual.
	USER INTERFACE AND LAYOUT	
User Interface and layout	Use intuitive design	Make the interface design self-evident, to help users to realize easily appropriate actions that can be taken with each object.
	Provide proactive assistance	To enables users to complete their tasks efficiently and easily. According to Kamper (1999), the application should be capable to improve the users' capabilities and guide them to become independent users.
	Design for a single screen	All the objects inside the current view must be accessible at any time in any sequence. Therefore, users can easily access it and browse faster.
	Make actions are reversible and predictable	Use images and terms that enable users to understand each object and its relation in the task accomplishment. To enhance the memorability and understandability.
	Build on the prior knowledge of users	Because users can learn how to accomplish any task by applying the concepts and techniques that learned from the similar tasks.
	Allow the user to personalize their interface	Personalizing the interfaces increase the users productivity and makes the interaction with the system more convenient. It will save time and effort of performing the frequently-used functions (Stadler & Lorenz, 2008).
	Do not relinquish usability for functionality	To keep the vital functions clear and simple as well as complex functions easy to learn, by minimizing the number of actions and objects in the interface whenever possible and organizing the system's functions in such a way easy to use and access.
	Support alternate interaction approaches	Provide a variety of interaction techniques with height efficiency that can work in different environments. So users can choose the appropriate interaction method as needed.

Having the above-mentioned design principles detailed in Table 4.19, Figure 4.7 illustrates how the design principles of multimodality, information architecture, and user interface architecture support usability. However, some of these are principles related to the production phase in the development process, which involves consultation of experts and developers. Next sub-sections discuss the technologies that will be used as well as the development process.

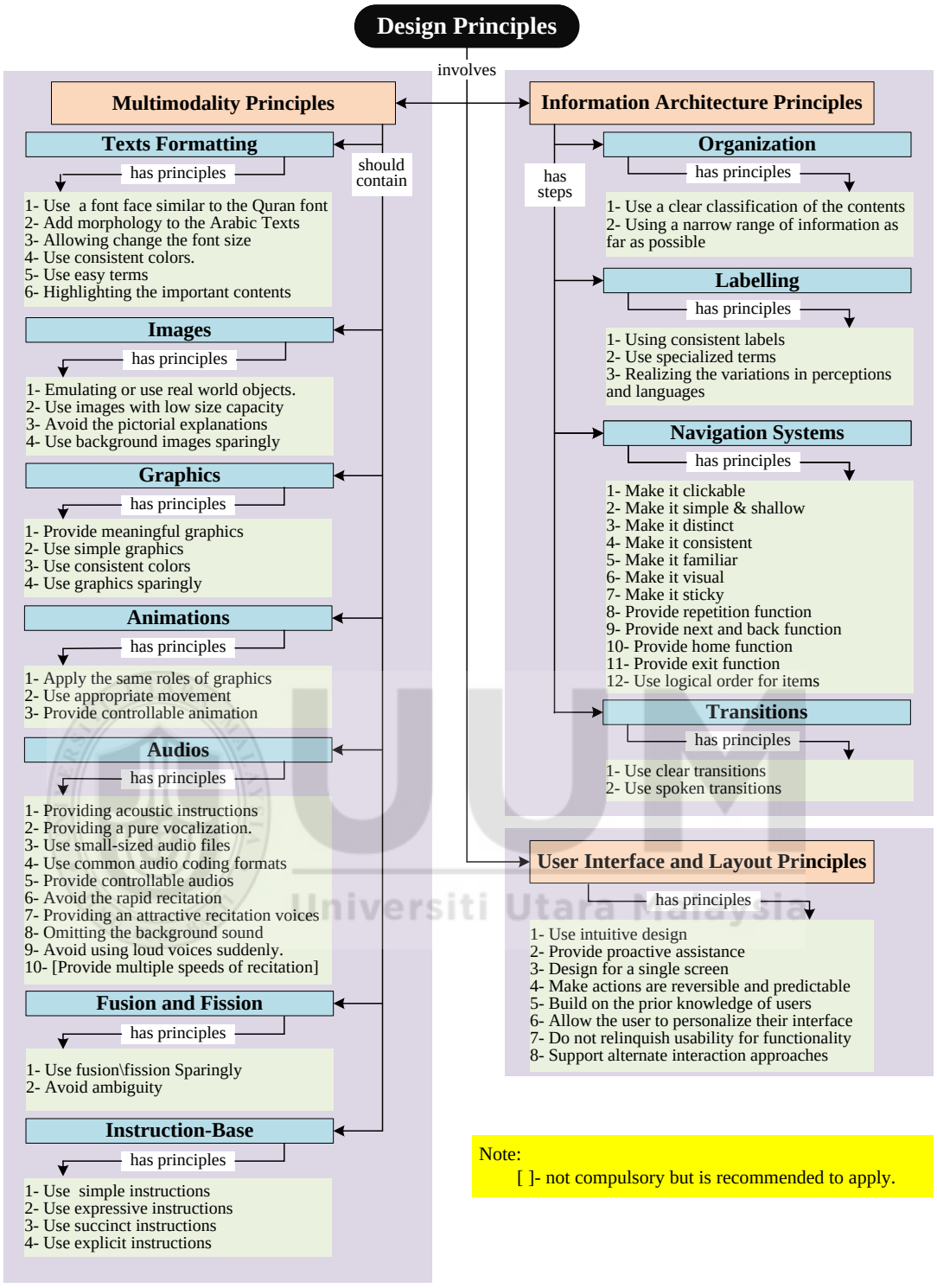


Figure 4.7. The Proposed Design Principles of *MMA-U*

4.4.4 Development Approach

The structural and content composition components have been derived by examining the existing models and mobile applications related to Hajj and Umrah through a

comparative analysis. In contrast, this study employed the UCD approach in designing MMA-U. Therefore, some ideas were derived through discussion with experts in areas such as mobile application development and information architecture, which reflect their experience to enrich the development approach of making PDM. Meanwhile, most of the ideas have been derived from the existing instructional design models such as ADDIE that aims to create instructional systems. ADDIE developed by Florida State University and it is acronyms of the following five steps:

Analysis: refers to information gathering, analysis and classification to fit the desired content.

Design: refers to the utilization of gathered information to create the application. It is involves activities such as sketching, blueprint, and prototyping.

Development: refers of the construction process of the actual product using the outcomes of design phase.

Implementation: refers to quality checking among the targeted users to ensure that the product is applicable and working as intended.

Evaluation: refers to the formative and summative assessment to ensure the product's effectiveness.

The phases in the previous paragraph can be shortened into three phases only, which are: (i) pre-production, (ii) production, and (iii) post-production. The pre-production combines analysis and design steps, whereas post-production phase combines implementation and evaluation steps. Further, each phase has its sub-activities which may involve iterations among each other until the PDM is ready for packaging. Chapter 5 elaborates deeply all the activities of the development process.

4.4.5 Technology

Technology refers to the platform of operating the PDM. Nowadays, individuals prefer to perform their works using their portable devices (Sean, 2008) and the computational capabilities of the portable devices are very high (Nusca, 2009). Furthermore, pilgrims need devices that can be operated and carried easily in the extremely crowded environments. On the other hand, the findings of the initial study show that only 6.7% of the respondents prefer to use computers to perform their daily activities, while 93.3% preferred portable devices. In terms of operating system 6.7% prefer Windows, 10% prefer iOS and 83.3% prefer Android. Therefore, this study considers that, to run PDM, the best platform is the portable devices (smartphone and tablet) with Android operating system.

Eventually, Figure 4.8 shows the first draft of the conceptual design model of MMA-U, which generally consists of five generic components, which are: (1) structural, (2) content composition, (3) design principles, (4) development approach, and (5) technology.

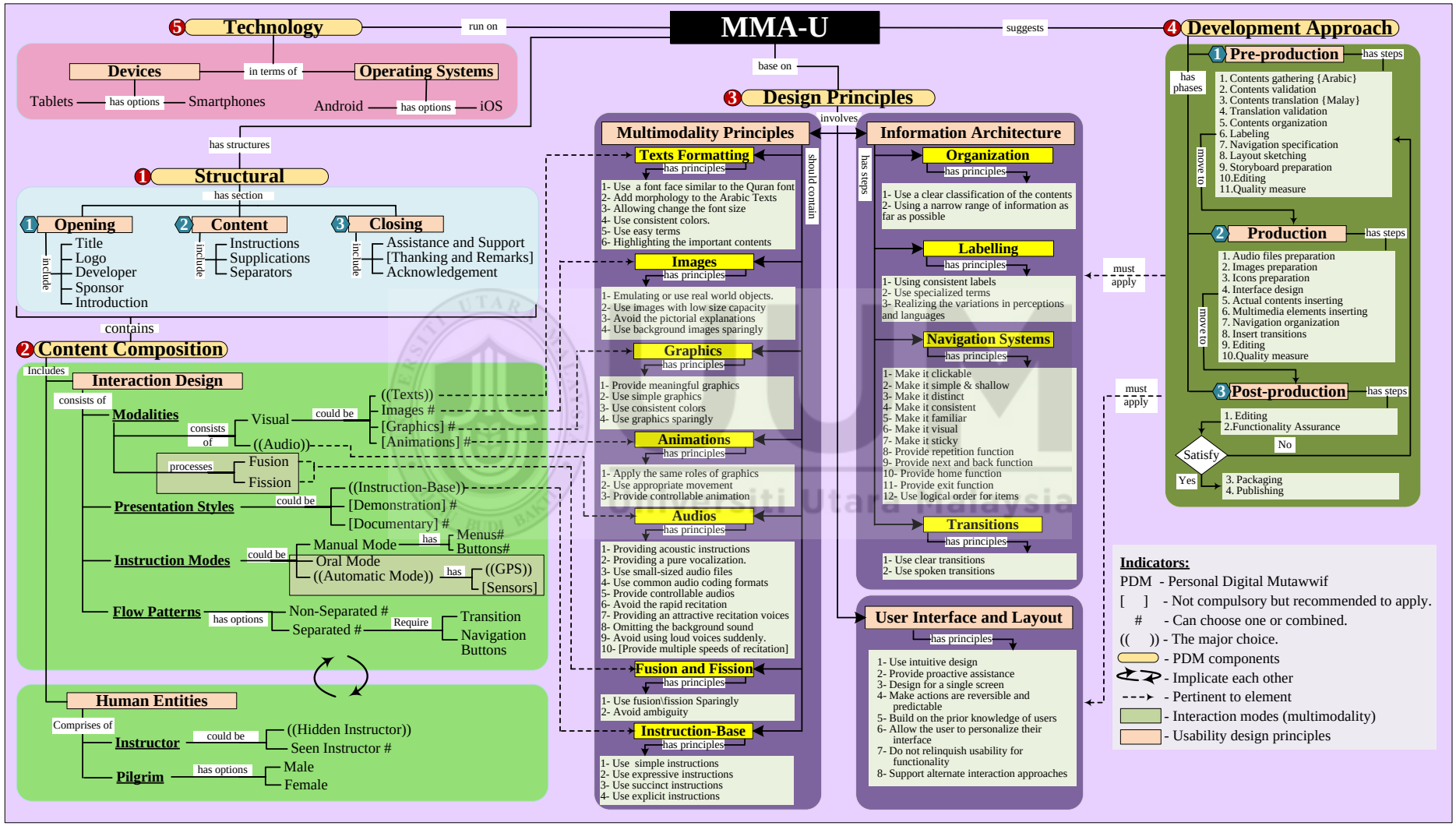


Figure 4.8. The First Draft of the Conceptual Design Model of MMA-U

4.5 Model Validation

Chapter 1 mentions that, one of the objectives of this study is to validate the conceptual design model of MMA-U through expert reviews. According to Radice (2002) and Wiegers (2002) expert review is accepted and adopted as one of the significant techniques for product quality improvement and complementary to other types of product tests. In addition, Morgan (1996) affirms that expert review is a popular technique that can be used in gathering qualitative data about a topic specified by the researcher. Therefore, this study employs expert review to evaluate and enhance the proposed conceptual design model of MMA-U. Meanwhile, the criteria listed below have been used to confirm the expert's expertise:

- PhD or master holder in either in Human Computer Interaction (HCI) or Usability or Mobile Applications or Multimedia or Software Engineering (SE) or Information Systems (IS) or Computer Science (CS) or any related areas, **and/or**
- Have a teaching background of five years or above in the above mentioned areas or any relevant area.
- At least have five years studying or researching in the above mentioned areas or any relevant area.
- Have been participated in constructing conceptual design model.

Based on those criteria 75 invitations were sent to the experts across the world via email. In return, 21 experts accepted to participate in the review. In the end, 15 completed the review. According to Folch-Lyon and Trost (1981), Kitzinger (1995), Morgan (1996), and Nielsen (1997), 15 experts are enough in order to obtain good and strong conceptual design model. In addition, Shneiderman et al. (2010) confirmed that the sufficient number of experts involved in the expert review is between three to five experts. Based on those recommendations, this study has

engaged more than enough experts, whom their details are listed in Table 4.20.

Table 4.20

The Demographic Profiles of Experts

No.	Gender	Education	Fields of Expertise	Experience (Year)	Affiliations	Location
1	Male	Master	Multimedia	30	Universiti Utara Malaysia (UUM)	Malaysia
2	Male	PhD	Multimedia	17	King Abdulaziz University (KAU)	Saudi Arabia
3	Male	PhD	Multimedia and Usability	18	Kwara State College of Arabic and Islamic Legal Studies	Nigeria
4	Male	PhD	HCI and IS	8	Jordan University of Science and Technology	Jordan
5	Male	PhD	HCI, Usability	15	Universiti Utara Malaysia (UUM)	Malaysia
6	Male	PhD	HCI and Usability	10	Universiti Utara Malaysia (UUM)	Malaysia
7	Female	PhD	HCI	10	International Islamic University Malaysia (IIUM)	Malaysia
8	Female	PhD	Multimedia	9	University Malaysia Terengganu (UMT)	Malaysia
9	Male	PhD	Multimedia	14	Universiti Utara Malaysia (UUM)	Malaysia
10	Male	PhD	Software Engineering	15	King Faisal University (KFU)	Saudi Arabia
11	Female	PhD	Multimedia, HCI, and User Centred Design	8	Universiti Utara Malaysia (UUM)	Malaysia
12	Female	PhD	Multimedia Systems Design	8	Universiti Teknikal Malaysia Melaka (UTeM)	Malaysia
13	Male	PhD	Multimedia, HCI and Usability	15	Universiti Utara Malaysia (UUM)	Malaysia
14	Male	PhD	HCI and Multimedia Technology	10	International Islamic University Malaysia (IIUM)	Malaysia
15	Male	PhD	HCI and Mobile Applications	11	Al-Ahgaff University	Yemen

Table 4.20 exhibits that, the experts represent a variety of expertise, affiliations, nationalities, and cultures. This diverse background of expertise is very germane to establish the validity of the evaluation of the proposed conceptual model of MMA-U. Majority of experts have experienced more than ten years in their respective fields. All experts hold a PhD in relevant to the development of MMA-U conceptual model,

except expert one who holds a master degree. However, he is an Associate Professor and has over thirty years of practice and scholarship in the field of multimedia. He has many publications on the development of desktop courseware on Hajj. This background recommends him for inclusion as expert. Meanwhile, expert number six specializes in human mobile interaction and usability.

4.5.1 Review Instrument and Procedures

The expert review was aimed at validating the proposed conceptual design model of MMA-U. Therefore, email has been used to communicate with the experts throughout the expert review procedure. Initially, a consent form as (shown in Appendix E) was attached with the invitation email (Appendix F provides an example of the invitation emails). The invitation is considered accepted when the stamped and signed consent form is received. Consequently, the first draft of the conceptual design model of MMA-U illustrated in Figure 4.8 together with an official appointment letter from UUM (Appendix G) and review instrument (see Appendix H) were attached with an acknowledgement email. An ample period of time was given to the experts to complete the review and return their feedback. They took between three to four weeks to finish the tasks.

As shown in Appendix H, a questionnaire adapted from Tosho (2016), Nurulnadwan (2015) and Siti Mahfuzah (2011) has been used as the main instrument for expert review. The instrument consists of five questions testing: (1) the proposed elements relevancy, (2) The proposed design principles understandability, (3) the clarity of the terminology used, (4) logically flows and connections of elements, and (5) the proposed model readability. Besides, a few demographic questions such as education level, field of expertise, age, and gender were also asked. On the other hand, experts were given appropriate space to write their further comments in the instrument

All the proposed components (i.e. structural, content composition, design principles, technology, and development approach) were listed in the first question, and the experts were required to verify the elements relevancy of each component, by ticking one of these choices: (1) all are relevant or (2) some may be not relevant or (3) some are definitely not relevant. While the second and third questions list the proposed design principles and used terminologies. Experts were required to verify their understandability and clarity (i.e. easy to understand or need some explanation or need very detail explanation). For questions four and five, the experts need to validate the items by ticking yes or no to report whether they agree or not with the question or statement. Finally, based on their experience, expertise, and perception, it is expected that they give their views or any further comments on the proposed model of MMA-U. The expert review findings are elaborated in the next sub-section.

4.5.2 Findings of Expert Review

Based on the questions, the data that were gathered from experts are tabulated in Table 4.21. Further, the gathered data are presented in clustered column charts (in Figure 4.9, Figure 4.10, Figure 4.11, and Figure 4.12) to provide a clear and straightforward illustration showing the different frequency of responses.

Table 4.21

Frequency of Responses from Expert Review

Items	Frequency (n=15)		
	Some are definitely not relevant	**Some may not be relevant**	**All are relevant**
Q1) The proposed elements in the following components are relevant			
a) Structural	0	0	15
b) Content Composition	1	1	13
c) Design Principles	1	2	12
d) Technology	1	1	13
e) Development Approach	0	1	15

Table 4.21 Continued

Items	Frequency (n=15)		
	Needs very detailed explanation	**Needs some explanation**	**It's easy to understand**
Q2) The proposed design principles			
a) Texts Formatting	0	0	15
b) Images	0	0	15
c) Graphics	0	0	15
d) Animations	0	2	13
e) Audios	0	1	14
f) Fusion or Fission	3	4	8
g) Instruction-Base	1	0	14
h) Organization	1	1	13
i) Labelling	1	1	13
j) Navigation Systems	0	1	14
k) Transitions	1	2	12
l) User Interface and Layout	0	2	13

Items	Frequency (n=15)		
	Needs very detailed explanation	**Needs some explanation**	**It's easy to understand**
Q3) The following terminology			
Modalities	0	5	10
Fusion	3	6	6
Fission	3	6	6
Manual Mode	1	3	11
Oral Mode	1	4	10
Automatic Mode	1	4	10
Instruction-Base	0	5	10

Question	Frequency (n=15)	
	Yes	**No**
Q4) The connections and flows of all the components are logical?	15	0
Q5) Overall, the production model is readable?	13	2

Note: Q= Question

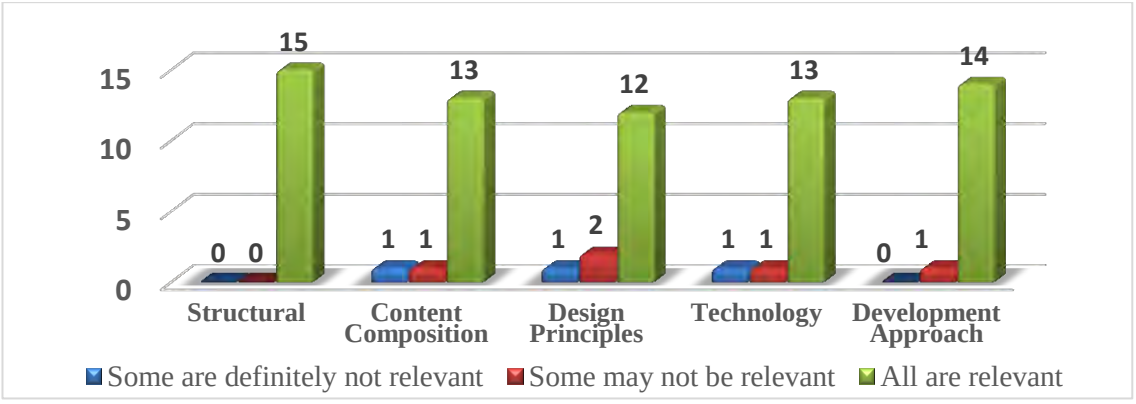


Figure 4.9. Relevancy of the Proposed Elements in the Components of MMA-U

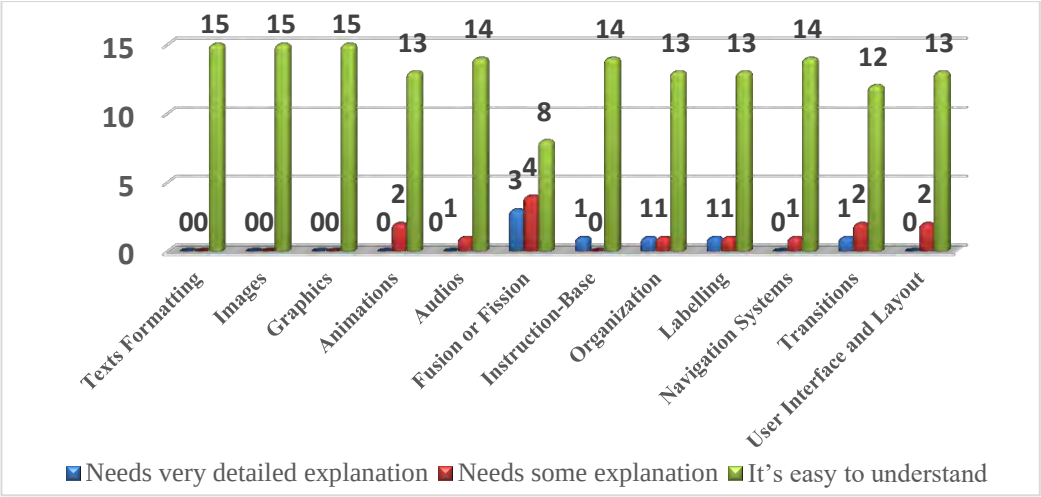


Figure 4.10. Understanding of the Proposed Design Principles in MMA-U

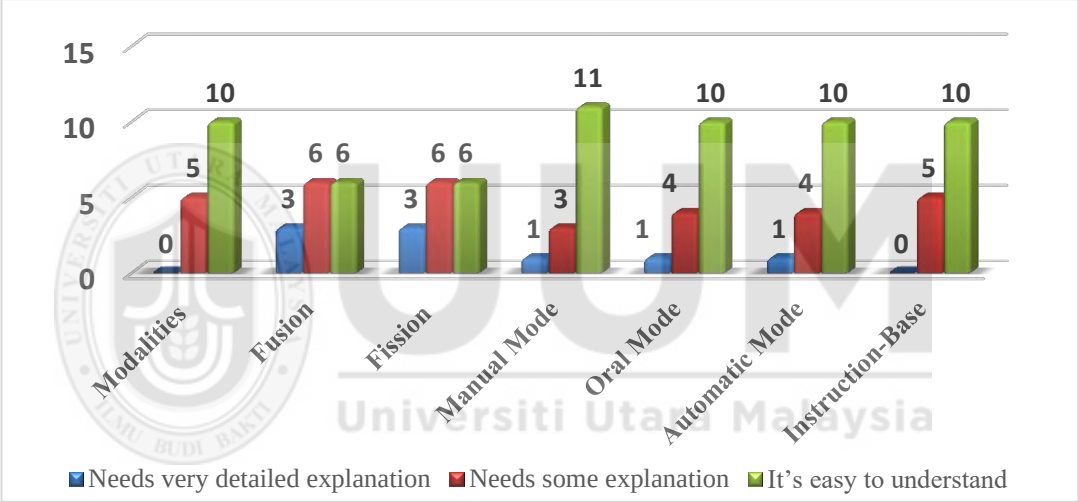


Figure 4.11. Clarity of Terminologies

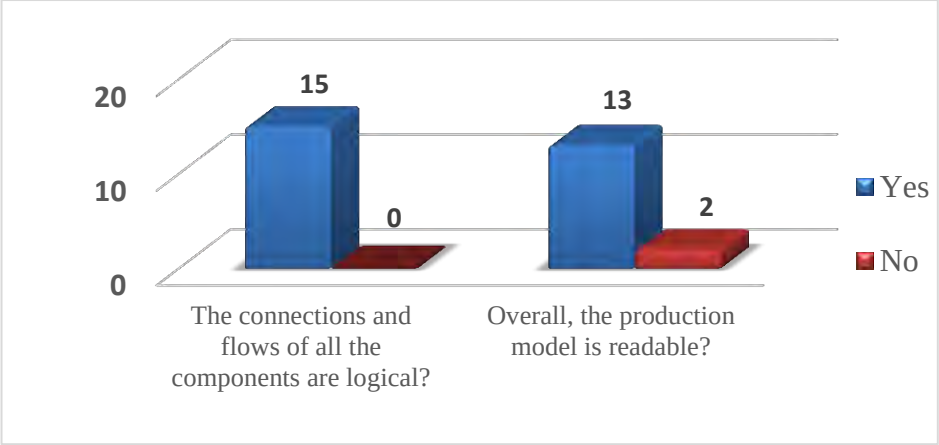


Figure 4.12. Connections and Flows, and Readability of the Conceptual Design Model of MMA-U

In Table 4.21, it is seen that majority of the experts agree that each component in MMA-U contains relevant elements (see Figure 4.9), the proposed design principles are easy to understand except the design principles contained in “Fusion\Fission”, in which about half of the experts agree that they need more or very detailed explanations (see Figure 4.10). The terminologies in MMA-U are found easy to understand (Figure 4.11) except “Fusion” and “Fission”. In addition, all experts report that the connections and flows of all the components in MMA-U are logical (Figure 4.12), while majority of them agree that the proposed conceptual design model for MMA-U is readable and usable for the development MMA-U.

Besides, experts’ comments are listed in Table 4.22. After, some little modifications for the purpose of providing clear meaning have been made.

Table 4.22

Further remarks from the expert reviews

Experts	Comments (Remarks)
Expert 1	Overall, the components of the model are clearly stated. Information related to each component has been listed in detail. If this model adapts/adopts any existing principle or theory, then they have to be mentioned.
Expert 2	The model seems reasonable. There are some minor grammatical and spelling errors that needs to be fixed, e.g., in the human entities section, "femake" to be "female"; in the production section, "perpetration" may be "preparation". The following could also be taken into consideration: design adoptation to future modifications and extensions, maintenance, and testing.
Expert 3	1- There is need to detail on the structural content (Instruction, Supplications and Separators) this is main content element. 2- Also, your content composition should only link toward content section not all element of structure. 3- Human entities should be: a) Instructor (Seen Instructor and Hidden Instructor) b) User (Male Pilgrims and Female Pilgrims) 4- Content composition must be sub-division of content element. There is no link between your content element and composition.
Expert 4	Great Job! However, the model is very complex. Therefore, I suggest simplify it and provide a much higher level abstraction of the model. For instance, it’s enough for you to show the main components and their sub-components (excluding the sub components of the sub components). I have a concern about the evaluation of your model; Are you going to conduct a user study to validate its usability? Good Luck!

Table 4.22 Continued

Expert 5	1- The model readability could be improved (May need some rearrangement to ease the flow of reading). 2- If the model is printed in black and white, some parts are hard to notice.
Expert 6	1- Need some arrangement on structure. 2- Need some modification on overall production.
Expert 7	It is too complicated. Reflect upon what are the objectives of the research and problem to be solved. Will the problem requires a complex or simple solution? Perhaps the model could be explained in stages, then followed by the overall view.
Expert 8	Congratulations you have come to this stage. Overall the flow of the model is easy to understand. 1-I can see the uniqueness of the application. 2-The Development Approach is compulsory or recommended? If it's compulsory the connection term is unsuitable to be "suggest". 3-With the existing knowledge that I have I still needs very detail explanation on Fusion and Fission. Is this two terms is different element? So you should spread them as different element. 4-It is only information architecture and user interface layout must apply the suggested development approach? Because the arrow is only point to them. 5-I can't see any theory and approach in the model. Which theory and approach you refer to construct all the components, elements, and the design principles? Do you have justifications on each of the components, elements and design principles? The justification must be based on theory and approach.
Expert 9	1-The production part has wrong spelling for "perpetration" 2-Fusion/ Fission or Fusion and Fission should be more clear explanation.
Expert 10	1-If you consider to add Smartwatch as one of the devices under Technologies that would be great to add Smartwatch Apps, as they are there are the latest growing technology and needs apps to be developed to support these devices. 2-It is advisable to rearrange the section (1) in the Structural (Opening) to have the Title first, Introduction and other things to follow. 3-Under the section (2) Content Composition, brief what principle you follow for Demonstration and Documentary? 4-The section of Fusion and Fission need to be discussed more as it removes the ambiguity. 5-Check for the spelling mistakes and typos for words like (female), Use of fullstops in Text formatting section under design principle point 4, in use (/) symbol instead of (\) in fusion/fission)
Expert 11	1-Please be consistent with the word use in "Design Principles", use root word e.g. provide (not providing, use (not using). 2-Drop "s" at the end of terminologies ("Audio", "Graphic", "Image", "Animation"). 3-Please use standard terminologies for better understanding. 4-Human Entities > Pilgrims > "Femake" [typo]. 5-In audio why not multi-languages. 6-I suggest to add Smartwatch as one of the devices under technology.
Expert 12	1-The conceptual design is too compact 2-Better focus to the major choice (e.g.: Text, Audio, Instruction Base, Automatic Mode-GPS, and Hidden Instructor etc.) 3-Overall, the design concept is easy to understand
Expert 13	I can't see any different or unique of the model that represents uniquely the MMA-U for Hajj. It seems similar to design principles, technology, structure, and content. It's too general for any software development. The model should represent the unique CONCEPT purposely for Hajj, not too complicated.
Expert 14	No comments

Table 4.22 Continued

Expert 15	Overall the model shows the uniqueness of MMA-U and the flow is easy to understand. My suggestions are: 1-Change the term "Modalities" to "Multimedia Elements". 2-The link between structure and content composition should linking content composition with content section only not all the structure elements. 3-Add Smartwatch to the devices in technology as recommended device. 4-Focus on male pilgrims and you can put female pilgrims as recommended because the difference is not that much.

4.6 Revision of the Conceptual Design Model of MMA-U

Based on the experts' comments in Table 4.22, the first draft of the conceptual design model for MMA-U was revised and redesigned shown in Figure 4.13 to enhance readability and to give adequate impression upon the model. This was achieved by applying the experts' remarks regarding the flow and connection of all elements as well as the consistency and understandability of the design principles and terminologies.

The experts' remarks listed in Table 4.22, show that the proposed conceptual design model for MMA-U is reasonable, easy to understand, and indicates the uniqueness of MMA-U. Also the experts agree that the components are clearly stated. However, the experts requested that this proposed model requires some corrections based on the following: (1) grammatical and spelling errors, (2) mention the theories being adapted/adopted for the model, (3) rearrange the model structure to reduce the model complexity and highlight the uniqueness of the application, (4) clarify some of the terminologies such as "Fusion" and "Fission", (5) focus on the male pilgrims only, and finally (6) add smartwatch to the list of devices in technology. The next sub-sections contain the response to the remarks of the experts.

4.6.1 Correction of the Grammar and Spelling Errors

For remarks on the corrections of the grammar and spelling mistakes, this study has taken the following actions:

1- Correcting the spelling errors e.g. femake to female and perpetration to preparation.
2- In design principles root words were used e.g. “provide” used instead of “providing“.
3- The plural marker “s” at the end of “Audio”, “Graphic” etc. was dropped.
4- The symbol “/” was used instead of “\” in Fusion/Fission.

4.6.2 Theories and principles that were adapted/ adopted for the model of MMA-U

The model is inline with many theories and principles such as the theories and principles of usability, multimodality (multi-modal interaction and multimodal human-computer interaction), information architecture, and user interface architecture as well as the existing studies and usability guidelines. Therefore, based on those theories and principles, this model comes out with appropriate components and elements for structure, contents, design principles, technologies, and development approaches. The model is proposed to facilitate the rituals of Hajj and Umrah and cater for the needs of pilgrims, by providing a usable multimodal mobile assistance application during Umrah. Therefore for clarity and better understanding of the model, the theories and principles that serve as basis for the model have been explained in the appropriate components of the model design. This is inline with the experts’ remarks about the theories used in the model design.

4.6.3 Highlight the Uniqueness of the Application and Reduce the Model Complexity

Even though some experts confirmed that the model is reasonable, easy to understand, and they can see the uniqueness of the application, but some experts remarked that the proposed conceptual design model for MMA-U is complicated, compact and needs some rearrangement to improve readability. Accordingly, the following actions have been taken:

- The main components of the MMA-U were rearranged to start with the component number at the top left of the figure. Also, the "Technology" component was shifted to the right side at the end of the figure.

- The sub-components were numbered with different numbers from the main components e.g. the main components numbers are 1, 2, 3, etc. while the sub-components numbered with A, B, C, etc. In addition, the "Content Composition" component was numbered with "B1" to show that it is an extension to the "Content" sub-component in "Structural". Also, the link between structure and content composition is modified to link the content composition with content section only not all the structure elements.

- Besides, the arrows that link the content composition elements with their corresponding design principles have been linked and numbered, with their corresponding elements of design principles.

- Regarding the comments about highlighting the uniqueness of the application, even though some experts state that they can clearly see the uniqueness of the application, this study highlights the uniqueness by putting the unique elements (such as "Oral Mode" and "Automatic Mode") within an engraved rectangular to show that those elements are different from others.

4.6.4 Clarification of Terminologies

Another issue that attracts the attention of the experts is the need for clarity of terminologies used in the study. All the terminologies have been already explained in this chapter. In addition, a note has been provided at the bottom of the model to clarify the vague terminologies such as "Fusion" and "Fission".

4.6.5 Focus on Male Pilgrims Only

Since the rituals of Hajj and Umrah are same for both gender but with slight differences in how male and female perform the rituals, then focusing on male pilgrims only is a good suggestion. Therefore, this study focuses on male pilgrims only with reference to the difference between male and female in accordance with the recommendations of the Umrah or Hajj rituals. It is to be noted that the addition of female pilgrims is recommended but not compulsory in the model.

4.6.6 Add Smartwatch as a Recommended Devices in Technologies

Smartwatch, one of the most promising devices nowadays and in the future, is a wearable devices that have many features, but with a very small screen and memory size. Therefore, this study agrees with the suggestion of adding smartwatch as a recommended device in technologies to expand the model scope in the future.

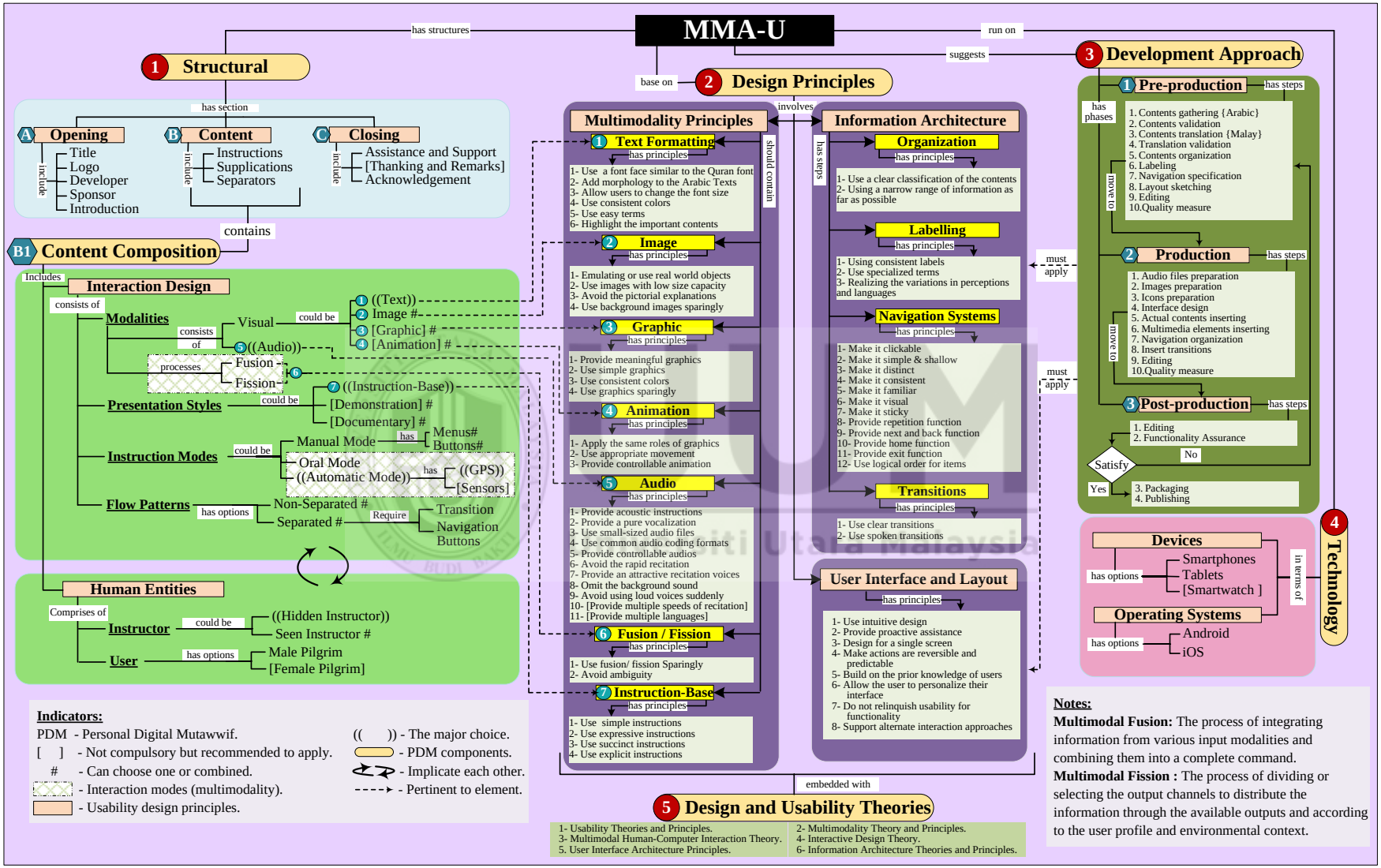


Figure 4.13. Revised Conceptual Design Model of MMA-U

4.7 Summary

This chapter elaborates on the steps in constructing and activities involved in the development of the proposed Conceptual Design Model of MMA-U in detail. It begins with identifying the usability attributes of mobile applications in general and selecting only the appropriate attributes for MMA-U by conducting SLR. This study realizes that the 27 attributes found in the previous studies are synonymous or a part of each other. Consequently, the results show that usability has three main dimensions: effectiveness, efficiency, and satisfaction, which are broken down into ten sub attributes: usefulness, errors rate, simplicity, reliability, ease of use, safety, flexibility, accessibility, attitude, and acceptability. The outcome of this activity serves to support the first objective of this study.

SLR is followed by the sub-activity of modes and models selection. To find the appropriate interaction modes, this study conducted a meta-analysis of the mobile applications that are related to Hajj and Umrah and other fields. In addition, as a part of UCD approach, this study conducted a series of discussions with peers and users in at least five international conferences to share and exchange ideas and consider suggestions about the different versions of MDZ4H that have been developed in the preliminary study. On the other hand, this study found five DT models and 12 MA that were published recently in Google Play. Therefore, those 17 models have been used as a basis in constructing MMA-U. After that, a series of comparative studies were conducted on the selected models to identifying and formalizing the components and elements of MMA-U.

Consequently, an initial model of MMA-U was constructed. Also, the components in the proposed conceptual design model were expected to contribute to the usability of the PDM. Finally, 15 experts were involved in an expert review to validate the initial

model of MMA-U. The outcome of expert review serves to support the second objective of this study, which is to revise and validate the conceptual design model of MMA-U. Next chapter elaborates in detail the process of developing the prototype of PDM based on the validated conceptual design model. Later, an evaluation was carried out to measure the usability of the PDM, explained in Chapter 6.

CHAPTER FIVE
PROTOTYPE DESIGN AND DEVELOPMENT

5.1 Overview

Chapter 4 describes in detail the construction activities of the proposed conceptual design model of MMA-U. After that, a detailed explanation on the process of reviewing the proposed model among experts follows, where 15 experts were involved in validating the model. Finally, the first draft of the proposed conceptual design model of MMA-U was revised based on the experts' remarks. To achieve the third objective of this study, the proposed model of MMA-U needs to be validated through prototyping approach, as carried out by Norshuhada and Shahizan (2013) and Tosho (2016).

Accordingly, this chapter demonstrates the phases carried out to develop the prototype of PDM. Generally, the development process of PDM involves three main phases which are (i) pre-production, (ii) production, and (iii) post-production. Meanwhile, every phase has its' own activities which include editing and quality checking. The following sections describe the phases of PDM development and their activities.

5.2 The Development of PDM

In this study, the proposed model of MMA-U clearly articulates the development process of PDM prototype. Applying the stated development approach in the proposed model is recommended especially for those beginner or non-technical developers. Also, developers are allowed to refer to any development approach to develop PDM such as instructional design (ID). This means that, PDM can be developed by anybody, including the pilgrims themselves by utilizing any

development approach. Meanwhile, the contents of PDM are very flexible. In case those developers are the pilgrims themselves, the PDM contents can be chosen according to their doctrine, sect, or preference. Also, they may use their existing knowledge to add any supplication or additional information that is related to the Hajj journey. Nevertheless, it is very important for the beginners or non-technical developers to follow the proposed design principals as well as any compulsory components or elements as stated in the proposed model.

5.2.1 Pre-Production phase

The pre-production phase consists of ten activities. It begins with content gathering in Arabic language and ended with quality checking, as shown in Figure 5.1.

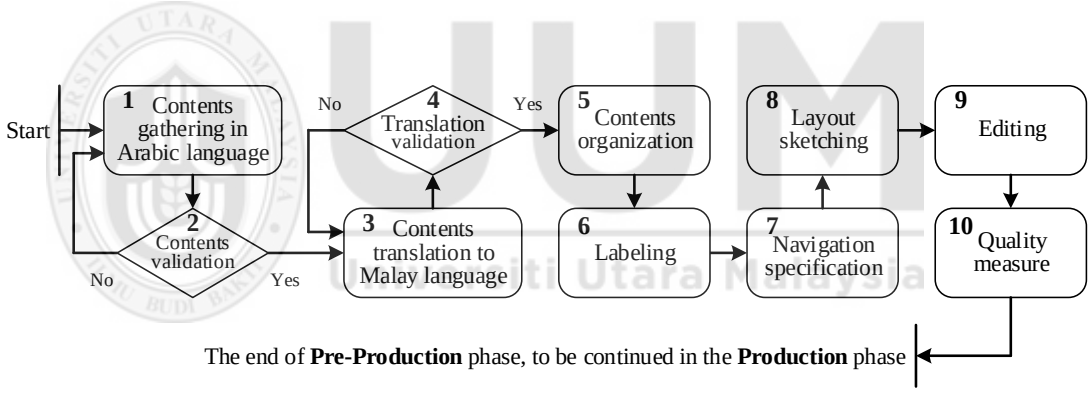


Figure 5.1. Pre-Production Phase

5.2.1.1 Contents Gathering in Arabic Language

First, the contents of PDM must be gathered from the proper and reliable scientific sources of Sharia in the field of Hajj. Since there are many Islamic doctrines (madhab), the content's sources can be proper if it follows the similar madhab of targeted users. According to Kuo (2011) Shafi'i madhab is the official madhab followed in Islamic countries in Southeast Asia. Therefore, the proper sources to gather the contents of PDM are books of Hajj in Shafi'i Jurisprudence. Therefore,

this study used the contents of some books/booklets published by Tabung Haji[6], because it is considered as standard and trusted book in Malaysia. In addition, this study refers to additional books of Hajj (not published by Tabung Haji) to cover the deficiencies in content and provide further information. Appendix I provides some pictures of the books' covers that used in contents gathering.

5.2.1.2 Contents Validation

After selecting the desired contents, this contents needs to be validated to make sure that the selected contents are perfect and complete. Therefore, the contents were sent to experts for checking. The contents have been validated by a lecturer at the UUM College of Arts and Sciences, Islamic Studies department, who is one of the qualified Hajj trainers for the Lembaga Tabung Haji of Malaysia. To avoid any omission or lack in the contents, the contents validation process involves iteration (see Figure 5.1) until the experts confirm that the contents are complete and valid.

5.2.1.3 Contents Translation to Malay Language

Having gathered the valid contents in Arabic language, they need to be translated into Malay language, because the Malay language is the mother tongue of the intended users. Therefore the Arabic contents were delivered to an expert translator who is a Malay native speaker but speaks Arabic as the second language. The reason for choosing Malay native translator not Arabic native translator is to make sure that the translated contents to Malay language is as simple as possible.

6- Tabung Haji is an organization established in 1963 by the Malaysian government for the Muslim for taking care of pilgrims to Mecca. It is basically act as a privately to facilitate the Muslims to perform their Hajj with the feeling of minimum financial burden.

5.2.1.4 Translation Validation

It is necessary to verify the validity of the translated contents to make sure that the Malay text exactly corresponds and matches the Arabic text. Therefore this study sent the contents (in Arabic and Malay language) to another person who speaks both languages to confirm that both versions (Arabic and Malay) are congruent.

5.2.1.5 Contents Organization

As mentioned in Chapter 2, this study adopts the definition that describes information architecture as the discipline of organizing and figuring out the functionality and content of the application into a structural design that enables users to navigate intuitively. Therefore, the contents of PDM must be organized in a manner that allows the users to navigate intuitively from a part to another. Since there are many organization structures, schemes and patterns, the contents organization in this study have been done using exact organization schemes, hub-and-spoke model, and multi-dimensional hierarchy pattern. Section 2.12.2.1 discusses how and when those organization structures, schemes and patterns can be applied, whereas the justifications are provided in Table 2.5.

According to Fathnan et al. (2010) rituals in Hajj and Umrah journey can be classified into five stages departure, on the way, in Madinah, in Makkah, and return as shown in Figure 5.2.

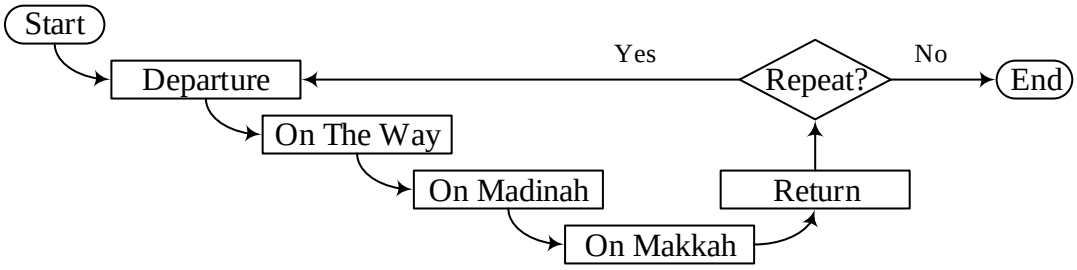


Figure 5.2. The Flowchart of Hajj Simulation Program
Source: (Fathnan et al., 2010)

With reference to that, this study categorizes the rituals of Hajj and Umrah journey into three logical groups only, which are: on the way, on Makkah, and on Madinah, because rituals of departure and return are considered as parts of other groups, for example Ihram is one of the rituals that must be done on the way to Makkah. According to Chen and Lin (2014), in the exact organization scheme each content element must belong to one and only one logical group. Therefore, in this study, every ritual can belong to only one logical group as illustrated in Figure 5.3. However, some rituals have sequential or pre-request rituals to be performed. For example in Tawaf and Sa'ai the pilgrims have to follow sequential steps to perform these rituals, they have to start from a certain starting point (faith) down to the end of that ritual. Another example is Ihram which is a pre-request of the main rituals of Hajj and Umrah. Therefore, it must be performed first. Hence, this study suggests the flowchart in Figure 5.3 to categorize the contents of PDM.

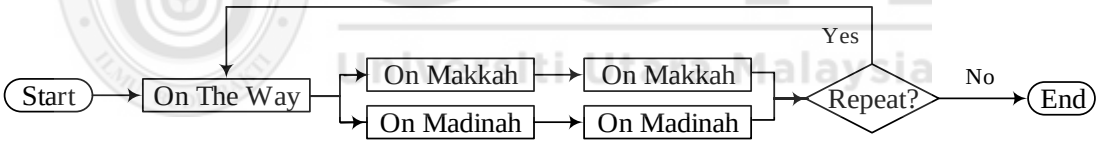


Figure 5.3. The Flowchart of PDM

5.2.1.6 Labeling

After the content organization the set of rituals have been grouped and labeled by a unique name according the place to perform. However, some rituals such as Tawaf and Sa'ai must be performed in sequence of steps. Therefore, each step has been labeled by a unique name that identifies the order of that step and shows the percentage of the performance. The consistency of labels must be taken into account in labeling process. Meanwhile, specialized terms must be used to make realization of the variations in perceptions and languages easy. Having considered those constraints, the categorization is schematized as depicted in Figure 5.4.

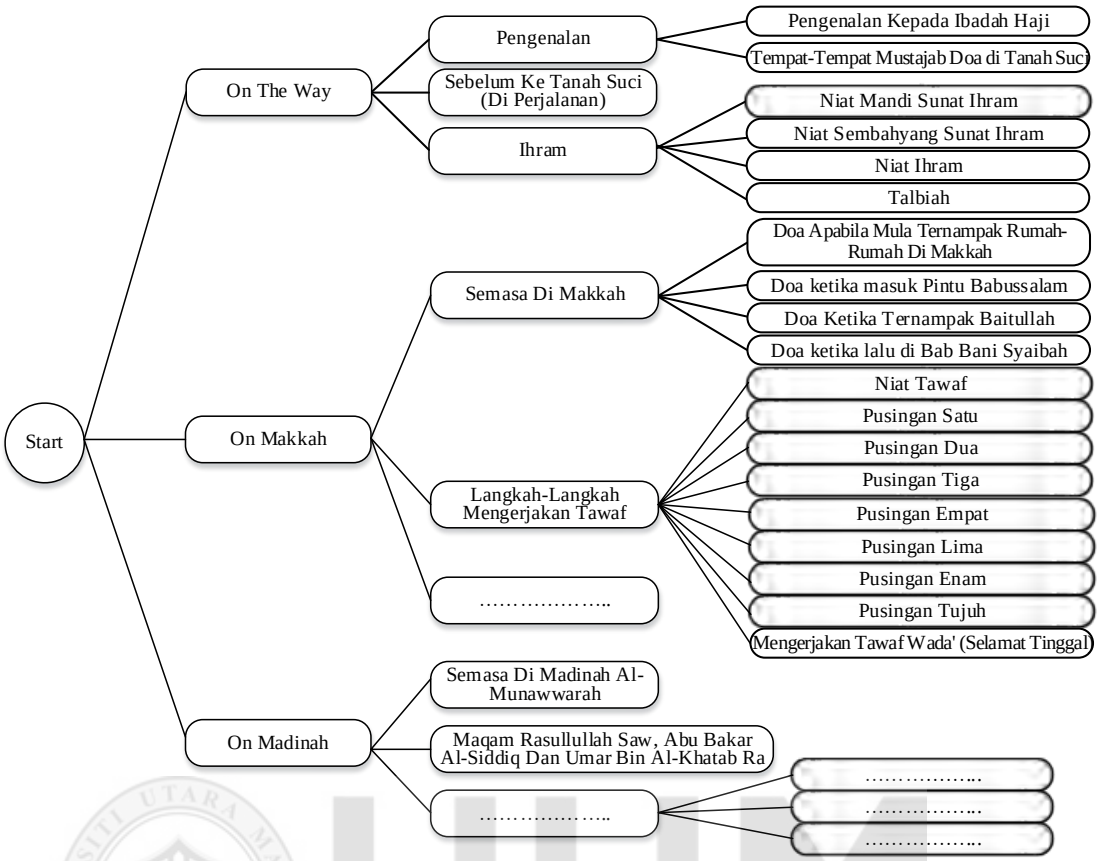


Figure 5.4. Examples of the Contents' Labels in PDM

5.2.1.7 Navigation Specification

As mentioned in Chapter 1, one of the difficulties faced by the pilgrims while using the current conventional approaches is to find pages of appropriate dua and zikr. Therefore, this study employs several manual navigational styles besides the proposed automatic navigational using voice command and GPS. As suggested by Nurulnadwan (2015), liner navigational style (Figure 5.5) is applied within the steps of rituals with multi-steps to support next-and-next task sequences. Meanwhile, hybrid navigational style is employed among the rituals of Hajj and Umrah. Factually, the hybrid navigational style (Figure 5.6) has been employed in the proposed automatic navigation system, where the required ritual is selected by pronouncing (voice command) the ritual name or based on the pilgrim's location (GPS) instead of clicking on buttons, links, or menu.

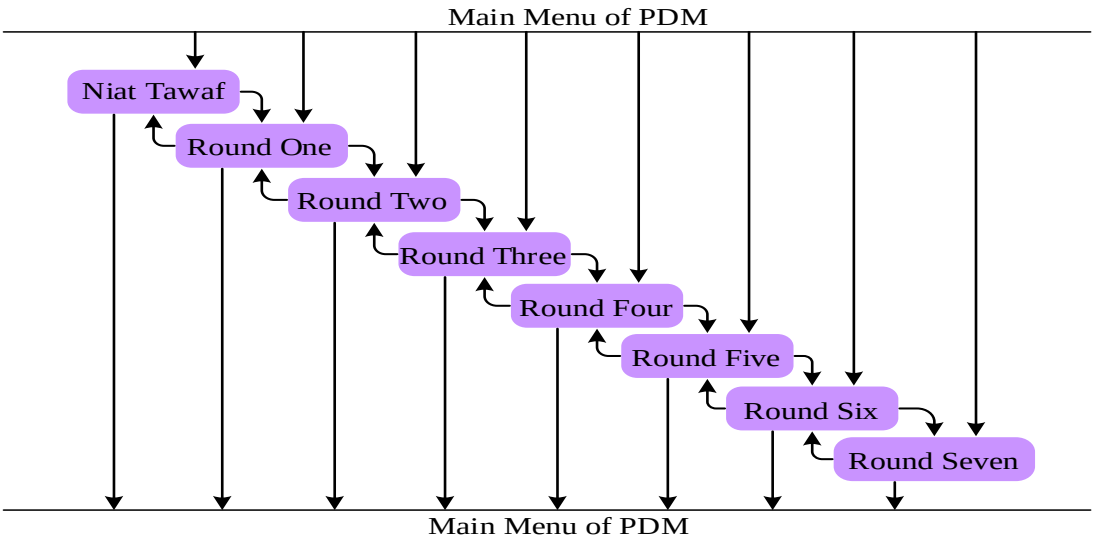


Figure 5.5. Liner Navigational Style for Next-and-Next Task Sequences in PDM

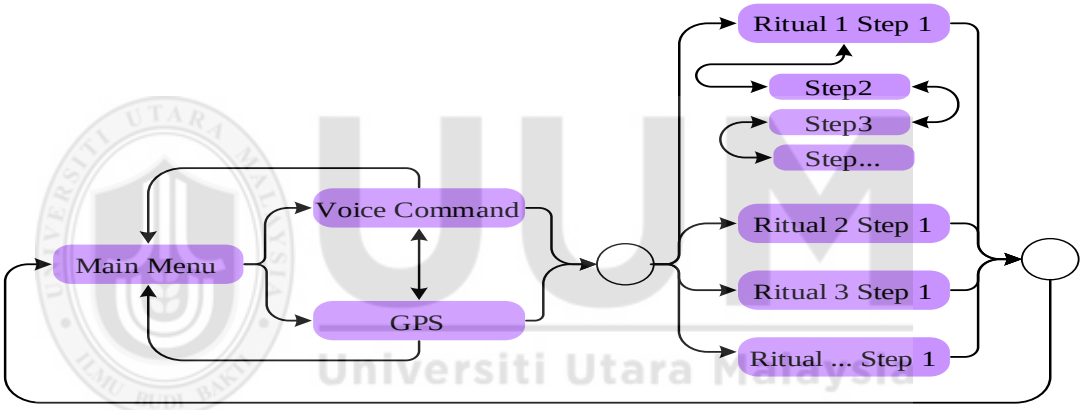


Figure 5.6. Hybrid Navigational Style in PDM

Figure 5.5 shows that all rituals screens are accessible from the main menu and the main menu is accessible all time. Also the users can exit from PDM at any time. This means that the pilgrim has the flexibility to exit from PDM or access any ritual or a step of ritual from the main menu. Furthermore, the pilgrim has the freedom to navigate sequentially through the steps of the multi-steps rituals by using next and forward buttons. Meanwhile it is seen in Figure 5.6 that the manual navigational style is the default style and the pilgrim can access one of the automatic navigational styles and they are free to change the style. If the voice command style has been activated then the pilgrims need to pronounce the rituals' name only to access the ritual screen or the first

step of the ritual in case a multi-step ritual has been selected. Whilst, in the GPS style the application will get the current location of the pilgrims and automatically opens the appropriate ritual screen (or the first step screen of the ritual).

5.2.1.8 Layout Sketching

The completion of navigation specification is followed with scripting and layout sketching. The benefit of script is to keep track all the provided elements in the show and easily allows the developer to sketch the layout. The script of PDM is very straight forward, where the user needs to select the required ritual from the main menu. The ritual screen consists of a toolbar containing navigation buttons that enable users to navigate between rituals screens or return to the main menu and two functional buttons for change the font size. It also consists of the text of the Dua and Zikr that are recited while performing the rituals in Arabic together with its' translation in Malay. The user can click on the Arabic text or the button beside it for recitation. Users can also scroll down to read the text at the bottom. All these are represented in Figure 5.7.

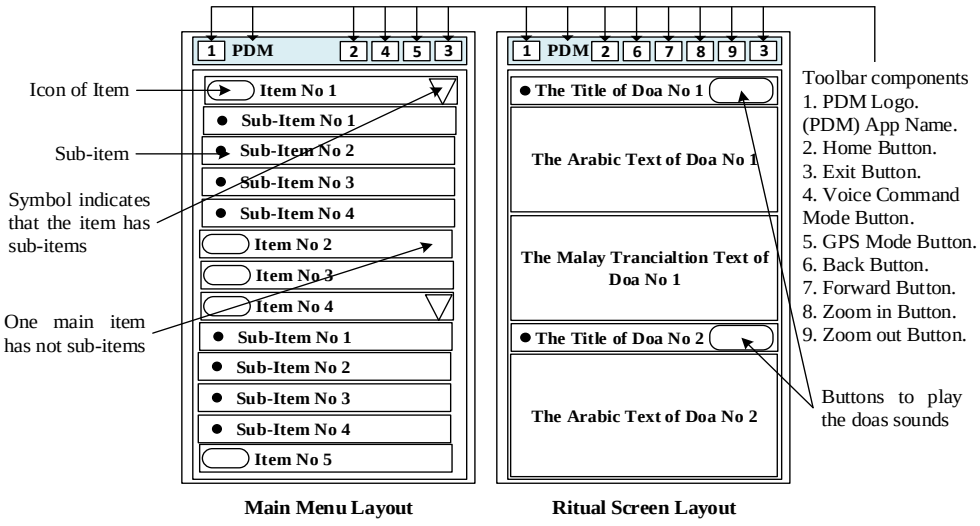


Figure 5.7. Layout Sketching of PDM

5.2.1.9 Editing

Editing process is very important to ensure that the navigational specification and layout sketching meet the design needs. The scripts and layout sketches were presented to experts and many adjustments have been made based on their remarks.

5.2.1.10 Quality Measure

At the end of the pre-production phase all materials being exposed to the process of formative test were named quality measure. In this study, two stages of quality measuring were performed. Firstly, the researcher, developer, and experts self-check the artifacts (contents organization, content labels, navigation specification, and layout sketch) and penned down a list of remarks and recommendation. Secondly, the researcher, developer, and experts all together checked the artifacts and discussed the outputs of the first stage (self-check). Based on this discussion, the required corrections were completed. After this step, all the materials were ready to procced to the production phase.

5.2.2 Production phase

This phase includes recording, manipulating, mixing, reinforcement and reproduction of sounds, images and icons in ten steps. It is clearly shown in Figure 5.8 that steps one to four would commence concurrently. It shortens the time period because it involves the teamwork of developers.

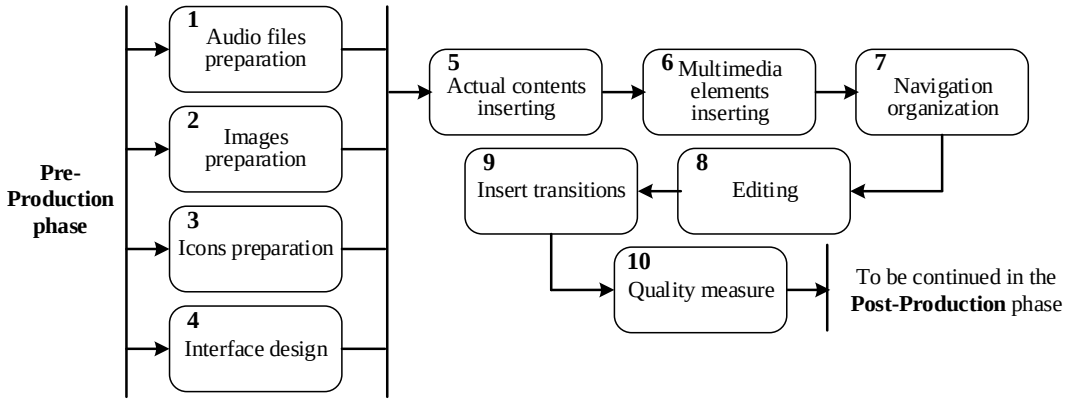


Figure 5.8. Production Phase

5.2.2.1 Audio files preparation

The Arabic texts of all Duas were prepared in the pre-production phase and ready for recording. However, one audio file is created for each Dua. Meanwhile, the design principles that have been proposed for audio files were referred to during the procedure of audio files preparation. According to Ojanen (2015) the audio files production involves three steps which are recording, mixing, and compressing. Recording is the process of inputting the sound either directly through the use of loudspeakers or insert files from registered prior to the program. After that, mixing the recorded sounds file for noise reduction, amplitude, balancing, normalization, and filtration. The Samplitude Professional 8.0 software was used in recording and mixing the sound files. There are saved in Wave at 44100 HZ sample rate. Finally, to reduce the sound files size, all files were compressed by changing the file format to MP3 and reducing the sample rate to 11025 HZ by using Format Factory 2.70 software.

5.2.2.2 Images preparation

Based on the proposed design principles of image and graphics in PDM, all the images and graphics were designed using Adobe Photoshop CS5 ME.

5.2.2.3 Icons preparation

Icons are part of images, so the designer must follow the design principles of image and graphics, especially principles related to the use of real world objects and meaningful icons.

5.2.2.4 Interface design

The interface of PDM was designed based on the layout sketches prepared in the first stage utilizing Android Studio and XML codes. During the interface designing the design principles for user interface and layout were referred to.

5.2.2.5 Actual contents inserting

This step involves the combination and integration of the actual contents such as the ritual instructions, Arabic text of Dua, and translation (Malay text) with the actual code (Java) of PDM utilizing Android Studio. It also involves the interaction modes (manual, voice commands, and GPS), which enable the users to interact with PDM utilizing menus, speech to text function, and google maps.

5.2.2.6 Multimedia elements inserting

In this step, the recorded audios were inserted into the appropriate contents.

5.2.2.7 Navigation organization

Based on the navigation specification prepared in the pre-production phase, the navigation elements were organized and activated.

5.2.2.8 Insert transitions

PDM does not need complicated transitions; therefore adding simple transitions when necessary is adequate.

5.2.2.9 Editing

In PDM, every ritual is performed through a series of steps (at least one step), so every step is represented by an activity. Meanwhile, every activity in PDM was developed separately. In this step, the separated activities related to every ritual were combined together. Editing process was carried out by the developers after several discussion sessions with the researcher. Changes were made on the navigational buttons and labels as well as the utilization of text size and colors for the content.

5.2.2.10 Quality measure

Quality measure in production phase is similar with that of the pre-production phase, in which a formative test comprising of two stages. It began with self-checking where the researcher, developer, and experts checked the quality of the prototype parts (sound files, images, icons, navigation organization and transitions) and penned down a list of remarks and errors. Secondly, the development team (researcher, developer, and experts) met together to discuss the outputs of the first stage. Based on this discussion, the required corrections were listed.

5.2.3 Post-Production phase

This is the last phase in the development process of PDM, which consists of four steps as shown in Figure 5.9.

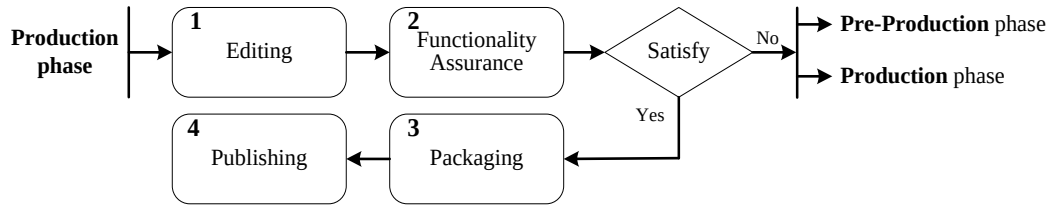


Figure 5.9. Post-Production Phase

5.2.3.1 Editing

In this step, the development teamwork edits the artifacts again based on the remarks and errors that have been listed in the production phase. This final editing process is necessary to enhance the prototype of PDM and correcting the errors.

5.2.3.2 Functionality Assurance

After completing the development of PDM there is a need for ensuring the prototype works functionality well as it should. Hence, a functionality test has been carried out after the PDM has been completely developed. However, as the main concern of this study is on the user feedback on the MMA-U, the functionality test is not discussed at length, but described in technically to show that this study has handled the functionality aspect of the prototype well.

The functionality test involved researcher, developers (technical and nontechnical), counsellors, experts and pilgrims (actual users), in which they have utilized the PDM in the Tabung Haji training sessions. In the test, in which the holy places in Makkah were simulated, they open the PDM with GPS-enabled function, test the location-aware function, go through with the audio instructions, actualize their voice commands, go through the contents, and all tasks were carried out at their maximum level.

Briefly, the functionality test was ended with success stories. Basically the subjects in the test were happy with the PDM. This explains that the PDM is ready for packaging.

5.2.3.3 Packaging

Since the intended platform to run PDM is Android, therefore packaging means processing the APK file of PDM to make it ready to publish.

5.2.3.4 Publishing

PDM is not published because it is purposely used for this study. Nevertheless, PDM is able to be published by exploiting the internet platform such as GooglePlay, which allows pilgrims to install PDM to their mobile devices anywhere anytime.

5.3 The Personal Digital Mutawwif

Finally, PDM has been produced after going through the three-phase PDM development process. Thereafter, this section maps the produced prototype with the proposed conceptual design model that described in Chapter 4. As stated earlier, the developed prototype of PDM is focusing on helping the pilgrims in reciting the required Duas and Zikr while performing Hajj and Umrah rituals. Based on that, PDM covers the dua and zikr that the pilgrims need for the whole journey of Hajj and Umrah starting from his house going through Makkah and ending with Madinah and return back home. The PDM is in Malay language to suit the target pilgrims from Malaysia and neighboring countries.

5.3.1 Opening Segment

The opening segment addresses the application name (title), logo, developer, sponsor, and introduction. In this study, the opening segment starts with a simple screen called welcoming screen showing the application name, logo, and sponsor with Quranic verse about Hajj as the background sound. However, the developer does not appear because the copyright of this study is owned by UUM, the sponsor of this study as depicted in Figure 5.10. The user can skip this welcoming screen by touching the screen or it will be displayed for several seconds only then automatically disappears to show the main menu of the application. The main menu

provides the default interaction mode, while the oral mode and GPS mode can be reached with a single-click from the main screen as shown in Figure 5.11.

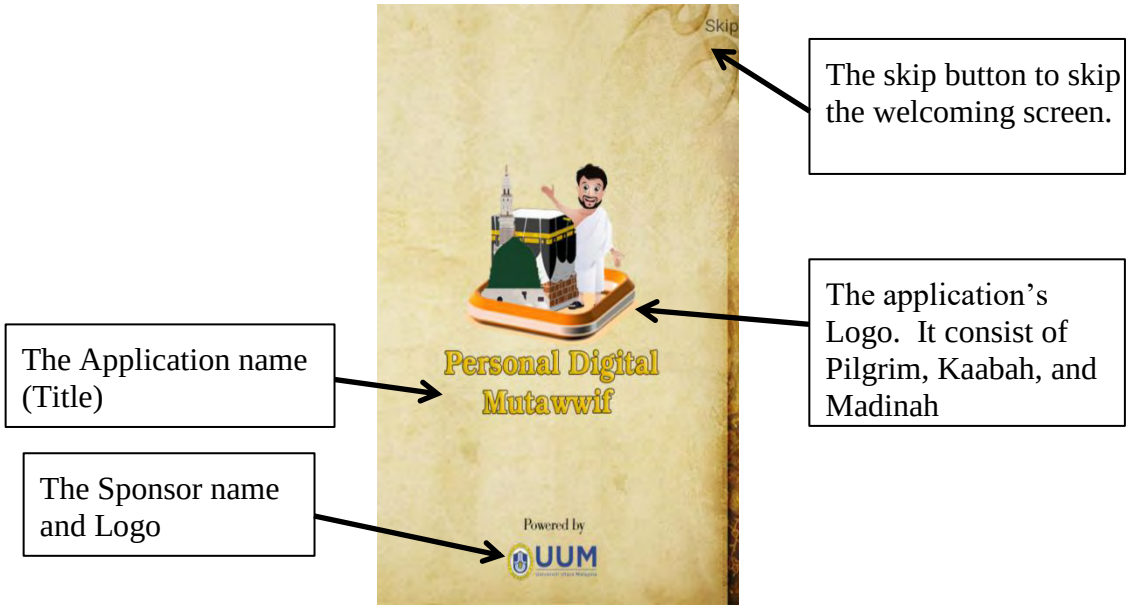


Figure 5.10. The Welcoming Screen of PDM (Opening Segment)

Figure 5.11. The Main Menu of PDM (Mode Selection)

Introduction is one of the components in the opening section, containing a brief explanation about Hajj and Umrah for pilgrims to build basic knowledge. Therefore, the introduction is presented in a separate screen because the contents cannot be displayed in the welcoming screen.

5.3.2 The Contents Segment

The content segment comprises of two divisions: interaction design and human entities. Both divisions are designed based on the design principles in PDM. Further, the interaction design is composed of modalities, presentation styles, instruction modes, and flow patterns. PDM combines two types of modalities: visual and audio, in which, the visual modality comprises different multimedia elements such as texts, images, graphics, and animations. The interaction design involves three types of presentation styles: instruction-base, demonstration and documentary. Besides, PDM offers three types of interaction modes: manual mode, oral mode, and automatic mode. The manual mode could be represented by menus or buttons, while the automatic mode offers GPS or the embedded sensors options. The flow patterns could be either separated or non-separated. Finally, the human entities are divided into two types: user and instructor. The following subsections explain the content composition components of the proposed prototype in this study.

A. Interaction Design

In this study, the components of interaction design in the prototype are composed to ensure that the PDM contents usable and can be delivered to the pilgrims while performing Hajj and Umrah rituals in the extremely crowded environment. The instruction modes in PDM are expected to solve problems faced by pilgrims and addressing the limitations of the conventional approaches and existing models.

i. Modalities

Two types of multimedia elements are used in PDM: audio and visual. The subsequent paragraphs explain them deeply.

Audio: - The main job of human mutawwif is indoctrination the dua and zikr to pilgrims. Thus audio is the paramount element in PDM. Hence, human voice is one of the audio forms, which has been utilized in PDM to indoctrination the dua and zikr. Meanwhile, the proposed conceptual model in Chapter 4 states eleven design principles for audios. The pilgrim is able to control the sound volume using the volume control buttons in mobile. They are also able to play, pause or stop the sounds by clicking appropriate button once. The screens in PDM may contain more than one sound file, but the pilgrims are allowed to play one sound file only at a time. But if they click the sound button of another dua while the sound is being played, the previous sound file will stop and then the selected dua sound file will be played (see Figure 5.12).

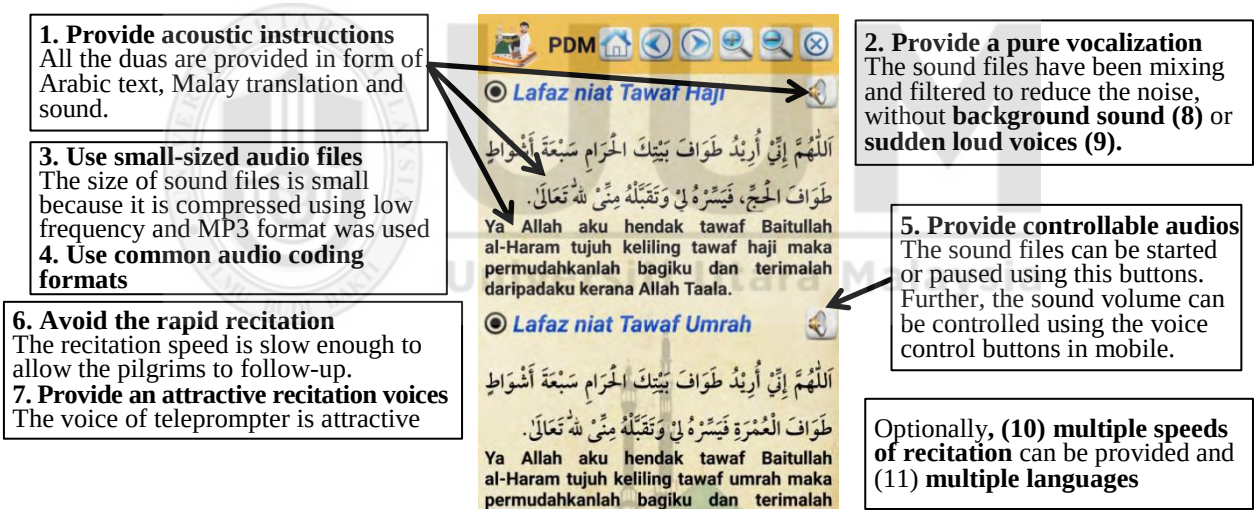
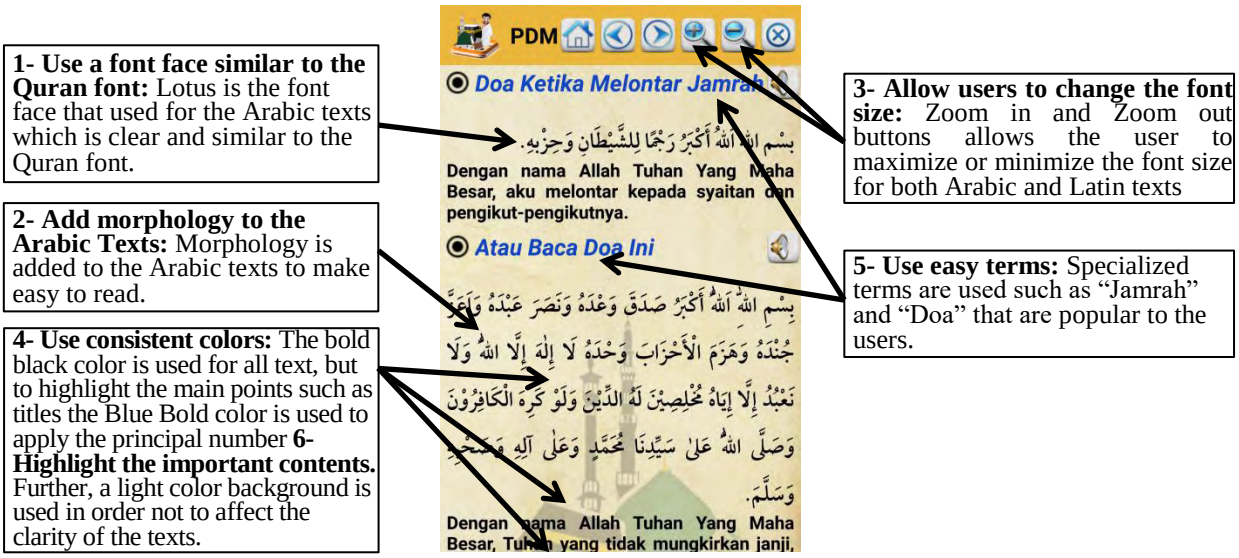
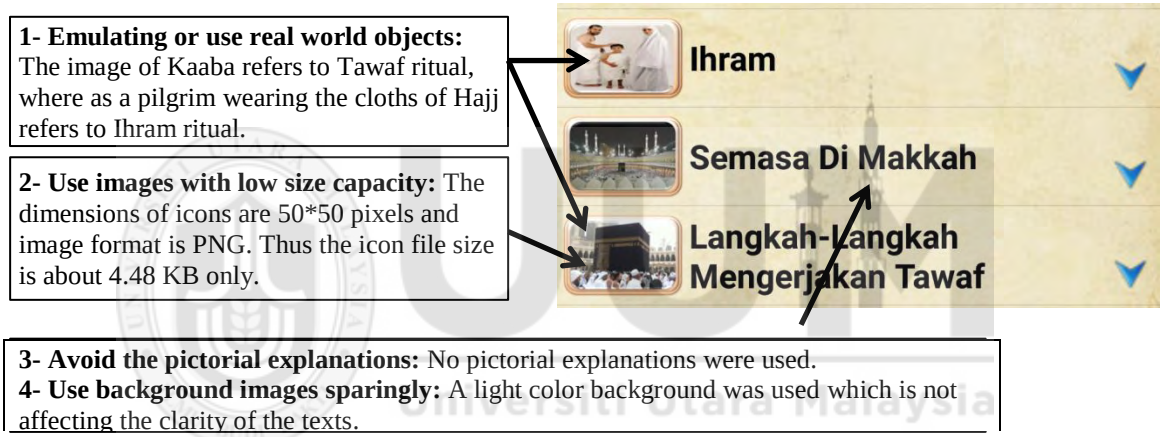


Figure 5.12. Audios in PDM

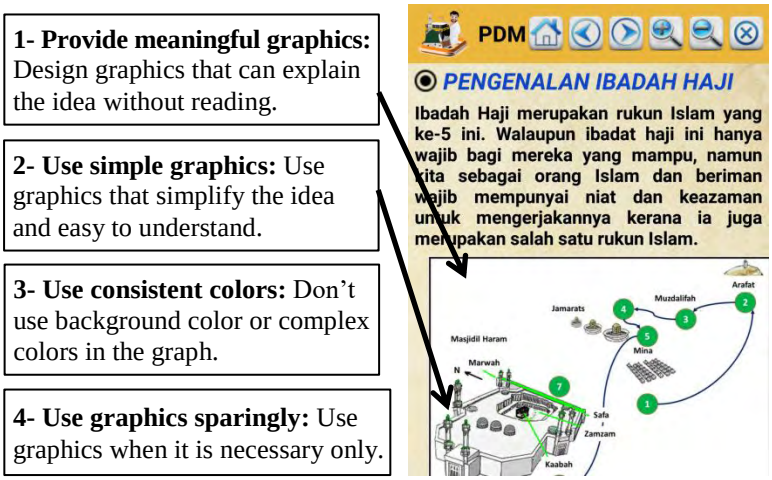
Visual: - The visual elements included in PDM are in forms of Arabic text, Latin text, graphics, animations, and icons. Each visual element has its own design principles. Figure 5.13 (A) shows how the text design principles are applied, (B) for images, and (C) for graphics and animations.



A) Texts Design Principles.



B) Images Design Principles.



C) Graphics and Animations Design Principles

Figure 5.13. The Visual Elements in PDM

ii. The Presentation Styles

The presentation styles are about the way of delivering the actual contents. This study applies there styles of presentation in PDM: instruction-based, documentary and demonstration.

Instruction-Based: - The most important presentation style is the instruction-base style in this study. This is possible because the pilgrims perform the rituals based on the human mutawwif's instructions and orders. This presentation style is the best style to deliver knowledge simply and quickly, because pilgrims listen to the instructions and see how those instructions perform in the same time. In PDM the instructions are given by a hidden instructor and the pilgrims follow. Figure 5.14 illustrates how the instructions are given.

Figure 5.14. The Instruction-Based Style in PDM

Demonstration: - In PDM, the demonstration presentation style is used as an alternative style to the instruction-based style to enhance the understanding of pilgrims before they start the performance of rituals. The demonstrations are visualized in the form of texts, animations or graphics, which are designed carefully, based on the proposed design principles in PDM. Furthermore, pilgrims are provided by repeatable functions to go

through the ritual steps. They can scroll up and down, go back and forward. Figure 5.15 exhibits samples of the provided demonstration style in PDM.

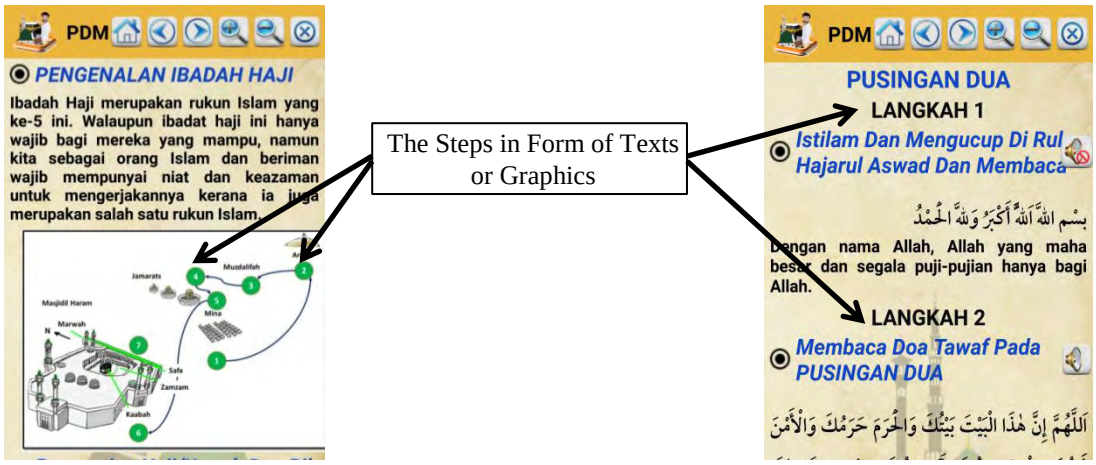


Figure 5.15. The Demonstration Style in PDM

Documentary: - In PDM, the documentary presentation style is rarely used to depict the chronology of events of Hajj and Umrah journey and rituals' steps. Also, it is used in the introduction part to give the pilgrims a brief explanation about Hajj and Umrah, types of Hajj, and the time and places of the acceptable dua.

iii. The Interaction Modes

The contents of PDM have been divided into several chunks of contents based on the rituals. Further, some rituals have been divided again into steps to ease understandability and reduce memory load. The information architecture principles were referred to during the contents division process. In Umrah with extremely crowded environment, those chunks of contents need good organization, labeling and navigation. In response to this, this study suggests two interaction modes besides the manual mode to support the content accessibility. Figure 5.16 illustrates how the chunks of contents are organized and libelled. The subsequent paragraphs explain the interaction modes in PDM.

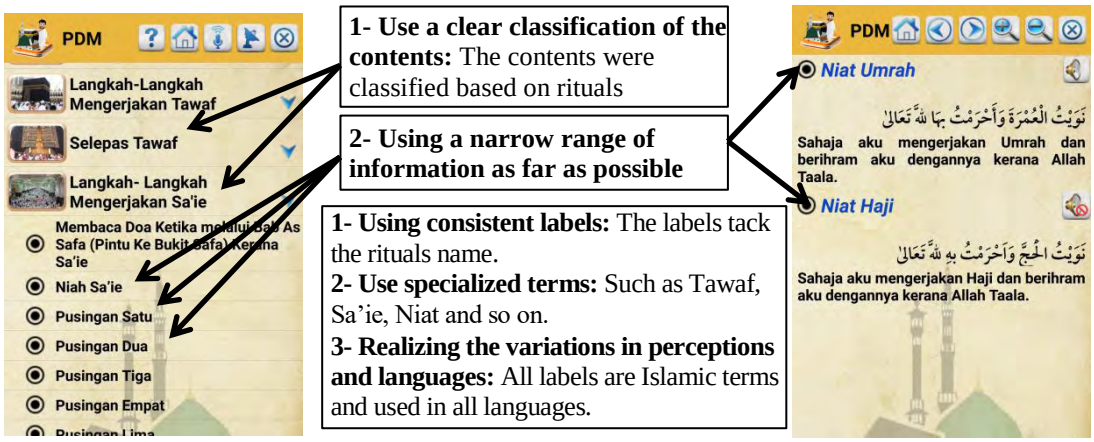


Figure 5.16. The Contents organization and Labelling in PDM

Manual Mode: - The manual interaction mode refers to the utilization of menus and buttons to access the contents. The design principle of IA was referred to during designing the main menu of PDM. Most existing models use the menus and buttons in the navigation system. Therefore, this study applies the manual mode as the default interaction in PDM. Figure 5.17 illustrates how the navigation principles are applied in PDM.

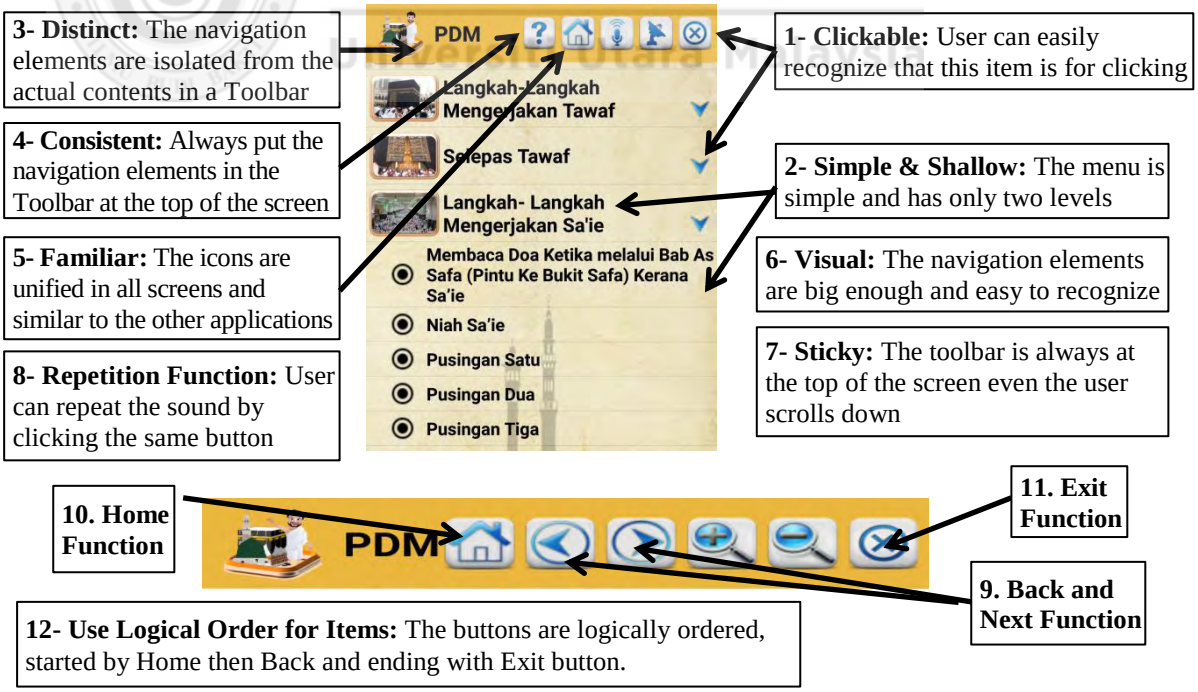


Figure 5.17. Applying the Navigation Principles in PDM

Oral Mode: - The oral instruction mode refers to the utilization of speech recognition to access the contents. The pilgrims need to click a button to start the speech recognition and pronouncing the name of the intended ritual only. If the name is correct, the first step of the requested ritual will start, otherwise PDM will give audio cue to pronouncing the name again as seen Figure 5.18.

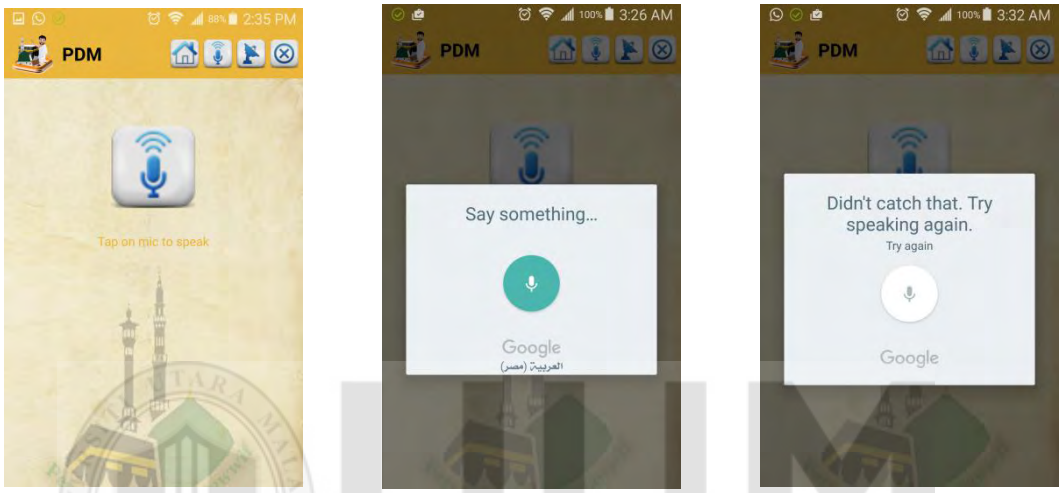


Figure 5.18. The Oral Instruction Mode in PDM

Automatic Mode GPS: - The automatic mode GPS (visualized in Figure 5.19) refers to the utilization of GPS service to access the contents. Hajj and Umrah means visiting the holy places for worship. This means the rituals of Hajj and Umrah must be performed in specific geographic locations (such as Tawaf must be performed around Kaabah inside the Masjid Al Haram). Therefore, this study utilizes the GPS services by identifying the pilgrim's current location and calculating the distance between the rituals locations and his location. When the pilgrim becomes closer to one ritual location, the PDM will alarm and ask to start giving the ritual instructions. Pilgrims can respond to the alarm message by choosing "Ya" to start the ritual instruction, "Tidak" to refuse the suggested ritual and continue tracking, or "Berhenti Menjejaki" to stop tracking and go to the main menu.

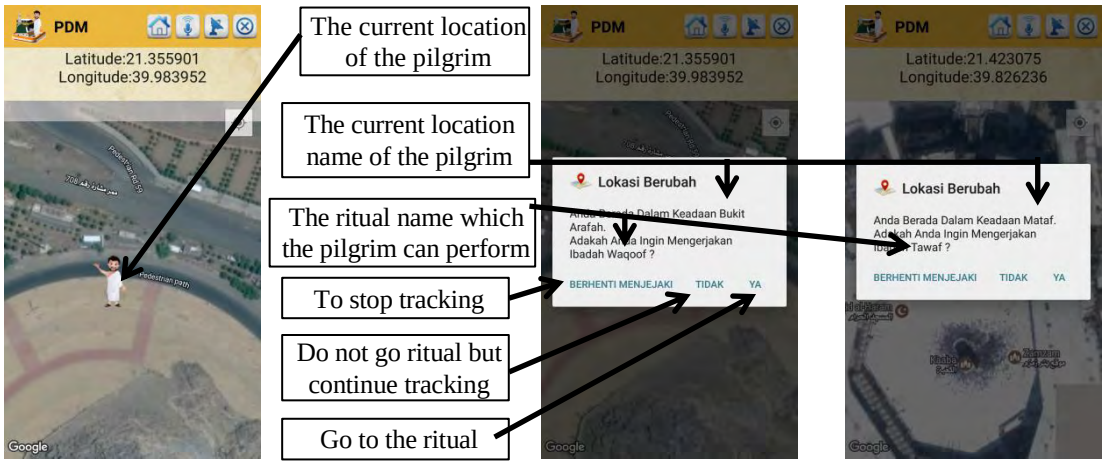


Figure 5.19. The GPS Instruction Mode in PDM

iv. Flow Patterns

PDM supports two flow patterns: non-separated and separated pattern. Non-separated pattern is used in rituals that consist of only one step, while the separated pattern is used for the rituals that involve multiple. In both patterns, PDM applies audio cue to alert the pilgrims about any change in the contents. Meanwhile, PDM uses navigation form such as home, back, and forward buttons and transmission alert when moving from one screen to another. Figure 5.20 shows the flow patterns in PDM.

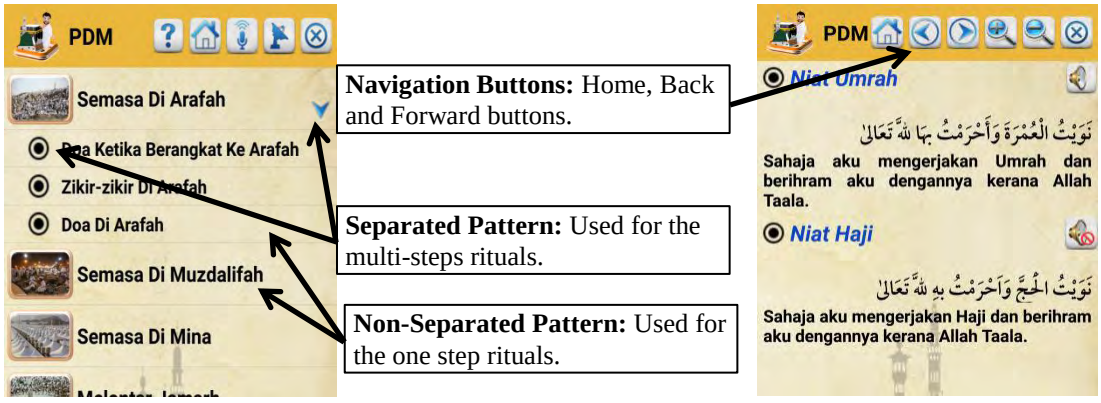


Figure 5.20. The Flow Patterns in PDM

B. Human Entities

In PDM, the human entity comprises instructor and user. In the real word, the human

mutawwif gives the ritual steps to pilgrims while they perform the ritual. Similarly, the instructions in PDM are given by seen or unseen instructor to the user who can be male or female pilgrims. Since in the conventional approach pilgrims have to carry handbook, booklet or device which is not suitable to follow in the crowdedness, PDM applies hidden instructor as the major choice of instructor. Further, some rituals such as Ihram and Hair Cut have a slight difference in the performance way between male and female pilgrims. Therefore, this study recommends applying the performance way of the male pilgrims, but with special reference for these differences that relate to the females.

5.3.3 The Closing Segment

In PDM, the closing section consists of acknowledgement for the sponsor and the contents contributor, as well as assistance and support to guide users on how to use the application. Also, the closing segment may contain user thanking for using the application or congratulation for completing rituals of Hajj successfully.

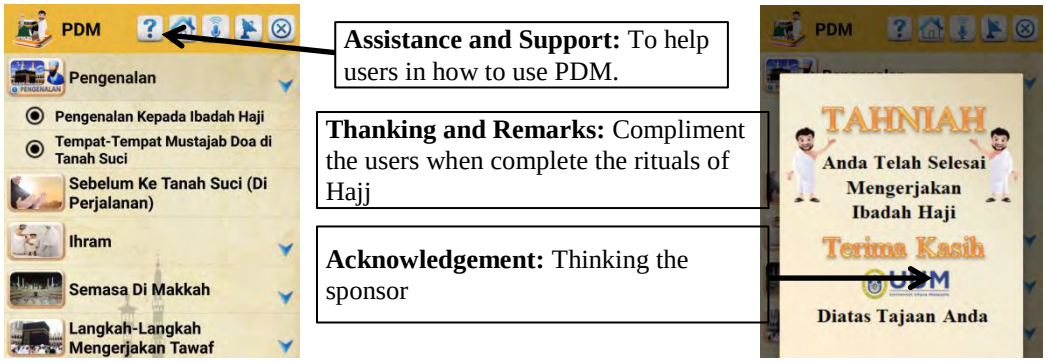


Figure 5.21. Closing Segment in PDM

5.4 Summary

This chapter describes in details the procedure of transforming the conceptual design

model which has been developed in Chapter 4 into a mobile application (prototype) named PDM. The proposed conceptual design model of PDM recommends a development approach consists of three phases: pre-production, production, and post-production. Based on that development approach the prototype of PDM was developed. Further, this chapter also shows how the proposed structure, modalities, interaction modes, and design principals have been applied in PDM.

In addition, this chapter aims at providing a means (the prototype of PDM) that can be used in validating the proposed conceptual model of PDM through end user testing. Meanwhile, having elaborated them in the previous sub-sections, this work concludes that the third research objective of this study was achieved by developing the PDM prototype.

Consequently, the prototype of PDM is ready to use for in field data collection as planned in the actual user experience texting. As stated earlier in the fourth research objective of this study, the developed prototype must be utilized in an experiment to determine whether the developed prototype in this chapter has the ability to assist the pilgrims during the Umrah. Chapter 6 provided further explanation about the users experiment.

CHAPTER SIX
USER EXPERIENCE

6.1 Overview

All the difficulties faced by pilgrims during Umrah and Hajj have been revealed in Chapter 1, while the usability issues and the limitations of the existing models have been explored in Chapter 2. As a response to that, this study proposes a conceptual design model for usable multimodal mobile assistance during Umrah and Hajj as a solution to address the identified research problem. Meanwhile, Chapter 4 deals with the process of constructing and validating the conceptual design model of PDM, which addresses that the process has gone through an SLR. Further, prototyping approach has been utilized to validate the revised model of PDM as described in Chapter 5. Consequently, the fourth objective which is to gather user feedbacks on the usability of a prototype that incorporates MMA-U is deliberated in this Chapter.

6.2 Instrument Design

As mentioned in Chapter 3, questionnaire is the main evaluation instrument that has been utilized by this study in conducting an empirical field study evaluation method named Trial-Run to evaluate the usability of PDM. It is considered as a reliable and widely used (Oppenheim, 2000). To fit the objective, questionnaire is designed to gather feedback regarding usability, and is named Questionnaire for Measuring the Usability of Multi-Modal Mobile Applications (Q-U3MA).

Since this study concerns about the usability of PDM and Chapter 4 has identified usability attributes through SLR. The instrument should be able to measure those attributes. Besides that, many researchers (Sekaran & Bougie, 2013; Nurulnadwan,

2015) suggest that a systematic approach needs to be adapted to develop the evaluation instrument. Figure 6.1 visually summarizes the development approach of the evaluation instrument.

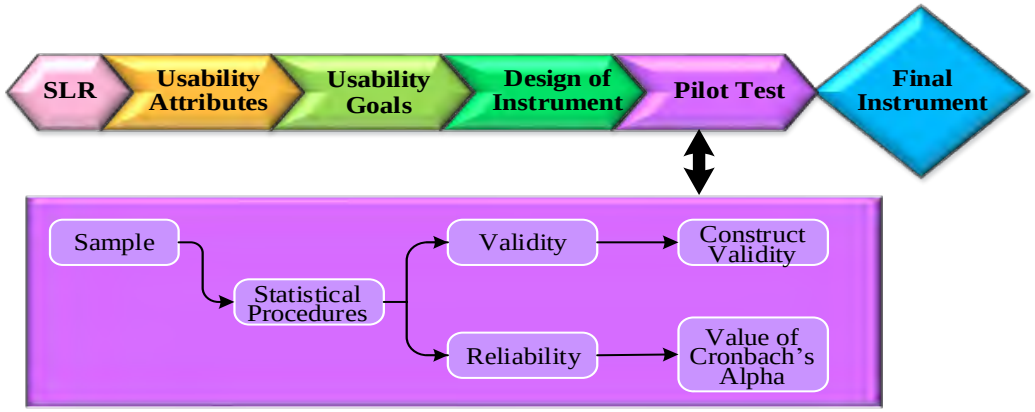


Figure 6.1. Summary of the Instrument Development Approach

As illustrated in Figure 6.1, the development process of the instrument began with an SLR to determine the instrument items. Based on the results of the SLR, the evaluation instrument must measure the main three attributes of usability which are effectiveness, efficiency, and satisfaction. In addition, the SLR results show that, each attribute could be measured through its own sub-attributes. Nevertheless, the SLR findings show that those sub-attributes have overlapping names and share the common connotation (refer to Figure 4.3). Therefore, this study decides to choose the three main attributes only as illustrated in Figure 6.2.

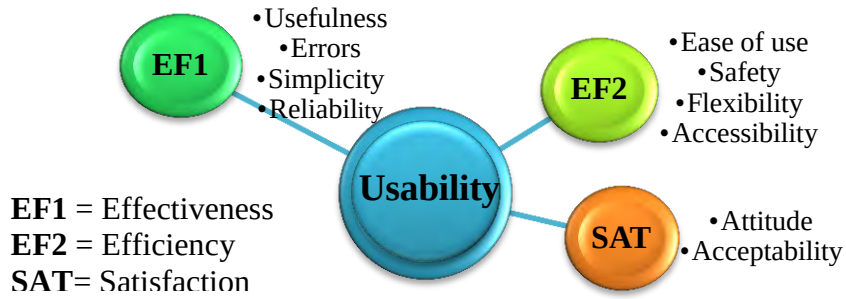


Figure 6.2. The Proposed Constructs for Measuring Usability of PDM

As mentioned in Chapter 3, many standard questionnaires (listed in Table 6.1) have been widely adapted in many researches for major attributes such as effectiveness, efficiency, and satisfaction (Harper & Norman, 1993; Kirakowski, 2000; Elias et al., 2014). Therefore, based on the constructs illustrated in Figure 6.2 for each construct all the relevant items have been assembled and used in drafting the instrument's first edition. Table 6.2 shows the proposed items of the first draft instrument while Appendix J contains the first draft of the questionnaire.

Table 6.1

List of Standard Questionnaires that the Instrument Items were adapted from

No.	Instrument Name	Acronym	Reference	Institution
1.	Questionnaire for User Interface Satisfaction	QUIS	Chin et al. 1988	Maryland
2.	Perceived Usefulness and Ease of Use	PUEU	Davis, 1989	IBM
3.	Software Usability Measurement Inventory	SUMI	(Kirakowski & Corbett, 1993)	HFRG
4.	Computer System Usability Questionnaire	CSUQ	Lewis, 1995	IBM
5.	System Usability Scale	SUS	Brooke, 1996	Redhatch
6.	Practical Heuristics for Usability Evaluation	PHUE	Perlman, 1997	OSU
7.	Purdue Usability Testing Questionnaire	PUTQ	Lin et al 1997	Purdue
8.	USE Questionnaire	USE	Lund, 2001	Sapient
9.	Mobile Phone Usability Questionnaire	MPUQ	(Ryu & Smith-Jackson, 2006)	TXSTATE

Table 6.2

The First Draft of Adapted Instrument Items

Attributes		Items	Source
Effectiveness	Usefulness	1. The information provided by PDM is enough and helpful.	4,8,9
		2. The information provided by PDM is effective in helping me complete the rituals of Hajj/Umrah.	2,4,8,9
		3. Using PDM would enable me to accomplish the rituals of Hajj/Umrah more quickly.	3
		4. Using PDM would enhance my effectiveness in performing the rituals of Hajj/Umrah.	2
		5. Using PDM would make it easier to perform the rituals of Hajj/Umrah.	3,9
		6. Using PDM would increase my productivity in performing the rituals of Hajj/Umrah.	2,3,9
		7. PDM meets my needs and does everything I would expect.	3,4,8
		8. The voice instructions in PDM are clear and easy to understand.	Researcher
		9. Sounds in PDM are sufficiently pure and not noisy.	Researcher
		10. In PDM, the recitation speed of voice instructions is sufficiently moderate.	Researcher
		11. I would find PDM useful in Hajj/Umrah.	2,8
	Errors	1. I think PDM prevents me from making errors.	6, 8, 9
		2. I can recover from mistakes quickly and easily while operating PDM.	8
		3. PDM has at some time stopped unexpectedly.	3
	Simplicity	1. The operations of PDM are simple and uncomplicated.	4,9
		2. The organization of information on PDM is clear and easy to understand.	1,3,4,9
		3. I learned to use PDM quickly.	1,2,3,9
		4. I easily remember how to use PDM.	1,7,9
		5. The information provided by PDM is easy to understand.	2,4
		6. PDM is designed for all levels of users.	1,8
		7. I found PDM simple to use.	5,8

Table 6.2 Continued

	Reliability	1. PDM is reliable, dependable, and trustworthy.	1,9
		2. PDM is accurate in identifying my exact location.	1,3
		3. PDM is accurate in interpreting my voice commands.	1,3
		4. PDM has all the functions and capabilities I expect it to have.	4
Efficiency	Ease of Use	1. I can use PDM without written instructions.	1,5,8,9
		2. PDM requires the fewest steps possible to accomplish what I want to do.	3,8,9
		3. The speed of PDM is fast enough.	3,9
		4. It is easy to make PDM does exactly what I want.	2,3,9
		5. It would be easy for me to become skillful at using PDM.	2,8
		6. It is easy to learn PDM.	2,8,9
		7. I can use PDM successfully every time.	1,3,4,8,9
		8. Using PDM is effortless.	5,8, 9
		9. Using PDM is sufficiently easy.	3,5,8,9
	Safety	1. The highlighting on the PDM screens is helpful.	9
		2. It is sufficiently easy to operate PDM with one hand.	9
		3. PDM is safe to use without causing harm or difficulty.	Researcher
		4. It is safe to use PDM while performing rituals of Hajj/Umrah.	Azham & Kutar, 2009
		5. PDM is suitable to use in a crowded environment like Hajj/Umrah.	Researcher
	Flexibility	1. It is easy to move from one part of a task to another.	3,9
		2. I do not notice any inconsistency as I use PDM.	8
		3. All operations in PDM can be carried out in a systematically similar way.	3,9
		4. In PDM, the control matches user skills.	7
		5. The visual representation in PDM is consistent with familiar conventions.	7
		6. The wording in PDM is familiar.	7
		7. PDM provides zooming for display expansion.	7
		8. The interface of PDM is consistent with other products I have used.	9
	Accessibility	1. It is easy to find the information I need in PDM.	1,4
		2. It is easy to navigate the PDM.	1,7
		3. The organization of the PDM menus is sufficiently logical.	1,9
		4. The buttons are sufficiently easy to locate.	9
		5. The amount of information displayed on the PDM screens is adequate.	1,3,7
		6. The characters on PDM screens are easy to read.	1,4,9
		7. The terminologies used in PDM are consistent and always related to the task.	1
		8. The sequence of PDM screens is clear and logical.	1
Satisfaction	Attitude	1. I feel I need to have PDM.	8,9
		2. I feel comfortable and confident using PDM.	4,9
		3. I feel excited when using PDM.	9
		4. I would recommend PDM to my friends.	8,9
	Acceptability	1)The interface of PDM is attractive and pleasant.	4,5,8,9
		2)PDM is wonderful.	8
		3)Overall, I am satisfied with PDM.	4,8,9

The evaluation instrument is shaped as a series of questions that can be answered by using predefined multiple choice answers. The evaluation instrument consists of two sections. The first section involves questions asking about the demographic data and the classification of the study sample. The second section involves questions asking the participants about their perception relating to the application in terms of the usability attributes. Besides, in the second section a five-point Likert scale answers anchored by

such as "Strongly Disagree" (1) and Strongly Agree (5), Very Difficult (1) and Very Easy (5) are used (available in Appendix J). Subsequently, the first draft of the instrument was piloted to test the validity and reliability before it is used in the real environment to measure the usability of PDM.

6.3 Pilot Study: Instrument Goodness Testing of Q-U3MA

According to Sekaran and Bougie (2013), the main objective of conducting a pilot study is to measure the consistency of the developed instrument because it has been adapted from other instruments. Also to make sure that the developed instrument (i) measures the intended variables or constructs and (ii) ready to use in the real user experience testing. Nurulnadwan (2015) confirms that this kind of investigation work can help in (i) determining the feasibility of the PDM (the prototype of proposed model) and (ii) identifying the problems that can be faced in real data collection stage. This investigation enables to apply the required revisions before conducting the real user experience testing (Hair, Black, Babin, & Anderson, 2010; Turner, 2010; Kim, 2011). Consequently, the following sub-sections separately detail subjects, validity and consistency test followed by the findings.

6.3.1 Face and Content Validity

The first draft of the instrument needs to be validated through content validity as well as Inter-item Consistency. On the other hand, Sekaran and Bougie (2013) confirm that face validity is one of the fundamental measuring methods that can be used for content validity. The instrument consists of three main attributes, and each consists of several concepts. However, each concept can be measured by a set of measuring questions called items. The purpose of content validity is to test the ability of the instrument to measure the targeted concepts and its capability to measure the desired

attributes. In other words, validity means whether the instrument really measures what is supposed to be measured or not (De Witte et al., 2013; Hayden, Keegan, Kardong-Edgren, & Smiley, 2014).

Face and content validity can be used to test the instrument validity. According to DeVon et al. (2007), face validity means whether the instrument contains flows or not, while content validity means whether the instrument elements relevance and represented the targeted aspects of the concept that researcher wants to measure (Haynes, Richard, & Kubany, 1995). Consequently, the next sub-sections separately detail the subject and findings of the face and content validity test.

6.3.1.1 Subject

As a subject of content validity test, many studies such as Zainuddin, Zaman, and Ahmad (2011), Cole and Lewis (2012) and Tosho (2016) suggest that, employing three to five experts is sufficient. Therefore, this study decides to engage five experts via email in order to review the items (Appendix K shows the instrument that was used to gather the experts' feedback about the first draft of Q-U3MA).

6.3.1.2 Findings of Content Validity Test

It was found that some items were not good enough. For example one of the important comments is "avoid double-barrel item" and "avoid the rivers questions". Therefore, applying the experts' remarks led to some adjustments, which involves repositioning, rewording, splitting, and omitting some contents in the instrument. Furthermore, Schreiber and Asner-Self (2011) state that existence of the neutral or middle choice is not acceptable within the five-point Likert scale of the instrument. Accordingly, this study decided to replace the neutral choice by "*Somehow agree*" to

force the respondent to choose one side, because the neutral opinion does not appropriate to respond to the constructs of this study. The overall Q-U3MA instrument is available in Appendix J, while the next sub-section discusses the findings of inter-item consistency analysis for Q-U3MA.

6.3.2 Instrument Reliability

Reliability refers to the fastness or constancy of responses (Punch, 2006). Sekaran and Bougie (2013) address, that instrument reliability ensures the instrument impartiality, neutrality and error free. It offers a steady and dependable scale across time as well as cross other items of the instrument. The internal consistency is one of the important aspects that assess reliability, which ensures no overlap among the instrument sections. In other words, the internal consistency of the instrument means that each section in the instrument is dedicated to only and only one attribute or dimension meanwhile all items of that section measure that attribute only (McCrae, Kurtz, Yamagata, & Terracciano, 2010). In the same vein, the instrument reliability can be increased by many procedures such as increasing the item number, standardizing the administrative procedure, very well written and clear questions, appropriate questions to the sample, and ensuring that questions are scored carefully (Jackson, 2015). For this study, the reliability text has been carried out involving subjects as described in the following sub-section.

6.3.2.1 Subject

As stated earlier, the Q-U3MA has adapted the existing works to measure the usability of PDM. Representative subjects are very important in this pilot test. This study obtains 35 responders among Malaysian pilgrims. The responders were randomly selected among the Malaysian pilgrims in Makkah as well as the trainees and trainers involved in the practical training program offered by the Islamic Centre UUM and Lembaga Tabung

Haji. The number of the engaged respondents in the pilot test is sufficient to obtain a reliable and acceptable outcomes in the statistical tests as emphasized by Sekaran (1992). Next sub-section discusses the findings of the reliability test

6.3.2.2 Findings of the Reliability Test

Cronbach's Alpha Coefficient has been confirmed by Bordens and Abbott (2013) to indicate the instrument reliability. The test's result must be a value between 0 and 1 whereas higher score of the test's result indicate higher reliability and vice versa. Bordens and Abbott (2013) affirm that an instrument is considered good if its Cronbach's Alpha is greater than 0.8. Anyway, a value over 0.6 is still acceptable if the instrument is a preliminary version. Meanwhile, Sajjad (2009) and Chin et al. (2003) earlier underlined that 0.50 is still adequate for a novel software or if the rest instrument items that measure the same construct score a high reliability value. Therefore, in this study the opinion of Sajjad (2009) and Chin et al. (2003) as well as Ray's opinion (1982) are combined. This implies that any value between 0.50 and 0.60 is considered sufficient in measuring reliability because this is a preliminary version instrument for evaluating a new application.

Referring to the results in Table 6.3 it is seen that all attributes score greater than 0.8. This explains that the instrument is considered good. Nevertheless, the results show that those values can be increased if some items are deleted (refer to Appendix L for more details).

Q- U3MA combines items from a few existing instruments. Hence, it is necessary to obtain confirmation (via factor analysis) to check whether the items fit the intended attributes of Q-3MA or not (Wang & Ahmed, 2004). In this context, the decision for eliminating any item from the instrument must be based on the value of factor loading through a Confirmatory Factor Analysis test as explained in the next sub-

section. Subsequently, another reliability test was conducted after Factor Analysis to assess the new construct reliability.

Table 6.3

Reliability Test before Factor Analysis

Constructs	N	Cronbach's Alpha	N of Items
Usefulness (USF)	**35**	**0.875**	**11**
Errors Rate (ERR)	35	0.848	4
Simplicity (SIM)	**35**	**0.891**	**7**
Reliability (REL)	35	0.901	4
Ease Of Use (EOU)	**35**	**0.896**	**7**
Safety (SAF)	35	0.916	4
Flexibility (FLE)	35	0.951	7
Accessibility (ACS)	**35**	**0.901**	**8**
Attitude (ATT)	35	0.923	5
Acceptability (ACP)	35	0.900	4

6.3.3 Construct Validity (Factor Analysis)

The construct validity test concerns about whether all the attribute's aspects that needs to be measured have been represented duly by the elements of the instrument. In other words, it refers to the instrument's ability to cover the important aspects of the concept that this study wants to measure (Patrick et al., 2011). Therefore, this study runs factor analysis test to verifying that the measurement attributes are operationally defined, and indicate the suitability of items for each attribute (Sekaran & Bougie, 2013). As suggested by Hair et al. (2010), the factor analysis is carried out in SPSS by using a statistical procedure called Principal Components Analysis (PCA) Varimax rotation.

Three indicators have been utilized for accepting each item (i) Kaiser-Meyer-Olkin (KMO) to measure the sampling adequacy, (ii) Bartlett test of sphericity as well as (iii) factor loading. According to Siti Mahfuzah (2011), both KMO and Bartlett tests of sphericity must be run before the factor loading test takes place. Because the KMO test

is used to investigate whether the obtained data is sufficient and ready for factor loading test, and Bartlett test of sphericity is used to determine whether it is worth continuing with the factor analysis. Meanwhile, the factor loading is used to determine the correlation between the measuring items and their intended factor. According to Hair et al. (2010), the significance level of the constructs can be determined via the practical significance of the loadings rather than the conservative significant test. Furthermore, the measures are considered acceptable if the following conditions are met:

I. Rule 1: KMO test ≥ .50
II. In Bartlett's test of sphericity, the significant value of $p < .05$
III. Although factor loadings of ±.30 to ±.40 are minimally acceptable, values greater than ±.50 are generally considered essential for practical significance.

6.3.3.1 Subject

In the pilot study of this study, 35 users were involved as respondents. It is not sufficient for running the construct validity test through factor analysis, because Hair et al. (2010) clearly state factor analysis requires at least 100 dataset. Regarding this, Siti Mahfuzah (2011) and Tosho (2016) recommend to combine the data in the pilot study with data in the actual study. Based on their practice, this study combines the gathered data. While the pilot test gathers 35 datasets, the actual test managed to gather 129 dataset, giving altogether 164 dataset for the factor analysis test.

6.3.3.2 Findings of Factor Analysis

In preparing the collected data for factor loading analysis, the KMO test was carried out and the results are tabulated in Table 6.4. It can be noticed that all the values for KMO test satisfy the condition of KMO test ≥ 0.50.

Table 6.4

The Results of KMO Test and Bartlett's Test of Sphericity

Constructs/Attributes	KMO	Significant Value of Bartlett's Test
Usefulness (USF)	0.864	0.000
Errors Rate (ERR)	0.808	0.000
Simplicity (SIM)	0.846	0.000
Reliability (REL)	0.842	0.000
Ease Of Use (EOU)	0.883	0.000
Safety (SAF)	0.820	0.000
Flexibility (FLE)	0.915	0.000
Accessibility (ACS)	0.897	0.000
Attitude (ATT)	0.836	0.000
Acceptability (ACP)	0.814	0.000

Further, the Bartlett's test of sphericity gives a significant value of 0.00 for all usability attributes, which means that the second condition ($p<0.05$) is met. Therefore, the collocated data is ready for conducting the factor analysis test via factor loading. Table 6.5 shows the factor loading of each item from the factor analysis test.

Table 6.5

The Results of Factor Loading for each Item in the Q-U3MA

Label	Items	Factor Loading
USF1	The information provided by PDM is helpful enough.	0.758
USF2	The information provided by PDM is effective in helping me to complete the rituals of Hajj/Umrah.	0.697
USF3	Using PDM would enable me to accomplish the rituals of Hajj/ Umrah contentedly.	0.713
USF4	**Using PDM would enhance my effectiveness in performing the rituals of Hajj/Umrah.**	**0.267***
USF5	Using PDM would make it easier to perform the rituals of Hajj/Umrah.	0.812
USF6	**Using PDM would increase my productivity in performing the rituals of Hajj/Umrah.**	**0.021***
USF7	PDM meets my needs and expectation.	0.714
USF8	The voice instructions in PDM are easy to understand.	0.795
USF9	Sounds in PDM are free of noise.	0. 793
USF10	In PDM, the recitation speed of voice instructions is sufficiently moderate.	0. 728
USF11	I would find PDM useful in performing Hajj/Umrah.	0. 713
ERR1	PDM prevents me from making errors.	0. 767
ERR2	In PDM, I can recover from mistakes quickly.	0. 768
ERR3	In PDM, the error messages effective in assisting me to fix problems.	0. 725
ERR4	PDM rarely stopped unexpectedly.	0. 596

Table 6.5 Continued

SIM1	The operations of PDM are simple.	0. 825
SIM2	The organization of information on PDM is clear.	0. 861
SIM3	It is easy to learn PDM.	0. 818
SIM4	I easily remember how to use PDM.	0. 822
SIM5	The information provided by PDM is easy to understand.	0. 846
SIM6	**PDM is designed for all levels of users.**	**0. 179***
SIM7	I found PDM simple to use.	0. 852
REL1	PDM is trustworthy.	0. 888
REL2	PDM is accurate in identifying my exact location.	0. 845
REL3	PDM is accurate in interpreting my voice commands.	0. 791
REL4	PDM has all the functions I expect it to have.	0. 774
EOU1	I can use PDM without written instructions.	0. 832
EOU2	**PDM requires the fewest steps possible to accomplish what I want to do.**	**0. 236***
EOU3	It is easy to make PDM does exactly what I want.	0. 821
EOU4	It would be easy for me to become skillful at using PDM.	0. 815
EOU5	I can use PDM successfully every time.	0. 721
EOU6	Using PDM is effortless.	0. 813
EOU7	Using PDM is sufficiently easy.	0. 839
SAF1	It is sufficiently easy to operate PDM with one hand.	0. 790
SAF2	PDM is safe to use without causing harm.	0. 836
SAF3	It is safe to use PDM while performing rituals of Hajj/Umrah.	0. 843
SAF4	PDM is suitable to use in a crowded environment like Hajj/Umrah.	0. 825
FLE1	It is easy to move from one part of a task to another.	0. 860
FLE2	I do not notice any inconsistency as I use PDM.	0. 783
FLE3	In PDM, the control matches user skills.	0. 820
FLE4	The visual representation in PDM is consistent with familiar conventions.	0. 817
FLE5	The wording in PDM is familiar.	0. 836
FLE6	PDM provides zooming for display expansion.	0. 854
FLE7	The interface of PDM is consistent with other products I have used.	0. 797
ACS1	It is easy to find the information I need in PDM.	0. 877
ACS2	It is easy to navigate the PDM.	0. 813
ACS3	The organization of the PDM menus is sufficiently logical.	0. 827
ACS4	The buttons are sufficiently easy to locate.	0. 863
ACS5	The characters on PDM screens are easy to read.	0. 860
ACS6	The terminologies used in PDM are always related to the task.	0. 834
ACS7	**The terminologies used in PDM are consistent.**	**0. 237***
ACS8	The sequence of PDM screens is clear and logical.	0. 852
ATT1	I feel I need to have PDM.	0. 796
ATT2	I feel comfortable using PDM.	0. 827
ATT3	I feel confident using PDM.	0. 749
ATT4	I feel excited when using PDM.	0. 823
ATT5	I would recommend PDM to my friends.	0. 846
ACP1	The interface of PDM is attractive.	0. 878
ACP2	PDM is pleasant to use	0. 768
ACP3	PDM is wonderful.	0. 814
ACP4	Overall, I am satisfied with PDM.	0. 827

As demonstrated in Table 6.5, all the items of Q- U3MA found valid and can be used to represent respective attributes except for items marked with asterisk (*) which

show loading values less than 0.50. As stated earlier, factor loadings ≥ 0.50 are considered practically significant and well-defined structure (Hair et al., 2010). Therefore, based on the third rule the items that have factor loading values equal or greater than 0.50 are included in the final version of the instrument. Subsequently, another reliability test has been conducted and the findings are tabled in Table 6.6 and detailed in Appendix L. As result, the final version of Q- U3MA has been obtained and is shown in Appendix M.

Table 6.6

Reliability Test

Constructs	N	Cronbach's Alpha	N of Items
Usefulness (USF)	**164**	**0.934**	**9**
Errors Rate (ERR)	164	0.848	4
Simplicity (SIM)	**164**	**0.943**	**6**
Reliability (REL)	164	0.901	4
Ease Of Use (EOU)	**164**	**0.929**	**6**
Safety (SAF)	164	0.916	4
Flexibility (FLE)	164	0.951	7
Accessibility (ACS)	**164**	**0.961**	**8**
Attitude (ATT)	164	0.923	5
Acceptability (ACP)	164	0.900	4

6.4 Experimental Study: Measuring Usability

As mentioned in Chapter 1, the last objective of this study is to gather user feedbacks on the usability of a prototype that incorporates MMA-U. Therefore, an experimental study was implemented in the fields (The holy places of Makkah and Medina) during Hajj and Umrah. In this experimental study the Q-U3MA was utilized for gathering data.

In Makkah, the pilgrims are the actual users who participate in the study. They were grouped into new and used users. The used users are those users who have been previously to Makkah for Hajj or Umrah, while new users are the pilgrims who visit

Makkah for the first time for Hajj or Umrah. Naturally, used users have previously experienced the conventional approaches of performing Hajj or Umrah, so they have the ability to compare between PDM and the conventional approaches. The main purpose of this experimental study is to test the effectiveness and efficiency of PDM during Hajj and Umrah as well as the users' perception and satisfaction.

6.4.1 Demographic Background

There were 129 participants in the experimental study of this work. However, out of the 129 respondents, 3 outliers were found. According to Tosho (2016), the outliers respondents must be removed. Therefore, the actual samples size in this study is 126, which is sufficient (Ariffin, 2009; Siti Mahfuzah, 2011).

Generally, 28 (22.2%) users are 25 years old or below, 45 (35.7%) between 26 and 40 years old, 36 (28.6%) between 41 and 55 years old, and finally 17 (13.5%) are 56 years old and older. Altogether, there are 90 (71.4%) males and 36 (28.6%) females. In terms of education level, 56.4% of the users are undergraduate holders (15.9% pre-bachelor degree holders and 40.5% bachelor degree holders) and 28.6% are post-graduate holders (master and Ph.D. holders). The remaining (15.1%) are not educated or they do not attend formal schools and universities. More than half of them (56.3 %) have experienced using mobile applications for more than one year, while the remaining (43.7%) have experienced using mobile applications for one year or less. They have been categorized into two groups, new users who have not been to Makkah to perform Hajj or Umrah, and used users who have been to Makkah to perform Hajj or Umrah. The results show that 62.7% of respondents are new users, while 37.3% of respondents are used users. The details described in this paragraph are summarized in Table 6.7. They are followed with an illustration in Figure 6.3.

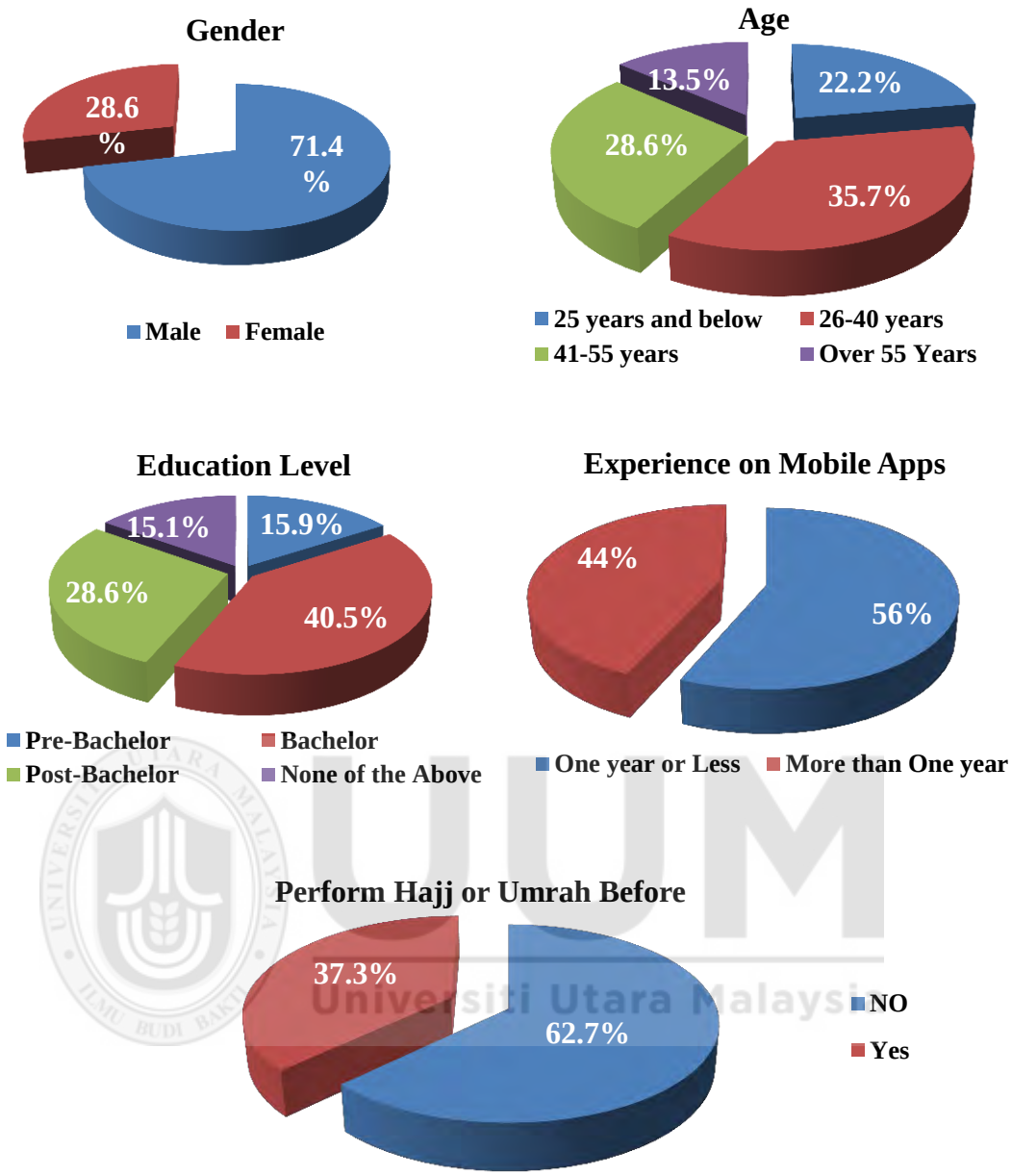


Figure 6.3. The Demographic Profile of Respondents

Table 6.7

The Demographic Profile of Respondents

Variable	Demographic Data	Frequency	Percentage %
Gender	Male	90	71.4
	Female	36	28.6
Age	25 Years and Below	28	22.2
	26 – 40 Years	45	35.7
	41 – 55 Years	36	28.6
	Over 55 Years	17	13.5

Table 6.7 Continued

Education Level	Pre-Bachelor Degree	20	15.9
	Bachelor Degree	51	40.5
	Post-Bachelor Degree	36	28.6
	None of the Above	19	15.1
Experience on Mobile Applications	One year or Less	55	43.7
	More than One year	71	56.3
Have you been to Hajj or Umrah before this	No	79	62.7
	Yes	47	37.3

6.4.2 Data Distribution

This study utilizes the Statistical Package for the Social Sciences (SPSS) software version 21 in analysing the collected data from the experiment study. Based on the statistical procedures listed below in Table 6.8, some inferences were made to test the hypotheses of this study. Consequently, some parametric tests such as Independent Sample *t*-Test and Pearson correlation test were carried out. However, such parametric tests rely on the assumption that the collected data are normally distributed. Therefore, a normality test has been conducted in this study to ensure that the collected data are normally distributed.

Table 6.8

The Research Hypothesis

Statistical Tests	Hypotheses
Independent Sample *t*-Test	**H_1:** There is a significant difference between positive attitude of new users and used users of PDM.
	H_2: There is a significant difference between the levels of acceptance between new users and used users of PDM.
Pearson Correlation Test	**H_3:** There is a positive relationship between the effectiveness of PDM and the users' satisfaction.
	H_4: There is a positive relationship between the efficiency of PDM and the users' satisfaction.
Descriptive	**H_5:** The mean score of overall effectiveness of PDM is high.
	H_6: The mean score of overall efficiency of PDM is high.
	H_7: The mean score of overall users' satisfaction of PDM is high.

6.4.2.1 Normality Test

There are many types of tests to check the normality of data such as Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. Meanwhile, Razali and Wah (2011) emphasized that Shapiro-Wilk test is considered the most powerful test that can be used for of sample sizes, whereas the least powerful test is Kolmogorov-Smirnov. However, the power of Shapiro-Wilk test is still low for a small sample size (Hair et al., 2010; Garson, 2012). On the other hand, Tabachnick and Fidell (2013), Pallant (2013), and Hair et al. (2010) confirm that normality can be assessed by using the value of kurtosis and skewness coefficients. It is also recommended to combine graphical techniques (such as Q-Q Plot, boxplot and scattered plot) with the formal normality test as well as shape parameters such as kurtosis and skewness coefficients (Razali & Wah, 2011).

Consequently, this study employs the procedure proposed by Pallant (2013) in assessing the normality of data. In regards to that, Hair et al. (2010) and Garson (2012) state that the values of skewness must be ranged between +1 and -1 for the data to be described as normal data, whereas Kline (2016) confirmed that the skewness value between +3 and -3 is still acceptable. Meanwhile, Coakes and Ong (2011) underline that kurtosis value should not be more than ±3. In addition, there is a rule of thumb, saying that if the skewness and kurtosis measure (Z-score) is greater than ±2.58 times its standard error, the assumption of normality is violated (Morgan & Griego, 1998; Pallant, 2013). The Z-score can be calculated by dividing the skewness and kurtosis' statistics by the standard error (Pallant, 2013). Based on this conditions, Table 6.9 exhibits the skewness, kurtosis, and Z-score for Mean Average of Usefulness Attribute (MAUSF), Mean Average of Errors Rate Attribute (MAERR), Mean Average of Simplicity Attribute (MASIM), Mean Average of Reliability Attribute (MAREL), Mean Average of Ease Of Use

Attribute (MAEOU), Mean Average of Safety Attribute (MASAF), Mean Average of Flexibility Attribute (MAFLE), Mean Average of Accessibility Attribute (MAACS), Mean Average of Attitude Attribute (MAATT), and Mean Average of Acceptability Attribute (MAACP) for the collected data.

Table 6.9

The Skewness, Kurtosis, and Z-score Values for All Attributes

	N	Skewness			Kurtosis		
	Statistic	**Statistic**	**Std. Error**	**Z-score**	**Statistic**	**Std. Error**	**Z-score**
MAUSF	126	-0.063	0.216	-0.292	-0.666	0.428	-1.556
MAERR	126	0.440	0.216	2.037	0.017	0.428	0.040
MASIM	126	0.231	0.216	1.069	-0.880	0.428	-2.056
MAREL	126	-0.097	0.216	-0.449	-0.820	0.428	-1.916
MAEOU	126	-0.078	0.216	-0.361	-0.346	0.428	-0.808
MASAF	126	0.000	0.216	0.000	-0.551	0.428	-1.287
MAFLE	126	0.446	0.216	2.065	-0.598	0.428	-1.397
MAACS	126	0.360	0.216	1.667	-0.855	0.428	-1.998
MAATT	126	-0.317	0.216	-1.468	-0.411	0.428	-0.960
MAACP	126	-0.013	0.216	-0.060	-0.899	0.428	-2.100

As indicated in Table 6.8 the Skewness and Kurtosis values of all attributes range between +1 and -1 (very close to zero). Likewise, the Z-score values of all attributes are within the range of ±2.58. Based on the results, therefore it is understandable that data gathered from this experiment study are normally distributed. Thus, this study proceeded with parametric tests for hypotheses testing.

6.4.3 General Findings

This sub-section highlights some of the general findings that have been obtained from the experiment. As stated earlier, the experiment was conducted in the actual environment during Hajj or Umrah in Makkah. At the beginning, the pilgrims were asked to perform some Hajj or Umrah rituals (one or two rounds of Tawaf or Sai'e)

using the conventional approach. After that, they were allowed to complete the same ritual with the assistance of PDM. This step aims to give them the opportunity to compare their experience using PDM and the conventional approach. The following sub-sections list some of the general findings of this study.

6.4.3.1 The Usefulness of PDM

Firstly, all subjects found that the information provided by PDM is helpful. Particularly, 34.1% of them strongly agree, 58.7% agree while 7.1% somehow agree. Similarly, all subjects (50 % strongly agree, 44.4% agree, and 5.6% somehow agree) confirm that the information provided by PDM is effective in helping them to complete the rituals of Hajj and Umrah. Secondly, the results show that all subjects (21.4% strongly agree, 31.8% agree, and 46.8% somehow agree) believe that using PDM would enable them to accomplish the rituals of Hajj or Umrah contentedly. Likewise, all subjects (58.7% strongly agree, 35.7% agree, and 5.6% somehow agree) found that using PDM makes the performance of the rituals of Hajj or Umrah easier. In addition, 45.2% of the subjects strongly agree that PDM meets their needs and expectation, while the rest agree (43.7% were agree and 11.1% somehow agree). Meanwhile, in terms of the understandability of the voice instruction, majority of them (31.7% strongly agree, 54% agree, and 14.3% somehow agree) state that the voice instructions in PDM are easy to understand. Similarly, they also confirm that the sounds in PDM are free of noise (39.6% strongly agree, 55.6% agree, and 4.8% somehow agree). Furthermore, the all of subjects (33.3% strongly agree, 39.7% agree, and 27% somehow agree) affirm that in PDM, the recitation speed of voice instructions is sufficiently moderated. In overall, all subjects found PDM is useful in assisting pilgrims during Hajj and Umrah (42.1% strongly agree, 50.8% agree, and 7.1% somehow agree). These are supported with bar chart and statistics in Figure 6.4 and Table 6.10.

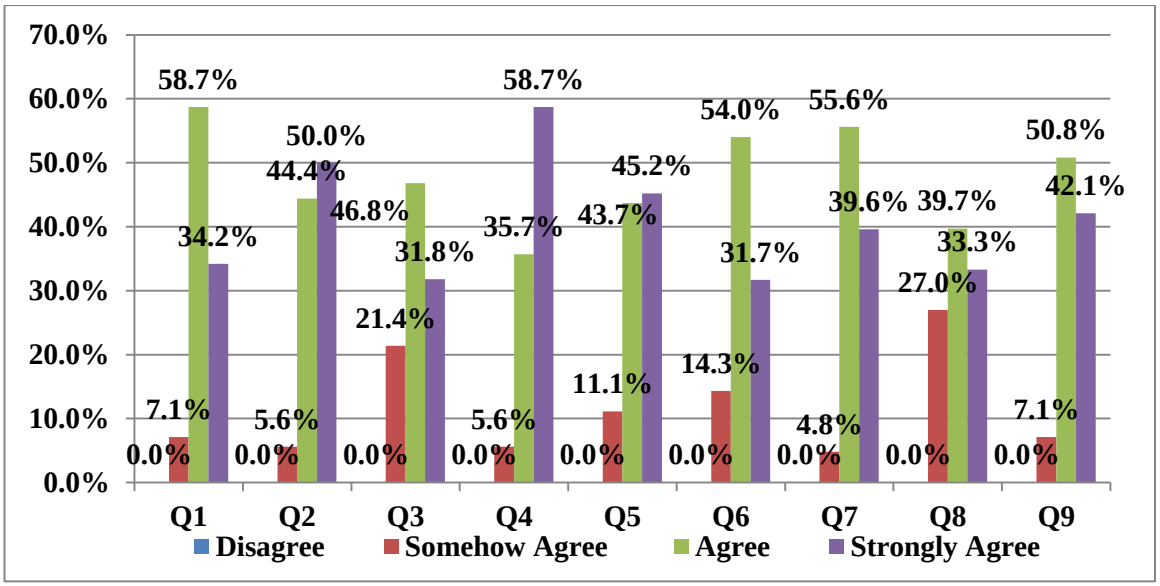


Figure 6.4. The Usefulness of PDM

Table 6.10

The Usefulness of PDM

NO	The Question	Mean	Frequency and Percent	Disagree	Somehow Agree	Agree	Strongly Agree
Q1	The information provided by PDM is helpful enough.	4.2698	N	0	9	74	43
			%	0.0%	7.1%	58.7%	34.1%
Q2	The information provided by PDM is effective in helping me to complete the rituals of Hajj/Umrah.	4.4444	N	0	7	56	63
			%	0.0%	5.6%	44.4%	50.0%
Q3	Using PDM would enable me to accomplish the rituals of Hajj/ Umrah contentedly.	4.1032	N	0	27	59	40
			%	21.4%	46.8%	31.8%	21.4%
Q4	Using PDM would make it easier to perform the rituals of Hajj/Umrah.	4.5317	N	0	7	45	74
			%	0.0%	5.6%	35.7%	58.7%
Q5	PDM meets my needs and expectation.	4.3413	N	0	14	55	57
			%	0.0%	11.1%	43.7%	45.2%
Q6	The voice instructions in PDM are easy to understand.	4.1587	N	0	18	68	40
			%	0.0%	14.3%	54%	31.7%
Q7	Sounds in PDM are free of noise.	4.3254	N	0	6	70	50
			%	0.0%	4.8%	55.6%	39.6%
Q8	In PDM, the recitation speed of voice instructions is sufficiently moderate.	4.0556	N	0	34	50	42
			%	0.0%	27%	39.7%	33.3%
Q9	I would find PDM useful in performing Hajj/Umrah.	4.3492	N	0	9	64	53
			%	0.0%	7.1%	50.8%	42.1%

6.4.3.2 Error Rate in PDM

The results reveal that the error rate in PDM is very small. Particularly, 12.7% of the

subjects somehow agree that PDM prevents them from making errors, while the majority (31.7% strongly agree and 55.6% agree as illustrated in Figure 6.5 and Table 6.11) affirm that PDM prevents them from making errors. However, when any error occurred, all subjects (18.25% strongly agree, 63.5% agree, and 18.25% somehow agree) confirm that they can recover from mistakes quickly. Likewise, all subjects (32.5% strongly agree, 51.6% agree, and 15.9% somehow agree) found that in PDM, the error messages are effective in assisting them to fix problems. Further, all subjects (15.9% strongly agree, 46.8% agree, and 37.3% somehow agree) agree that PDM rarely stops unexpectedly.

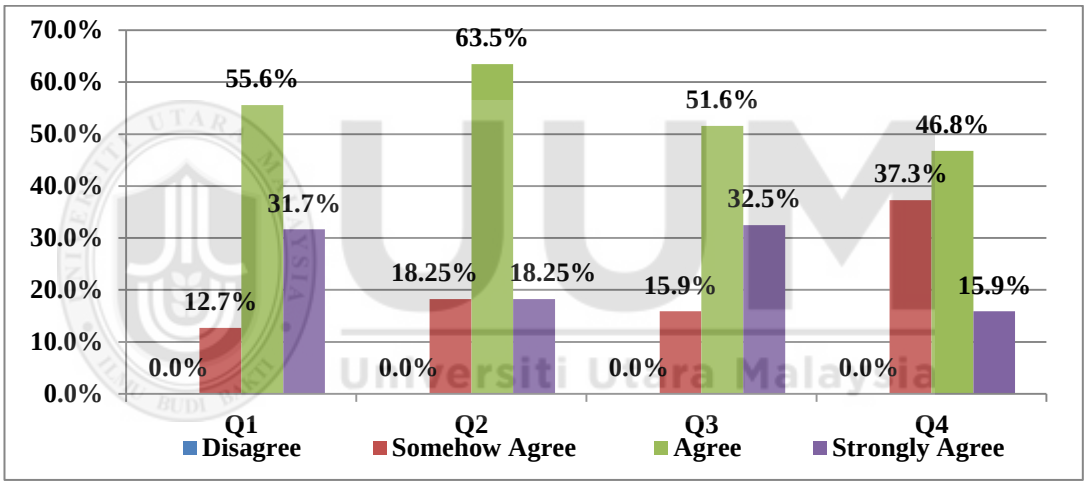


Figure 6.5. The Errors Rate in PDM

Table 6.11

The Errors Rate in PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	PDM prevents me from making errors.	4.2698	**N**	0	16	70	40
			%	0.0%	12.7%	55.6%	31.7%
Q2	In PDM, I can recover from mistakes quickly.	4.4444	**N**	0	23	80	23
			%	0.0%	18.25%	63.5%	18.25%
Q3	In PDM, the error messages effective in assisting me to fix problems.	4.1667	**N**	0	20	65	41
			%	0.0%	15.9%	51.6%	32.5%
Q4	PDM rarely stopped unexpectedly.	3.6667	**N**	0	47	59	20
			%	0.0%	37.3%	46.8%	15.9%

6.4.3.3 The Simplicity of PDM

As shown in Figure 6.6 and Table 6.12, all subjects found that PDM is simple to use (40.5% strongly agree, 59.5% agree). Similarly, they also confirm that the operations of PDM are simple (39.7% strongly agree, 56.3% agree, and 4% somehow agree). In terms of the information organisation, majority of them (34.9% strongly agree, 50% agree, and 15.1% somehow agree) state that the organization of information on PDM is clear. Additionally, 43.7% of them strongly agree that PDM is easy to learn (46.8% of them agree and 9.5% somehow agree). Likewise, all of them (45.3% strongly agree, 46% agree, and 8.7 % somehow agree) confirm that PDM is easy to remember. In terms of the information provided by PDM, majority (40.5% strongly agree, 48.4% agree, and11.1% somehow agree) clearly state that the information is easy to understand.

Table 6.12

The Simplicity of PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	The operations of PDM are simple.	4.3571	**N**	0	5	71	50
			%	0.0%	4.0%	56.3%	39.7%
Q2	The organization of information on PDM is clear.	4.1984	**N**	0	19	63	44
			%	0.0%	15.1%	50.0%	34.9%
Q3	It is easy to learn PDM	4.3413	**N**	0	12	59	55
			%	0.0%	9.5%	46.8%	43.7%
Q4	I easily remember how to use PDM.	4.3492	**N**	0	11	56	57
			%	0.0%	8.7%	46%	45.3%
Q5	The information provided by PDM is easy to understand.	4.2937	**N**	0	14	61	51
			%	0.0%	11.1%	48.4%	40.5%
Q6	I found PDM simple to use.	4.4048	**N**	0	0	75	51
			%	0.0%	0.0%	59.5%	40.5%

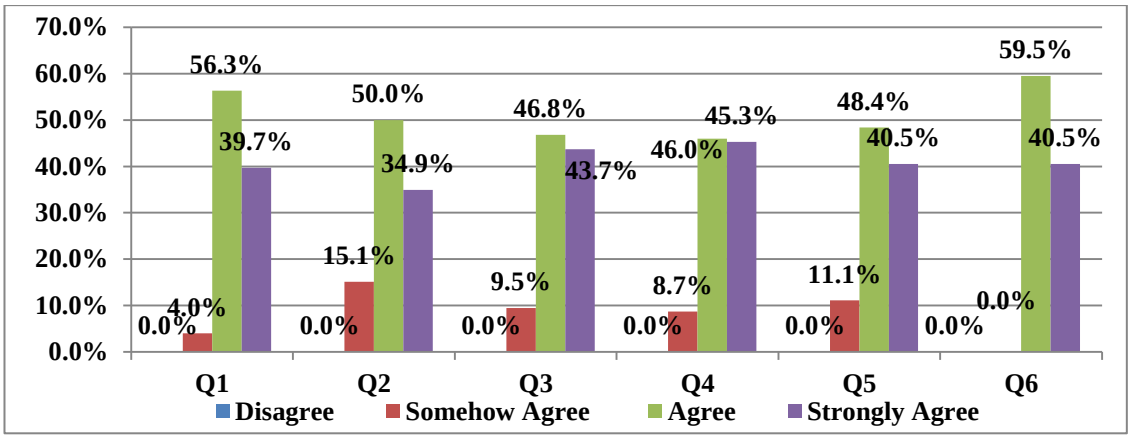


Figure 6.6. The Simplicity of PDM

6.4.3.4 The Reliability of PDM

In terms of the reliability of PDM, Figure 6.7 and Table 6.13 exhibit that all subjects (29.4% strongly agree, 67.5% agree, and 3.1 % somehow agree) found PDM is trustworthy. In addition, all subjects (24.7% strongly agree, 56.3% agree, and 19.0 % somehow agree) confirm that PDM is accurate in identifying their exact location. Likewise, majority of them (20.6% strongly agree, 60.3% agree, and 18.3% somehow agree) agree that PDM is accurate in interpreting their voice commands, while the remaining (0.8%) disagree due the difficulty of pronouncing the ritual names. In fact, all subjects (38.1% strongly agree, 37.3% agree, and 24.6% somehow agree) affirm that PDM has all the functions they expect it to have.

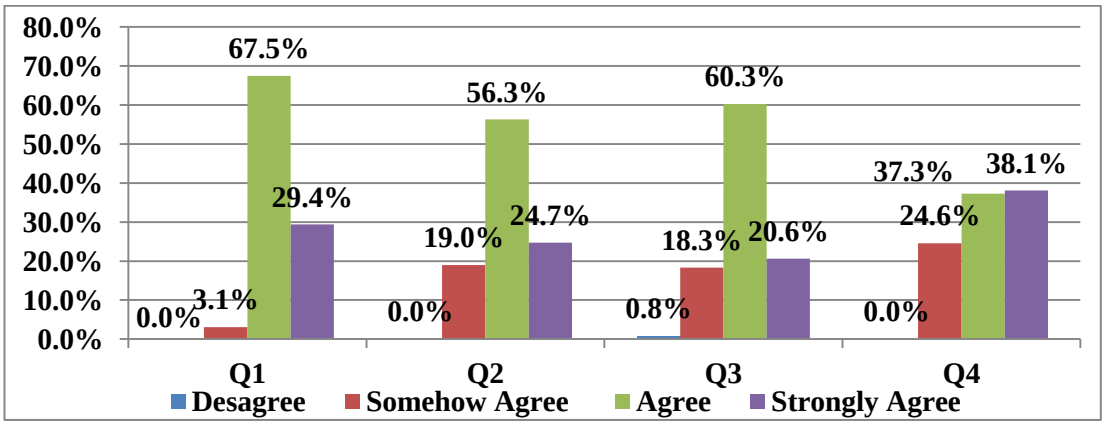


Figure 6.7. The Reliability of PDM

Table 6.13

The Reliability of PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	PDM is trustworthy.	4.2619	**N**	0	4	85	37
			%	0.0%	3.1%	67.5%	29.4%
Q2	PDM is accurate in identifying my exact location.	4.0556	**N**	0	24	71	31
			%	0.0%	19.0%	56.3%	24.7%
Q3	PDM is accurate in interpreting my voice commands.	4.0079	**N**	1	23	76	26
			%	0.8%	18.3%	60.3%	20.6%
Q4	PDM has all the functions I expect it to have.	4.1349	**N**	0	31	47	48
			%	0.0%	24.6%	37.3%	38.1%

6.4.3.5 PDM Ease of Use

The results in Figure 6.8 and Table 6.14 show that PDM is sufficiently easy to use (38.9% strongly agree, 56.3% agree, and 4.8% somehow agree). While all of them confirm that PDM is effortless (35.7% strongly agree, 54.0% agree, and 10.3% somehow agree). This justifies the reason for subjects to agree that they can use PDM without written instructions (36.5% strongly agree, 54.8% agree, and 8.7% somehow agree), and they can use PDM successfully at any time (41.3% strongly agree, 48.4% agree, and 10.7% somehow agree). In addition, all subjects (29.4% strongly agree, 61.9% agree, and 8.7% somehow agree) affirm that they can easily make PDM does exactly what they want. Also, all of them (21.4% strongly agree, 51.6% agree, and 27% somehow agree) believe that it is easy to become skillful at using PDM.

Table 6.14

The Ease of Use of PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	I can use PDM without written instructions.	4.2778	**N**	0	11	69	46
			%	0.0%	8.7%	54.8%	36.5%
Q2	It is easy to make PDM does exactly what I want.	4.2063	**N**	0	11	78	37
			%	0.0%	8.7%	61.9%	29.4%

Table 6.14 Continued

Q3	It would be easy for me to become skilful at using PDM.	3.9444	**N**	0	34	65	27
			%	0.0%	27.0%	51.6%	21.4%
Q4	I can use PDM successfully every time.	4.3095	**N**	0	13	61	52
			%	0.0%	10.3%	48.4%	41.3%
Q5	Using PDM is effortless.	4.2540	**N**	0	13	68	45
			%	0.0%	10.3%	54%	35.7%
Q6	Using PDM is sufficiently easy.	4.3413	**N**	0	6	71	49
			%	0.0%	4.8%	56.3%	38.9%

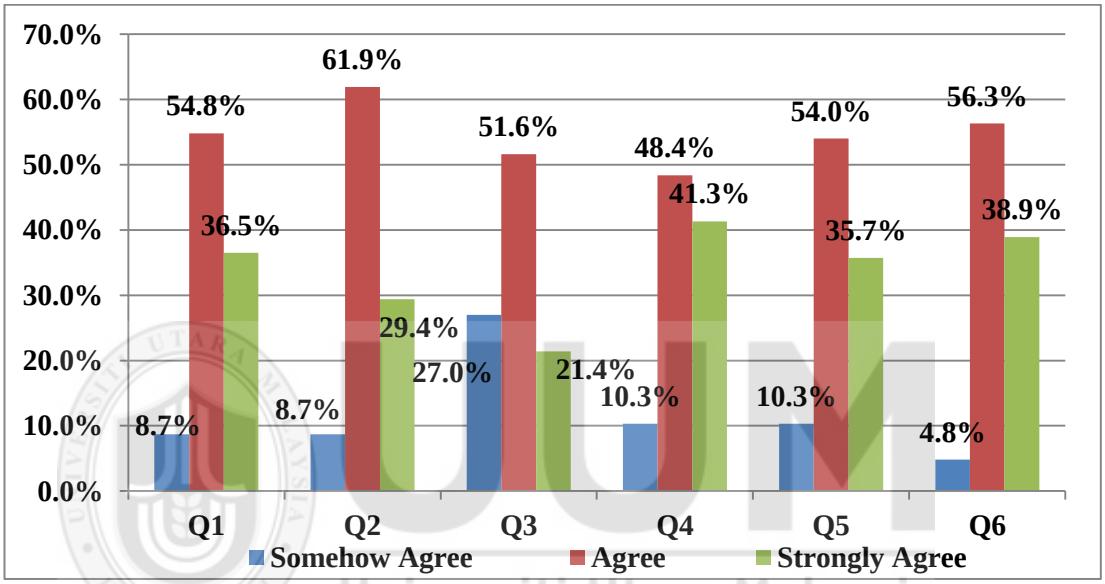


Figure 6.8. The Ease of Use of PDM

6.4.3.6 Safety in PDM

In terms of safety, the results in Figure 6.9 and Table 6.15 show that PDM is safe to use without causing harm (30.2% strongly agree, 54.8% agree, and 15.1% somehow agree). More importantly, all subjects agree that PDM can be operated easily by one hand (33.4% strongly agree, 56.3% agree, and 10.3 % somehow agree). Also, all subjects agree that using PDM while performing the rituals of Hajj and Umrah is safe (30.2% strongly agree and 57.9% agree, and 11.9 % somehow agree). Furthermore, all subjects agree that PDM is suitable to use in the extremely crowded environment (during Hajj and Umrah) (27.8% strongly agree, 56.3% agree, and 15.9% somehow agree).

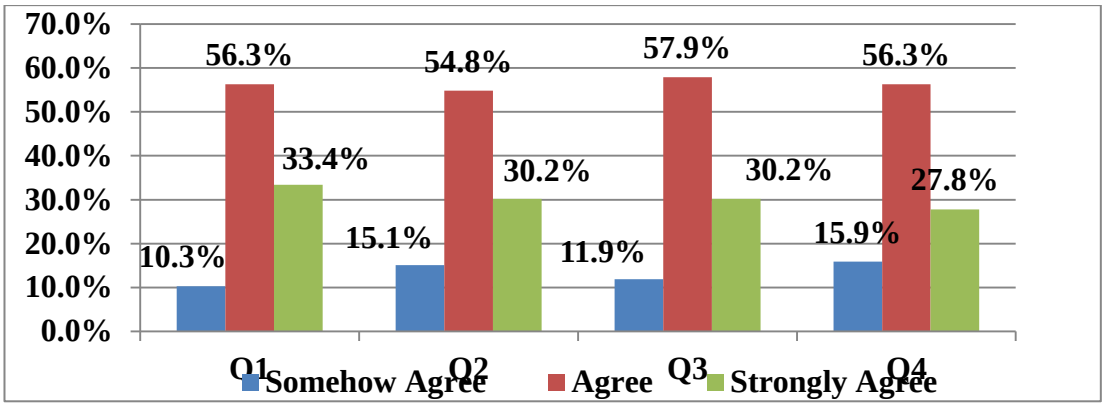


Figure 6.9. The Safety of PDM

Table 6.15

The Safety of PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	It is sufficiently easy to operate PDM with one hand.	4.2302	**N**	0	13	71	42
			%	0.0%	10.3%	56.3%	33.4%
Q2	PDM is safe to use without causing harm.	4.1508	**N**	0	19	69	38
			%	0.0%	15.1%	54.8%	30.2%
Q3	It is safe to use PDM while performing rituals of Hajj/Umrah.	4.1825	**N**	0	15	73	38
			%	0.0%	11.9%	57.9%	30.2%
Q4	PDM is suitable to use in a crowded environment like Hajj/Umrah.	4.1190	**N**	0	20	71	35
			%	0.0%	15.9%	56.3%	27.8%

6.4.3.7 The Flexibility of PDM

In terms of flexibility, the details are illustrated in Figure 6.10 and Table 6.16. It is seen that all subjects found that in PDM it is easy to move from one part of a task to another (31% strongly agree, 61.1% agree, and 7.9% somehow agree). Furthermore, the pilgrims do not notice any inconsistency as they use PDM (25.4% strongly agree, 47.6% agree, and 27% somehow agree), making them agree that the interface of PDM is consistent with other products they have used (28.6% strongly agree, 61.9% agree, and 9.5% somehow agree). In addition, all subjects (32.5% strongly agree, 50.8% agree, and 16.7% somehow agree) confirm that in PDM the control matches the user skills, because they (23.8% strongly agree, 58.7% agree, and 17.5% somehow agree)

found that the visual representation in PDM is consistent with familiar conventions, and the wording in PDM is familiar (37.4% strongly agree, 56.8% agree, and 6.3% somehow agree). Also, all subjects (32.5% strongly agree, 62.7% agree, and 4.8% somehow agree) affirm that the PDM provides zooming for display expansion.

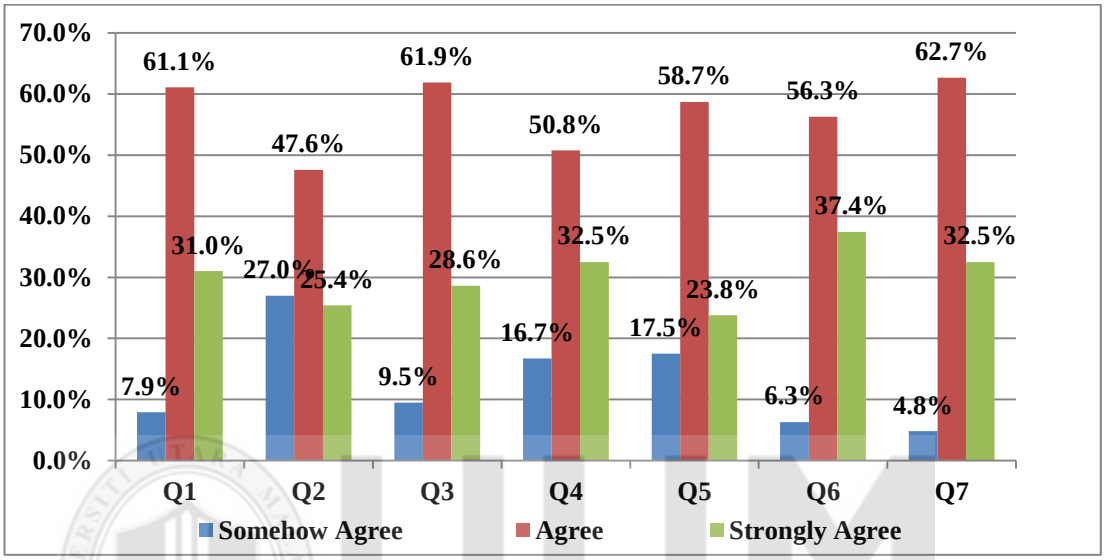


Figure 6.10. The Flexibility of PDM

Table 6.16

The Flexibility of PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	It is easy to move from one part of a task to another.	4.2302	**N**	0	10	77	39
			%	0.0%	7.9%	61.1%	31.0%
Q2	I do not notice any inconsistency as I use PDM.	3.9841	**N**	0	34	60	32
			%	0.0%	27.0%	47.6%	25.4%
Q3	The interface of PDM is consistent with other products I have used.	4.1905	**N**	0	12	78	36
			%	0.0%	9.5%	61.9%	28.6%
Q4	In PDM, the control matches user skills.	4.1587	**N**	0	21	64	41
			%	0.0%	16.7%	50.8%	32.5%
Q5	The visual representation in PDM is consistent with familiar conventions.	4.0635	**N**	0	22	74	30
			%	0.0%	17.5%	58.7%	23.8%
Q6	The wording in PDM is familiar.	4.3095	**N**	0	8	71	47
			%	0.0%	6.3%	56.3%	37.4%
Q7	PDM provides zooming for display expansion.	4.2778	**N**	0	6	79	41
			%	0.0%	4.8%	62.7%	32.5%

6.4.3.8 The Contents Accessibility in PDM

The results for content accessibility are exhibited in Figure 6.11 and Table 6.17. It has been found, that all subjects (34.9% strongly agree, 63.5% agree, and 1.6% somehow agree) confirm that it is easy to find the information they need in PDM. In addition, all of them (34.1% strongly agree, 42.1% agree, and 23.8% somehow agree) affirm that the organization of PDM menus is sufficiently logical. Additionally, all subjects (32.5% strongly agree, 62.7% agree, and 4.8% somehow agree) indicate that buttons in PDM are sufficiently easy to locate and the sequence of screens in PDM is clear and logical (38.1% strongly, and 51.6% agree, and 10.3% somehow agree). This justifies the reason for subjects to agree that the navigation system in PDM is very easy. Nevertheless, all subjects (28.6% strongly, and 50.8% agree, and 20.6% somehow agree) indicate that the characters on PDM screens are easy to read and the terminologies used in PDM are always related to the task (34.1% strongly, and 51.8% agree, and 14.3% somehow agree)

Table 6.17

The Accessibility in PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	It is easy to find the information I need in PDM.	4.3333	**N**	0	2	80	44
			%	0.0%	1.6%	63.5%	34.9%
Q2	It is easy to navigate the PDM.	4.2778	**N**	0	7	77	42
			%	0.0%	5.6%	61.1%	33.3%
Q3	The organization of the PDM menus is sufficiently logical.	4.1032	**N**	0	30	53	43
			%	0.0%	23.8%	42.1%	34.1%
Q4	The buttons are sufficiently easy to locate.	4.2778	**N**	0	6	79	41
			%	0.0%	4.8%	62.7%	32.5%
Q5	The sequence of PDM screens is clear and logical.	4.2778	**N**	0	13	65	48
			%	0.0%	10.3%	51.6%	38.1%
Q6	The characters on PDM screens are easy to read.	4.0794	**N**	0	26	64	36
			%	0.0%	20.6%	50.8%	28.6%
Q7	The terminologies used in PDM are always related to the task.	4.1984	**N**	0	18	65	43
			%	0.0%	14.3%	51.6%	34.1%

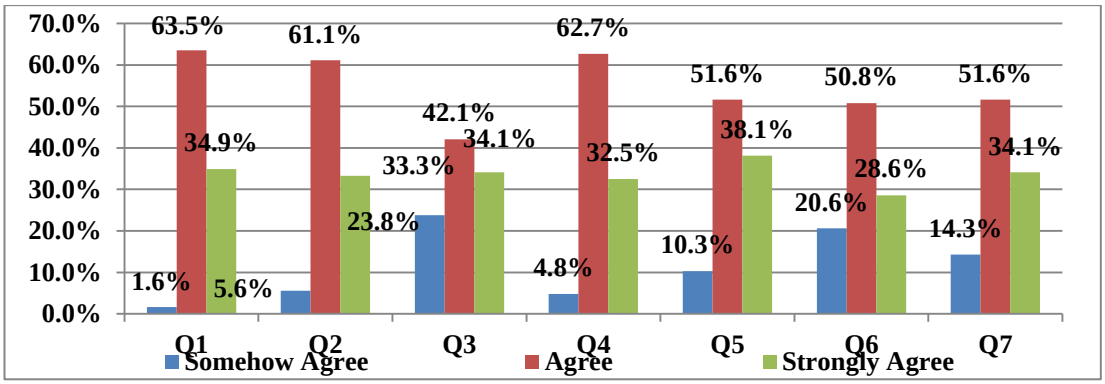


Figure 6.11. The Accessibility in PDM

6.4.3.9 The User's Attitude

The results in Figure 6.12 and Table 6.18 show that all subjects (37.3% strongly, and 51.6% agree, and 11.1% somehow agree) feel comfortable, and they (35.7% strongly, and 46.8% agree, and 17.5% somehow agree) feel confident using PDM. In addition all subjects (39.7% strongly, and 47.6% agree, and 12.7% somehow agree) feel excited when using PDM. Hence, all subjects (69.8% strongly, 27.8% agree, and 2.4 % somehow agree) agree that they recommend PDM to their friends. Meanwhile, almost all subjects (43.7% strongly, and 46.8% agree, and 8.7% somehow agree) agree that they feel the need to have PDM, while only one user (0.8%) disagrees. Based on the demographic profile of that user, it is found that his age is over 55 years and experience on mobile applications is one year or less. Thus he may feel that he cannot coexists with the new generation technology (Vuong et al., 2012).

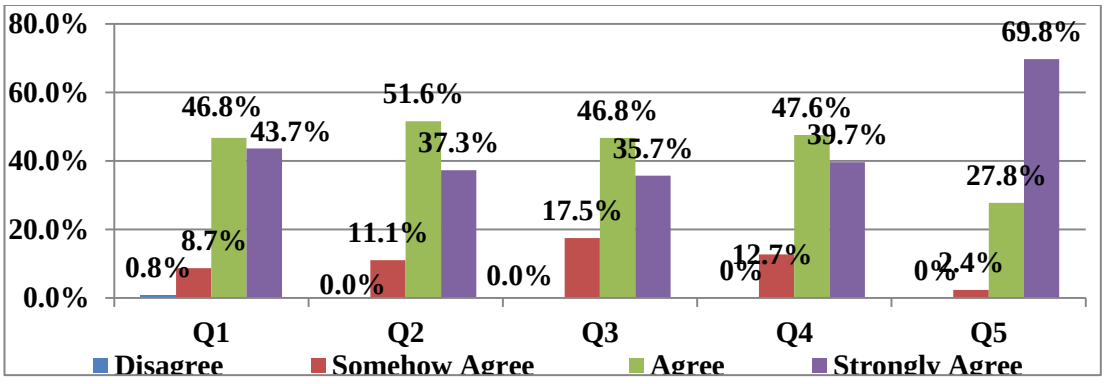


Figure 6.12. The User's Attitude

Table 6.18

The User's Attitude

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	I feel I need to have PDM.	4.3333	**N**	1	11	59	55
			%	0.8%	8.7%	46.8%	43.7%
Q2	I feel comfortable using PDM.	4.2619	**N**	0	14	65	47
			%	0.0%	11.1%	51.6%	37.3%
Q3	I feel confident using PDM.	4.1825	**N**	0	22	59	45
			%	0.0%	17.5%	46.8%	35.7%
Q4	I feel excited when using PDM.	4.2698	**N**	0	16	60	50
			%	0%	12.7%	47.6%	39.7%
Q5	I would recommend PDM to my friends.	4.6746	**N**	0	3	35	88
			%	0%	2.4%	27,8%	69.8%

6.4.3.10 The Acceptability of PDM

As shown in Figure 6.13 and Table 6.19, all subjects (54.8% strongly, 39.7% agree, and 5.5% somehow agree) are satisfied with PDM. The results heighted that PDM is also wonderful (48.4% strongly, 43.7% agree, and 7.9% somehow agree), and that the interface of PDM is attractive (32.5% strongly agreed, 61.2% agreed, 6.3% somehow agreeing). Finally, the majority of subjects (32.5% strongly, 43.7 % agree, and 19.8% somehow agree) found that PDM is pleasant to use, while the remaining (4%) disagree. Its found that the subjects who disagree with the statement "PDM is pleasant to use" are female users. According to different genders have different tendencies, this may explain why female users feel not pleasant because they dependent on the product's appearance (Lan et al., 2013).

Table 6.19

The Acceptability of PDM

NO	The Question	Mean	Frequency and Percent				
				Disagree	Somehow Agree	Agree	Strongly Agree
Q1	The interface of PDM is attractive.	4.2619	**N**	0	8	77	41
			%	0.0%	6.3%	61.2%	32.5%
Q2	PDM is pleasant to use	4.0476	**N**	5	25	55	41
			%	4.0%	19.8%	43.7%	32.5%
Q3	PDM is wonderful.	4.4048	**N**	0	10	55	61
			%	0.0%	7.9%	43.7%	48.4%
Q4	Overall, I am satisfied with PDM.	4.4921	**N**	0	7	50	69
			%	0.0%	5.6%	39.7%	54.8%

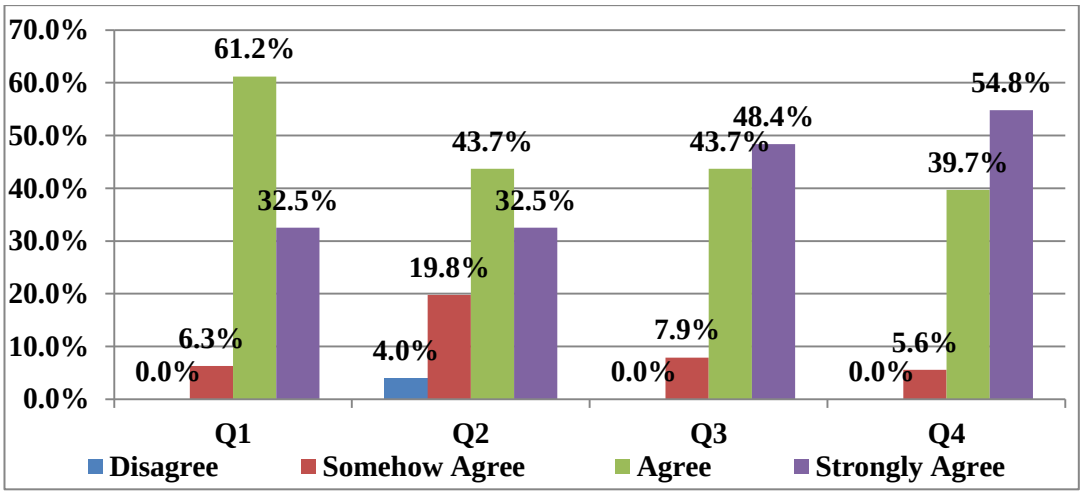


Figure 6.13. The Acceptability of PDM

6.5 Hypotheses Testing

The hypotheses of this study have been discussed individually in this section. Again, it has been mentioned previously that the sample of the experimental study are divided into two groups: New users who have never been in Makkah previously and used users, who have been previously to Makkah for Hajj or Umrah. This study managed to collect data from 79 new pilgrims and 47 used pilgrims.

In proving H_1 and H_2, Independent Sample t-Test has been tested. The independent samples t-test is a parametric test comparing the means of two independent groups in order to investigate whether there is a statistical proof that the means are significantly different. According to Pallant (2013) the *P* value decides to reject or accept the null hypotheses (H_0). Therefore, when *P* value is equal or less than 0.05, the H_0 will be rejected, which means there is significant difference in the means between the 2 groups. Otherwise the H_0 will not be rejected and no significant difference. Meanwhile, Bakker and Wicherts (2014) state that before running the independent samples t-test the following assumptions must be considered:

- Samples come from normally distributed populations.

- Homogeneity of variances and no outliers.

Subsequently, the Pearson correlation test was utilized in testing H_3 and H_4. The value of Pearson's correlation coefficient (r) is used to investigate whether the strength of the association (positive or negative) between the two variables. The value of (r) should be between ±1. A positive value indicates a positive relationship and a negative value indicates a negative relationship. Significant correlations are highlighted with an asterisk (*) for a significance of p greater than or equal 0.05 and double asterisks (**) for p greater than or equal 0.01. Again, before running the Pearson correlation test the following assumptions must be considered

- Samples come from normally distributed populations.
- Homogeneity of variances and no outliers

Finally, descriptive statistics was utilized in testing H_5, H_6 and H_7. Measurements such as mode, median and mean are examples of instances of descriptive statistics to measure the central tendency. Meanwhile, standard deviation, standard error and variance used to measure the dispersion. The results of hypotheses testing are discussed in the following subsection.

6.5.1 Testing H_1

H_1: There is a significant difference between positive attitude of new users and used users of PDM.

In Table 6.20, the t-value (Sig. = 0.210) of Levene's Test for Equality of Variances is greater than 0.05, which implies that the equal variances assumption is not violated. Obviously, the significant value is p= 0.002 (lesser than 0.05). Therefore there is a significant difference between responses by new pilgrims and used pilgrims. Hence, the H_1 is accepted.

Table 6.20

The t-Test Results for Users' Attitude in Different Groups

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
MAATT	Equal variances assumed	1.585	**0.210**	-3.155	124	**0.002**
	Equal variances not assumed			-3.263	107.044	0.001

6.5.2 Testing H_2

H_2: There is a significant difference between the levels of acceptance between new users and used users of PDM.

Table 6.21 exhibits that the t-value (Sig. = 0.956) of Levene's Test for Equality of Variances is greater than 0.05, implying that the equal variances assumption is not violated. It is significant (p= 0.001; p <0.05), and therefore the H_2 is accepted. Hence, it is understood that there is significant difference between responses by new pilgrims and used pilgrims.

Table 6.21

The t-Test Results for Users' Acceptance in Different Groups

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
MAACP	Equal variances assumed	0.003	**0.956**	-4.515	124	**0.000**
	Equal variances not assumed			-4.526	97.563	0.000

6.5.3 Testing H_3

H_3: There is a positive relationship between the effectiveness of PDM and the users' satisfaction.

Table 6.22 shows enough evidence not to reject H_3, because the correlation coefficient r = 0.578 and value of p = 0.000. As the r value reported is positive and p < 0.01, it means that the effectiveness of PDM and users' satisfaction has a positive relation and it is significant at 0.01 level.

Table 6.22

Correlations of Effectiveness and Users' Satisfaction in PDM

		Effectiveness	Satisfaction
Effectiveness	Pearson Correlation	1	**0.578****
	Sig. (2-tailed)		**0.000**
	N	126	126
Satisfaction	Pearson Correlation	**0.578****	1
	Sig. (2-tailed)	**0.000**	
	N	126	126

**. Correlation is significant at the 0.01 level (2-tailed).

6.5.4 Testing H_4

H_4: There is a positive relationship between the efficiency of PDM and the users' satisfaction.

Table 6.23 shows enough evidence not to reject H_4, because the correlation coefficient r = 0.692 and value of p = 0.000. As the r value reported is positive and p < 0.01, it means that the efficiency of PDM and users' satisfaction has a positive relation and it is significant at 0.01 level.

Table 6.23

Correlations of Efficiency and Users' Satisfaction in PDM

		Effectiveness	Satisfaction
Efficiency	Pearson Correlation	1	**0. 692****
	Sig. (2-tailed)		**0.000**
	N	126	126
Satisfaction	Pearson Correlation	**0. 692****	1
	Sig. (2-tailed)	**0.000**	
	N	126	126

**. Correlation is significant at the 0.01 level (2-tailed).

6.5.5 Testing H_5, H_6 and H_7

Hypotheses H_5, H_6, and H_7 are classified with reference to the classification below. However, in interpreting these mean scores, the gap classification of interval scales is applied. As explained in Zulkarnain (2001), Siti Mahfuzah (2011), and (Tosho, 2016), the gap classification of interval scales used in research instrument may follow the formula below:

Gap = (highest score –lowest score)/ number of scale

Gap= (5-1)/5

Gap = 0.8

Therefore, for a 5-point scale, the classifications shown in Table 6.24 were obtained for the response gap. Accordingly, in order to support the H_5, H_6 and H_7, the mean scores of the overall effectiveness, efficiency, and users' satisfaction have to be equal or greater than 3.41.

Table 6.24

Responses Classification

Gap	Classification
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Average
3.41 – 4.20	High
4.21 – 5.00	Very High

H_5: The mean score of overall effectiveness of PDM is high.
H_6: The mean score of overall efficiency of PDM is high.
H_7: The mean score of overall users' satisfaction of PDM is high.

In validating the above listed hypotheses (H_5, H_6, and H_7), descriptive statistics analyses were carried out. Table 6.24 displays the results in mean, standard deviation, and standard error of mean values.

Table 6.25

Descriptive Statistics of Overall Effectiveness, Efficiency, and Satisfaction of PDM

Pilgrims Group		Effectiveness	Efficiency	Satisfaction
New Pilgrims	Mean	**4.1315**	**4.1092**	**4.2264**
	N	79	79	79
	Std. Deviation	0.33353	0.29054	0.33021
	Std. Error of Mean	0.03752	0.03269	0.03715
Used Pilgrims	Mean	**4.3626**	**4.3502**	**4.4917**
	N	47	47	47
	Std. Deviation	0.31356	0.33216	0.33313
	Std. Error of Mean	0.04574	0.04845	0.04859
Total	Mean	**4.2177**	**4.1991**	**4.3254**
	N	126	126	126
	Std. Deviation	0.34378	0.32706	0.35421
	Std. Error of Mean	0.03063	0.02914	0.03156

As seen in Table 6.25, the overall mean score for effectiveness for new pilgrims is 4.1315, efficiency is 4.1092, and users' satisfaction is 4.2264. Meanwhile for used pilgrims the mean scores are 4.3626, 4.3502, and 4.4917 respectively. When the both groups are combined, the mean score for effectiveness is 4.2177, efficiency is 4.1991, and users' satisfaction is 4.3254.

Based on the classification in Table 6.24, it is found that the mean score of the overall effectiveness of PDM by new pilgrims is (4.1315) falls under "*High*", likewise by used pilgrims (4.3626) and combined groups (4.2177) fall under "*Very High*".

With reference to the findings, H_5, H_6, and H_7 are statistically well-supported. Hence it is evidenced that PDM is efficient and effective to be utilized by pilgrims during Hajj and Umrah. Not only efficient and effective, but also the pilgrims are very satisfied with it. When results of all hypotheses are combined, they address that the PDM is usable in assisting pilgrims during Hajj and Umrah.

6.6 Summary

This chapter discusses the results of the experimental study. The experimental study was carried out in the real environment of Hajj or Umrah (in Makkah) using PDM. The study aims at measuring the usability of PDM on users' satisfaction. Data were collected through an instrument named as Q-U3MA, which comprises of three main constructs; effectiveness, efficiency, and satisfaction. The effectiveness is measured through usefulness (USE), error rate (ERR), simplicity (SIM), and reliability (REL), whereas the efficiency is measured through ease of use (EOU), safety (SAF), flexibility (FLE), and accessibility (ACS). Meanwhile, satisfaction is measured through attitude (ATT) and acceptability (ACP).

Many general findings are obtained from the experimental study. (1) In terms of usefulness; 92.8% stated that they found the information provided by PDM is helpful enough, and 94.4% found that using PDM make the performance of the rituals of Hajj and Umrah easier. In addition, PDM meets the needs and expectation of 88.9% of the subjects, whereas, 92.9% found PDM useful in performing Hajj and Umrah. (2) In terms of error rate; 87.3% affirm that PDM prevents them from making errors. However, if the error occurred 81.8% confirm that in PDM they can recover from mistakes quickly. (3) In terms of simplicity; all the subjects 100% found PDM simple to use, and 90.5% stated that the PDM is easy to learn. (4) In terms of reliability; 96.9% found PDM is trustworthy and 80.9% confirm that PDM is accurate in identifying their exact location. (5) In terms of ease of use; 95.2% confirm that using PDM is sufficiently easy, and 89.7% confirm that PDM is effortless. Likewise, 91.3% state that they can use PDM without written instructions. (6) In terms of safety; 89.7% affirm that PDM can be easily operated by one hand, and 88.1% state that using PDM is safe and suitable while performing the rituals of

Hajj/Umrah. (7) In terms of flexibility; 83.3% of the subjects confirm that the controls in PDM matched their skills and 90.5% of them do not notice any inconsistency as they use PDM. (8) In terms of accessibility; 98.4% confirm that in PDM they can find the information that they need easily, also 89.7% declare that the sequence of screens in PDM is clear and logical, while 94.4% stated that the navigation system in PDM is very easy. Besides (9) the users' attitude toward PDM was positive, 90.5% feel that they need to have PDM, and 97.6% affirm that they would recommend PDM to their friends. Finally, (10) PDM received full acceptance among users, 93.7% found that the interface of PDM is attractive, and 92.1% found PDM is wonderful, whereas 94.5% were satisfied overall with PDM.

Further, this chapter also discusses and illustrates the results for seven hypotheses testing. In testing H_1 and H_2 the independent sample test shows that there is a significant difference in positive attitude as well as the level of acceptance between the new users and used users of PDM. In testing H_3 and H_4 the results of the person correlation test show that the efficiency and effectiveness constructs have positive correlations with the users' satisfaction. Finally, in testing $H_{5,}$ H_6 and H_7 the descriptive statistics have confirmed that the mean score of overall effectiveness, efficiency, and satisfaction of PDM were very high. Next chapter includes more discussions on the results of measuring usability of PDM prototypes and also some concluding remarks.

CHAPTER SEVEN
DISCUSSION AND CONCLUSION

7.1 Overview

As discussed in Chapter 1, this study is conducted based on these three research questions.

i. What are the most appropriate usability attributes MMA-U?
ii. How to conceptualize the MMA-U?
iii. Is the MMA-U able to support usability from users' perspective?

Additionally, this study aims at proposing a multimodal mobile assistant that assists pilgrims in performing Hajj and Umrah. While the context is extremely different than any other contexts (gathering extremely large crowds performing similar activity simultaneously), usability aspects of the product is highly specific. Hence, this study attempts to propose a usability conceptual model specifically for the multimodal mobile assistant. To accomplish that, the following objectives have to be achieved:

i. To identify the most appropriate usability attributes for MMA-U.
ii. To propose the conceptual model for MMA-U with the identified usability attributes.
iii. To validate the conceptual design model of MMA-U through expert reviews.
iv. To gather user feedbacks on the usability of a prototype that incorporates MMA-U.

7.2 Research Question 1

What are the most appropriate usability attributes MMA-U?

To answer this research question a SLR has been conducted to identify the usability attributes of mobile applications by using "Usability", "Evaluation", and "Mobile"

keywords. In this SLR, four criteria as the protocol of selecting references are: (1) the study has been published in a high impact journal titles in HCI or Usability Studies (see Table 7.1) (2) published not earlier than 2000, (3) empirical study, and (4) on mobile technology.

Table 7.1

The List of Selected Journals Titles in HCI and Usability and Number of Candidates and Selected Papers

Journal Title	Short Journal Title	Publisher	ISSN	Candidate	Selected
Computers in Human Behavior	CHB	Elsevier	0747-5632	52	6
Human-Computer Interaction	HCI	Taylor & Francis	0737-0024	25	0
Interacting With Computers	IWC	Oxford	0953-5438	44	2
International Journal Of Human-Computer Interaction	IJHCI	Taylor & Francis	1044-7318	82	5
International Journal of Mobile Human Computer Interaction	IJMHCI	IGI Global	1942-390X	15	1
Journal of Usability Studies	JUS	Usability Professionals' Association	1931-3357	17	2
Transactions on Computer - Human Interaction	TOCHI	ACM	1073-0516	26	2
	Total			**261**	**18**

However, to avoid repetitions, a quick search was performed looking for the previous meta-analysis and systematic reviews that addressed the same research question by using the same protocol. As a result, four studies have been founded (Coursaris & Kim, 2006; Azham & Kutar, 2009; Coursaris & Kim, 2011; Rosnita et al., 2013). Accordingly, the research protocol time limit has been changed to retrieve the studies that have been published from 2013 up to now.

The results showed that the analysis process highlights 27 usability attributes. In addition, the selected studies focused clearly on the usability measurements defined by ISO 9241-11 which are effectiveness, efficiency, and satisfaction, while the other measures come independently or listed under these three measurements according to

the nature of the study. However, some of these measurements are synonymous or a part of other measures. Therefore, the original list has been removed down (illustrated in Figure 4.3) by combining the synonymous measures to each other under one name as well as incorporating the sub measures under the main measures.

7.3 Research Question 2

How to conceptualize the MMA-U?

In answering this research question, the components of the conceptual design model of MMA-U must be identified first. Since MMA-U stretches the ideas of the existing conceptual models, the existing models and applications of Hajj or Umrah have been used as the basis in constructing MMA-U. Therefore, to get the generic components of MMA-U; the existing applications, and models have been compared. Altogether, five Desktop models (DT) and twelve Mobile applications (MA) for Hajj or Umrah in google play have been compared. Overall, the proposed model contain five main components; (i) structural components (SCs) which has sub-component called (B1) content composition components (CCCs), (ii) design principles, (iii) development approach, (iv) technology, and (v) the design and usability theories. Apparently, these components and elements are in line with many theories and principles such as the theories and principles of usability, multimodality (multi-modal interaction and multimodal human-computer interaction), information architecture, and user interface architecture as well as the existing studies and usability guidelines.

Secondly, the components and elements were integrated together and made up the proposed conceptual design model of MMA-U. Meanwhile, all the components were numbered sequentially to clarify the flow in MMA-U. During the construction process, the components and elements were classified as compulsory and

recommended based on a comparative analysis. All the elements especially in the content composition component have implication to each other. MMA-U is proposed to facilitate the rituals of Hajj and Umrah and cater for the needs of pilgrims, by providing a usable multimodal mobile assistance application during Umrah and Hajj. Therefore, the contents of MMA-U are organized and labelled based on Information Architecture theories and principles to enhance the contents usefulness and simplicity reducing the error rate. Meanwhile, the navigation system was designed based on the theories of Multimodality and Information Architecture to support the reliability, ease of use, safety, flexibility and accessibility. In other words, MMA-U highlights modalities such as audio, text, graphic and animation to enhance usefulness and simplicity reducing the error rate. Meanwhile, the interaction modes, presentation styles, and user interface and layout to support reliability, ease of use, safety, flexibility and accessibility. As a result, the users' satisfaction (attitude and acceptability) is achieved through the effectiveness and efficiency of MMA-U.

7.4 Research Question 3

Is the MMA-U able to support usability from users' perspective?

Having the Conceptual Design Model of MMA-U reviewed, the model was incorporated into prototype called PDM (Chapter 5). In addition, an evaluation instrument called Q-U3MA was developed specially to evaluate the usability attributes in PDM. Subsequently, an experimental study was carried out through field user experience testing.

Generally, 88.9% of the subjects agree that PDM successfully meets their needs and expectations. Also, all the respondents admit that the use of PDM facilitates the

rituals of Hajj and Umrah, preventing them from making errors; it is trusted, and simple to use. This implies that the PDM is effective.

In addition, the results show that 95.2% of pilgrims confirm that PDM is easy to use, effortless, and can be used without written instructions. Likewise, they state that PDM is easily operated with one hand, safe and is suitable to use in the extremely crowded environment while performing rituals of Hajj and Umrah. Nevertheless, all the subjects affirm that the navigation system in PDM is flexible enough, enhances the contents accessibility. This means the PDM is highly efficient.

As a consequence, the prototype of PDM is well-accepted by all users. The results show that all subjects feel excited when using PDM and they feel they need to have the PDM. Thereby, they would recommend PDM to their friends. Likewise, all of them found that PDM is wonderful and has attractive interface. Thus, they were satisfied with PDM. Accordingly, it can be concluded that the incorporation of usability attributes in the proposed Conceptual Design Model of PDM makes PDM suitable to use during Hajj and Umrah.

7.5 Aim and Objectives: Revisit

This study aims at proposing a multimodal mobile assistant called Personal Digital Mutawwif; the PDM that assists pilgrims in performing Hajj and Umrah. While the context is extremely different than any other contexts (gathering extremely large crowds performing similar activity simultaneously), usability aspects of the product is highly specific. The conceptual model for MMA-U is specifically constructed to ensure the usability of PDM. To accomplish that, four objectives were formulated.

At the end, the essential aim of this study has been accomplished via the achievement of the above-mentioned supporting objectives. Firstly, the first supporting objective of this study is accomplished through an SLR, which led to identification of the usability attributes (see section 4.2). Secondly, completing the construction process of the proposed conceptual model of MMA-U means that the second supporting objective of this study is accomplished. The construction process involves many activities and shows how the identified usability attributes are incorporated in the proposed conceptual design model of MMA-U (see section 4.3). Thirdly, the third supporting objective in this study is accomplished via the model validation. The validation process was made through expert review (see section 4.5) and prototype development (see Chapter 5). Lastly, the fourth supporting objective in this study is accomplished with the usability testing of PDM prototype using the developed instrument which named as Q-U3MA (see Chapter 6).

7.6 Research Contribution

This study aimed to address the limitations in the current approaches used in performing Hajj and Umrah rituals and facilitating these difficulties faced by pilgrims during Hajj and Umrah. Therefore, conducting this study will provide many contributions to the current literature. Those contributions can be summarized in the following sub-sections.

7.6.1 Addressing the Difficulties Faced by Malaysian Pilgrims

The Prelim study of this research helps in identifying the difficulties faced by Malaysian pilgrims. This study aimed to facilitating, some of those difficulties are listed below and how this study facilitates those difficulties:

- ✓ **The ability of reading Arabic text:** The majority of Malaysian pilgrims cannot read the normal plain Arabic text, but they can read the Holy Quran. This study facilitated this problem by using the Holy Quran font format (such as AlQalam Quran Majeed font) supported by diacritics in formatting the Arabic texts in the applications, since the pilgrims are familiar with this type of fonts.

- ✓ **The Arabic Words Pronunciation:** Based on literature the Malaysian students as well as all non-native Arabic language people facing difficulties in pronouncing some Arabic characters and they are facing difficulties in distinguishing between similar characters. Therefore, this study contributes a new method of representing the Arabic text by utilizing the sound files features to help pilgrims to pronouncing the Arabic words correctly by using recitation instead of reading.

- ✓ **Minimizing the Memory Load:** Memorizing a large number of Duas and Ziker is very difficult, since there are many rituals in Hajj and Umrah accompanied with Duas or Ziker that pilgrims need to recite. Meanwhile, in Islam Hajj and Umrah must be performed once a time in the lifetime the capable Muslim, which means considerable costs and a lot of competitions to get a traveling visa for Hajj and Umrah. Therefore, recollection such Duas and Ziker is almost impossible because it is not repeated continuously in the Muslims life compared with Duas and Ziker associated with praying which can be memorized by repetition over time. In this side, this study provides in time help to pilgrims while performing rituals, as good contribution to minimizing the memory load which gives an opportunity to focus in their performance.

- ✓ **Giving the Appropriate Instructions and Duas Timely:** With congestion of pilgrims it becomes very difficult for them to have a look in their books or booklets to find the right Duas timely. Therefore, this study contributes a new method of speeding up the search process of the finding the appropriate Duas and instructions timely, by utilizing the positions identification features in GPS to deliver the appropriate instructions automatically based on the pilgrim's location.

7.6.2 Conceptual Model for Multimodal Mobile Assistance during Umrah

Constructing a good conceptual model includes incorporating all the relevant aspects and entities in the subject and shows the relationships among each other. Therefore, one of the great contributions of this study is proposing a conceptual model for usable multimodal mobile assistance for Hajj and Umrah. Meanwhile, the capabilities of smartphones and portable devices evolved continuously, this development has made it a strong competitor for personal computers in many areas. Thus, this study investigates the appropriate input/output modalities that can be integrated in an interaction design to assist pilgrims during Hajj and Umrah.

According to Chen (2011), smartphones can carry out professional services and applications such as GPS, functionalities, E-Banking, email clients, and web browser besides to the typical functions like contacts, calendar, diary, notepad, and voice recorder (Charlesworth, 2009). However, many mobile applications addressed the Hajj and Umrah, but the majority of those applications are classified under the training or education categories. In the other hand, mobile technologies comprise of many interaction modes for representing information and receiving data. Therefore, integrating properly some of these modes as well as utilizing some of smartphone computational capabilities and services such as GPS, speech recognition, and sensors in an interactive

design will improve the users' interaction. Consequently, the conceptual model proposed by this study fetching in multimodality to increase accessibility in the mobile applications, which means increasing the assistance usability. Therefore, this study shows how multimodality supports usability in mobile applications.

7.6.3 Providing a Usable Multimodal Mobile Assistance during Umrah

In this study after constructing the conceptual model, the new model must be reviewed by experts in the field. The final model (which have been reviewed and validated considered as the first artifact in this study) needs to be prototyped in order to perceiving the pilgrims satisfaction, usefulness, and acceptance of the model. Hence, this study involved in prototype development (the second artifact in this study) which mostly resembling the final product by taking into account the pilgrims' needs. It is believed that such product will gain the users satisfaction and acceptance since it comes from their sufferance and meets their aspirations as well as because it is developed based on their requirements by using a User-centred design process. Therefore, this valued prototype is considered one of the valued contributions of this study.

Therefore, this contribution means that by the end of this study multimode interaction design assistance will be delivered as a new technology to facilitating the rituals of Hajj and Umrah by incorporating such interaction modes and services. For example, the GPS services can be utilized for tracking pilgrims' location and movements. Therefore, when pilgrim reaches one of the rituals places, the proposed assistant will automatically provide the pilgrim required information in that ritual. Meanwhile, the pilgrim can use his voice to interact with the assistant to perform and navigation task in the assistant, which means the utilizations of the speech recognition in the assistant.

7.6.4 Providing a New Usability Evaluation Framework

In this study, a systematic literature review (SLR) has been conducted to investigating the right usability attributes that must be taken into account in the design of the proposed prototype, to ensure usability. Therefore, this study will list the appropriate and right usability attributes and the attributes that must be measured by the instrument in the usability testing of such application. Furthermore, to evaluate the developed prototype in this study and perceiving users satisfaction, an evaluation framework must be developed, because different types of application require different framework to test. This framework includes the evaluation instrument, sampling, and the evaluation procedure of conducting the evaluation process and collecting valued and reliable data form responders. Therefore, this study proposed an evaluation framework fits to evaluate the developed prototype in this study. Since the prototype's development process based on the findings of SLR in this study (the usability attributes), so a new evaluation instrument must be developed that can measure the usability attributes obtained from the SLR in this study. This new instrument is one of the contributions of this study as well.

7.7 Limitation and Recommendation

In this study, the limitations are matter of time only; it requires extra time to overcome and can be outlined into four points: (I) the incorporation of the sensor based interaction mode, (II) providing PDM in various other languages, (III) perception, and (IV) gather data from users from other countries. The following sub-sections separately discuss these limitations in detail.

7.7.1 The Incorporation of the Sensor Based Interaction Mode

Besides the manual mode (menus and buttons), this study proposes three new interaction modes to be included in PDM, which are: (1) oral mode, (2) GPS mode, and (3) embedded sensors mode. Unfortunately, the embedded sensors mode was excluded (based on the developers' recommendation) because it needs special infrastructure in the holy places, which requires the permission of the local government. However, obtaining such permit requires additional time to process an official application in the government departments and Ministry of Hajj with the possibility of rejection. Therefore, this study recommends the embedded sensors mode should be included in future studies.

7.7.2 Providing PDM in Various other Languages

This study is conducted in Malaysia, and the targeted users are pilgrims of Malaysia and the neighboring countries. Hence, PDM is provided in Malay language besides Arabic. In the matter of fact, pilgrims from other countries also face similar difficulties that Malaysian pilgrims faced. In addition, this study reviewed 17 models (5 DTs and 12 MAs) in Arabic, English, Urdu, Malay and even Ethiopian language. The results show that existing models have similar limitations and usability issues. Therefore, there is a need to provide a multilingual PDM. Unfortunately, providing PDM in various languages requires budget and extra time to translate the contents from Arabic language and validate the translation. Hence, as a future works this study recommends providing PDM in languages such as Urdu and English.

7.7.3 Perception

This study utilized the focus group and UCD approach to strengthen the elements,

interaction modes and design principles derived from content analysis, comparative analysis, and elicitation works involving pilgrims, counselor (schoolers and trainers), experts (peers, academicians), and developers. However, the UCD was implemented in different places and times. Nevertheless, it complies with a very rich input, but it is still considered as personal and individual opinion. Perhaps utilising other techniques/approaches or even engaging more extensive group of respondents (i.e., potential users) in the focus group might lead to another elements, interaction modes and design principles.

Additionally, the proposed conceptual design model of PDM was constructed according to the rules and provisions of Madhhab Shafi'i and the training program of Lembaga Tabung Haji of Malaysia. This makes the conceptual design model of PDM a general and comprehensive model that can be used as a reference to develop the PDM for any Hajj agency following Madhhab Shafi'i. By way of contrast, following another Madhhab or other specific requirements of another Hajj agency could lead to another conceptual design model.

7.7.4 Gather Data from Users from Other Countries

In this study, the targeted users were pilgrims of Malaysia and the neighboring countries. Therefore, PDM is developed in Malay language. Hence, to save time a questionnaire called Q-U3MA was distributed among the Malaysians and Indonesians pilgrims in Makkah to gather data for evaluating PDM. Perhaps, gathering data from pilgrims from other countries lead to different results. Therefore, this study recommends to collect data from other nationalities pilgrims in the future works if PDM available in different languages.

7.8 Future Research

This section focuses on the future studies based on the recommendations of this study. These future studies can be outlined below:

- Exploitation of the embedded sensors of smartphone practically in PDM as an automatic interaction mode after extracting all the required governmental permits to install the infrastructure in the holy places.
- The results of this study showed that PDM is an urgent need for all Muslims in the world, which indicates that there is a need to provide a multilingual PDM.
- In this study MMA-U have been applied as guide for developing PDM for Android smartphones, but MMA-U has been designed to be suitable for developing PDM on platforms such as Android and Apple (iOS) as well as devices such as smartphones, tablets, and wearable devices (smartwatch). Therefore, this study recommends applying MMA-U for developing PDM for all the suggested technologies in MMA-U especially for wearable devices.
- This study was conducted within a specific scope, by targeting the Malaysian pilgrims and following the rules of Madhhab Shafi'I and Lembaga Tabung Haji. In addition, this study involves experts (not developers) and users in the process of MMA-U evaluation. Hence, as a future works this study recommends extend the scope to include other Madhhabs and Hajj agencies in terms of contents as well as involves the developers in the evaluation process of MMA-U. In addition, this study was carried out on the pilgrims of Malaysia and its neighbouring countries (Malay language speakers) further the researcher recommends to collect data from other nationalities pilgrims.

7.9 Conclusion

This study has carried out a systematic investigation to identify the usability attributes of multimodal mobile applications and how those attributes can be incorporated a comprehensive conceptual design model for MMA-U. All relevant elements and components in designing a MMA-U were considered and validated through focus group expert reviews and the users' feedback gathered through a field experimental study via prototype. From the findings obtained in this study, there were indications that the PDM which is based on the proposed conceptual design model has the following advantages which could be listed as:

- The proposed Conceptual Model of MMA-U is reliable.
- The proposed Conceptual Model of MMA-U is useful in guiding the professional and beginner developer in developing the PDM.
- The proposed interaction modes in PDM enhance the usability.
- The proposed PDM is useful in assisting the pilgrims during Hajj and Umrah.
- The proposed PDM is safe and suitable to use during Hajj and Umrah.
- The proposed PDM is attractive, wonderful and received full acceptance among users, and they were satisfied overall with PDM.

It is important that the pilgrims benefit from the new interaction modes and contents that reflect the relevant theoretical framework in its design and development. The contents should be accessible and helpful enough in assisting the pilgrims while performing the rituals of Hajj and Umrah easily and safely. As well as, the proposed interaction modes need improvement to become standalone in the future.

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Appendix A

Questionnaire for User Interface Satisfaction of Mobile Dua and Zikr for Hajj (MDZ4H)

Please rate your satisfaction with the system.

- Try to respond to all the items.
- For items that are not applicable, use: **NA**
- Add a comment about an item in 1-6.

OVERALL REACTION TO THE SOFTWARE		**1**	**2**	**3**	**4**	**5**		**NA**
1.	terrible	☐	☐	☐	☐	☐	wonderful	☐
2.	difficult	☐	☐	☐	☐	☐	easy	☐
3.	frustrating	☐	☐	☐	☐	☐	satisfying	☐
4.	inadequat	☐	☐	☐	☐	☐	adequate	☐
5.	dull	☐	☐	☐	☐	☐	stimulating	☐
6.	rigid	☐	☐	☐	☐	☐	flexible	☐
SCREEN		**1**	**2**	**3**	**4**	**5**		**NA**
7. Reading characters on the screen	hard	☐	☐	☐	☐	☐	very clear	☐
8. Organization of information	confusing	☐	☐	☐	☐	☐	very clear	☐
9. Sequence of screens	confusing	☐	☐	☐	☐	☐	very clear	☐
TERMINOLOGY AND SYSTEM INFORMATION		**1**	**2**	3	**4**	**5**		**NA**
10. Use of terms throughout system	inconsiste	☐	☐	☐	☐	☐	consistent	☐
11. Position of messages on screen	inconsiste	☐	☐	☐	☐	☐	consistent	☐
LEARNING		**1**	**2**	**3**	**4**	**5**		**NA**
12. Learning to operate the system	difficult	☐	☐	☐	☐	☐	Easy	☐
13. Exploring new features by trial and error	difficult	☐	☐	☐	☐	☐	Easy	☐
14. Remembering names and use of commands	difficult	☐	☐	☐	☐	☐	Easy	☐
15. Performing tasks is straightforward	never	☐	☐	☐	☐	☐	always	☐
SYSTEM CAPABILITIES		**1**	**2**	**3**	**4**	**5**		**NA**
16. System speed	too slow	☐	☐	☐	☐	☐	fast enough	☐
17. System reliability	unreliable	☐	☐	☐	☐	☐	reliable	☐
18. System tends to be	noisy	☐	☐	☐	☐	☐	quiet	☐
19. Designed for all levels of users	never	☐	☐	☐	☐	☐	always	☐

List the most **negative** aspect(s):	List the most **positive** aspect(s):
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

Thank you very much for your cooperation

Appendix B

Questionnaire for Application Usability

System to be rated:

Mobile Dua and Zikr for Hajj (MDZ4H).

Objective:

Obtain your view on the evaluation of the MDZ4H.

Introduction:

This questionnaire consists of two sections:

- General Information
- Mobile Dua and Zikr for Hajj (MDZ4H) Evaluation.

Please answer **ALL** questions from each segment.

1) General Information

This segment is about your background information. *Please fill up the blanks and mark [√] where appropriate.*

1. Gender: [ ] Male [ ] Female

2. Age: [ ] 10-25 Years. [ ]26-40 Years.

[ ]41-55 Years. [ ]Over 55 Years.

3. Education background

[ ] Diploma [ ] Degree [ ] Master [ ] Ph.D.

4. Your mobile applications experience _____ months.

5. Have you been to Makkah to perform Hajj or Umrah? [ ] Yes [ ] No.

If yes how many times _____ .

6. Can you read Arabic? [ ] Yes [ ] No.

If yes please rate you Arabic reading level [ ] Excellent [ ] Good [ ] Bad.

2) Mobile Dua and Zikr for Hajj MDZ4H Prototype Evaluation

This segment is intended to obtain your view on the Mobile Dua and Zikr for Hajj prototype. Please check or shade the answer to the following questions.

1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

Perceived Usefulness	1	2	3	4	5
7. Using MDZ4H would enable me to accomplish the reciting of dua and zikr for Hajj more quickly.	☐	☐	☐	☐	☐
8. Using MDZ4H would improve my performance in reciting the dua and zikr for Hajj.	☐	☐	☐	☐	☐
9. Using MDZ4H would increase my productivity in reciting the dua and zikr for Hajj.	☐	☐	☐	☐	☐
10. Using MDZ4H would enhance my effectiveness in reciting the dua and zikr for Hajj.	☐	☐	☐	☐	☐
11. Using MDZ4H would make it easier to recite the dua and zikr for Hajj	☐	☐	☐	☐	☐
12. I would find MDZ4H useful in every Hajj or Umrah task.	☐	☐	☐	☐	☐
Perceived Ease Of Use	1	2	3	4	5
13. Learning to operate MDZ4H would be easy for me.	☐	☐	☐	☐	☐
14. I would find it easy to get MDZ4H to do what I want it to do.	☐	☐	☐	☐	☐
15. My interaction with MDZ4H would be clear and understandable.	☐	☐	☐	☐	☐
16. I would find MDZ4H to be flexible to interact with.	☐	☐	☐	☐	☐
17. It would be easy for me to become skilful at using the MDZ4H.	☐	☐	☐	☐	☐
18. I would find MDZ4H easy to use.	☐	☐	☐	☐	☐
Outcome / Future Use	1	2	3	4	5
19. I was able to complete the recitation of the dua and zikr for Hajj quickly using MDZ4H.	☐	☐	☐	☐	☐
20. I could effectively complete the recitation of the dua and zikr for Hajj using MDZ4H.	☐	☐	☐	☐	☐
21. I was able to efficiently complete the recitation of the dua and zikr for Hajj using MDZ4H.	☐	☐	☐	☐	☐
22. I believe I could become productive quickly in reciting the dua and zikr for Hajj using MDZ4H.	☐	☐	☐	☐	☐
23. From my current experience with using MDZ4H, I think I would use it regularly.	☐	☐	☐	☐	☐

Thank you very much for your cooperation

Appendix C

A Brief Overview of the Usability Testing Methods

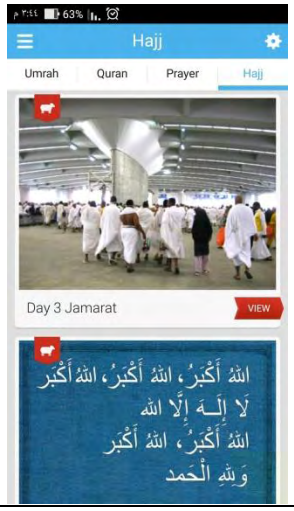
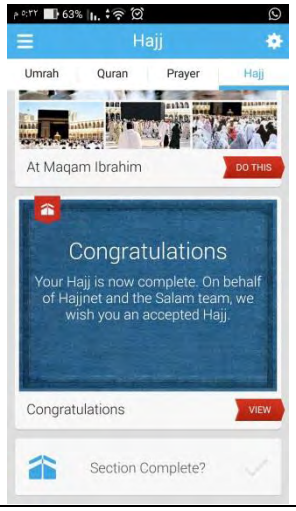
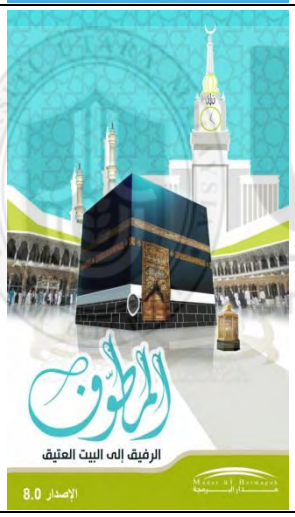
Type Of Evaluation	Evaluation Method	Purpose Of Evaluation	Data Generation And Collection Techniques	Description Of The Method	Design And Development Stage	Evaluation Performed By	Advantages	Disadvantages
USABILITY INSPECTION								
Analytic	Formal usability inspection	Examine usability of user interface; find design flaws early in design process	Specifications; questionnaire; observation; verbal protocols; video or audio recording	Inspections walk through tasks with the user's goal and purpose in mind	Early in design and development process	Experts in the field, specially assigned inspectors	Can be held on early prototypes of design specifications of paper mock-ups	Does not provide insights into real user patterns of use and problems
Analytic	Heuristic evaluation	Find usability defects early in design process	Heuristics; checklist; verbal protocol; video or audio recording	Experts assess design guided by heuristics	Particularly well suited for earlier stages of the design process	Experts (usually 2-5)	Diagnostic; high potential return on investment; cost-effective	Subject to bias; locating experts may present a problem; no real user involved
Analytic	Cognitive walkthrough	Find interaction design flaws and user difficulties	Usability specifications; checklist; verbal protocol; video or audio recording	Experts role play users performing the real task on early prototype	Early in design process	Expert evaluators	Cost-effective; can be held specifications; can provide a typical usage scenario	Restrictions in role playing locating experts may be problematic ; no real users involved
USABILITY INSPECTION								
Analytic	Pluralistic walkthrough	Evaluate user interface on interaction	Verbal protocols; observation; critical incident taking; questionnaire	User developers' and usability professionals collaborate to analyze the system	Early in development process	Users together with developers and usability professionals	Interaction between users and developers helps resolve usability problems faster	Requires special organizations; involves high costs and time investments

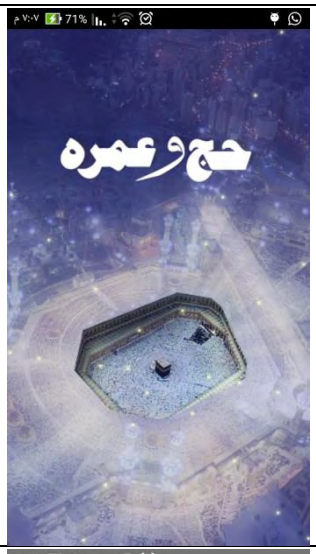
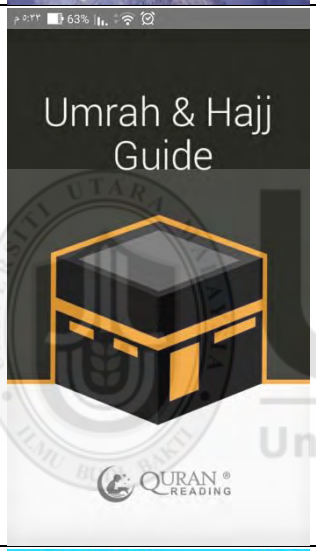
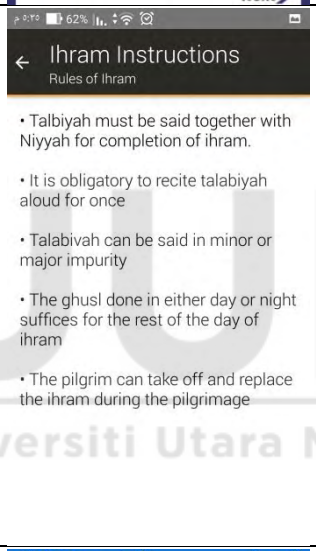
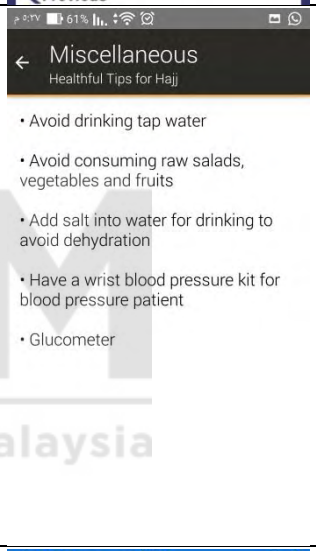
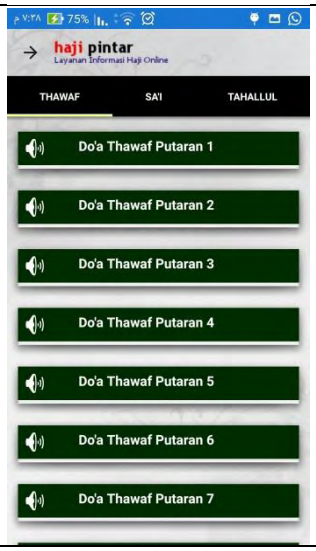
Type Of Evaluation	Evaluation Method	Purpose Of Evaluation	Data Generation And Collection Techniques	Description Of The Method	Design And Development Stage	Evaluation Performed By	Advantages	Disadvantages
USABILITY INQUIRY								
Empirical	Survey	Obtain information about users' preferences or understanding of the system	Questionnaire; user interview	Data collected from questionnaires or interviews	Implementation users and evaluation stage (late in design process)	Users	Can be diagnostics; can be used for large groups; replicable	Information is subjective; low response rates; time-consuming
Empirical	Interview; focus group; panel	Obtain information on users' needs; get user feedback on the system	User interview; retrospective verbal protocols	Data collected from user interviews, panels or focus groups	Analysis (formulation of users' needs); implementation and evaluation stage	Users	Flexible; allow in-depth attitude and experience probing	Information is subjective; time-consuming; requires special organization; data analysis may be complex
USABILITY INQUIRY								
Empirical	Contextual Inquiry	Gather information about problems experienced by users on product use	Contextual interviews; observation; verbal protocols; video or audio recording	Developers observe users performing real tasks and discuss the process with them	Early in development process	Users	Natural context of use; can help identify the causes of users' actions and decisions	High costs; difficult to analyze and interpret data
USABILITY TESTING								
Empirical	Experiments	Examine user performance on the structured tasks; gain insights into what users actually do	Logging of activities; performance measures; verbal protocols; observation; video recording; questionnaires	Users perform clearly defined 'typical' user tasks in a controlled environment	Development implementation and evaluation stage (late in design process)	Users (5-20) or experts as user to distinguish patterns of use	Powerful; reliable; finds highly used (or in used) features	High costs; data analysis; time consuming; low ecological validity; can affect user's performance level

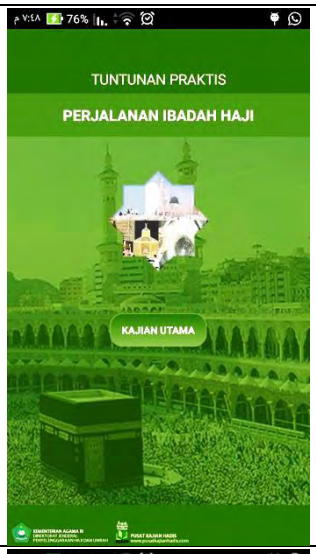
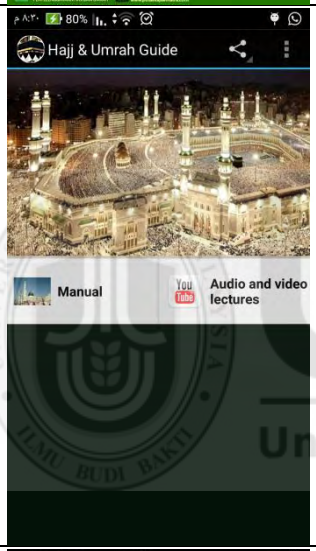
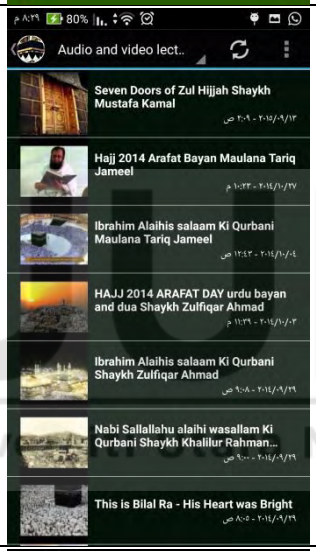
Type Of Evaluation	Evaluation Method	Purpose Of Evaluation	Data Generation And Collection Techniques	Description Of The Method	Design And Development Stage	Evaluation Performed By	Advantages	Disadvantages
Empirical	Co-discovery	Gather information about problems Experienced by users on product use	Participant observation; verbal protocols; video or audio recording	Developers observe 2 users who work together and verbalize the process	Any stage of design and development process	2 users	Can bring out more insights than a single participant vocalizing his or her thoughts	High cost; difficult to analyze and interpret
USABILITY TESTING								
Empirical	Prototype evaluation/ testing	Get feedback from users on the system 'under construction'	Verbal or written protocols or notes; informal feedback	Designers let users try out the product and get their feedback	Any stage of design and development process	1-2 users and/ or experts	Provides data on user preferences and experiences; low cost; can be held in natural	Information can be subjective; provides incomplete picture
Empirical	Trial-run	Reveal problem and improve usability of the system before release	Performance measures; logging of activities; questionnaires; interviews	User perform the whole range of tasks and activities they would in the real life	Implementation users and evaluation stages (late in the design process)	Users	Powerful; reliable; valid data; high ecological validity	High costs; time-consuming; requires special organization; user behavior can be effected by evaluation

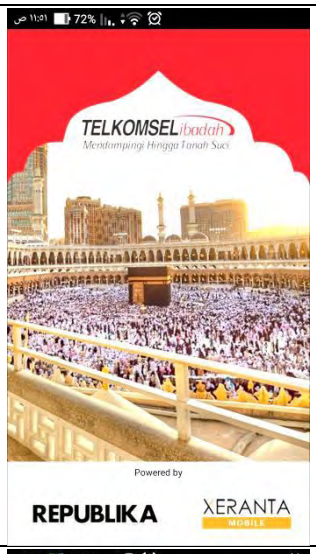
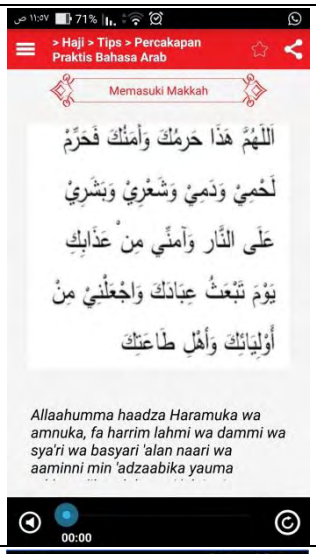
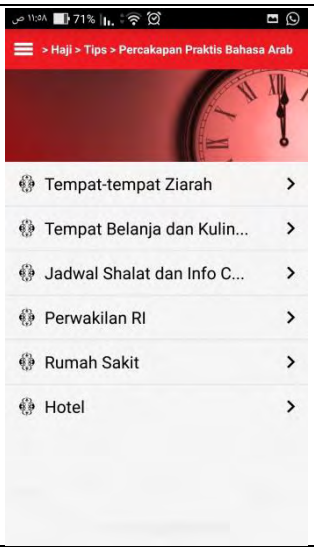
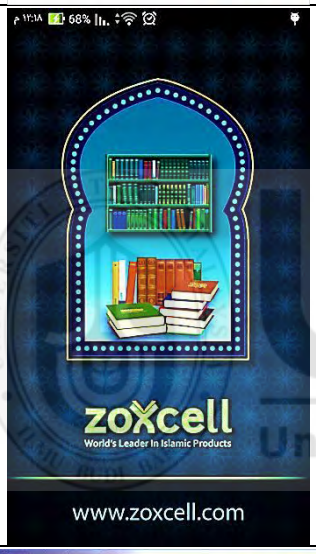
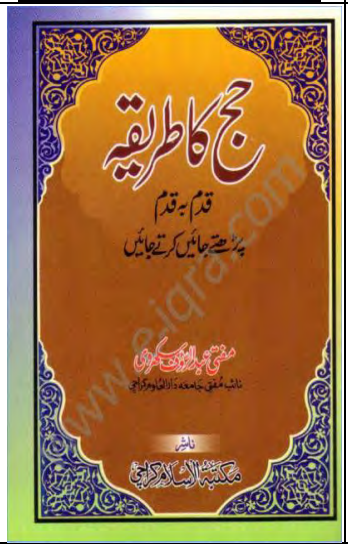
Appendix D

User Interface of the Selected Mobile Applications

Apps Name	Opening Section	Contents Section	Closing Section
Salam: Hajj & Umrah Guide			
Al-Mutawif for Hajj, Umrah and Ziarah (المطوف الحج والعمرة والزيارة)			
Hajj and Umrah Guide			

Apps Name	Opening Section	Contents Section	Closing Section
Hajj and Umrah			
Umrah & Hajj Guide			
Haji Pintar			

Apps Name	Opening Section	Contents Section	Closing Section
Manasik Haji dan Umrah			
Hajj & Umrah Guide			
Lovers' Hajj (حج العاشقين)			

Apps Name	Opening Section	Contents Section	Closing Section
Telkomsel Ibadah			
Hajj and Umrah Guide English			**No Closing Section**
Hajj aur Umrah in Urdu			**No Closing Section**

Appendix E

Sample of Consent Form for Expert

Consent Form of Expert Reviewer for Conceptual Design Model of Personal Digital Mutawwif (PDM)

School of Multimedia Technology and Communication
College of Arts and Science
Universiti Utara Malaysia (UUM)

1. I have accepted the official appointment letter from UUM. With the expertise and the existing knowledge that I have, I volunteer to be an expert reviewer for *"Personal Digital Mutawwif (PDM)"* proposed by Ahmad Sheikh Abdullah Al-Aidaroos under supervision of Dr. Ariffin Abdul Mutalib.

2. I understand that the expert review process is designed to gather information and comments in improving the proposed model.

3. I understand that no part of the proposed model may be reproduced, stored in retrieved system, or transmitted in any form or by any means, electronic, mechanical photocopying, recording, or otherwise, without prior permission from the researcher and her supervisor.

4. I understand that the researcher will not identify me by name in any report using information obtained from the questionnaire, and that my confidentiality as a participant in this study will remain secure. Subsequent uses of records and data will be subject to standard data use policies which protect the anonymity of individuals and institutions.

5. I understand that this study has been reviewed and approved by the School of Multimedia Technology and Communication, College of Arts and Science, UUM.

6. I have read and understood the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

7. I am given a copy of this consent form.

My Signature

ASSOC. PROF. DR. AKRAM M.ZM KHEDHER
Deputy Director
Centre for Islamisation (CENTRIS)
International Islamic University Malaysia

Akram MZM Khedher

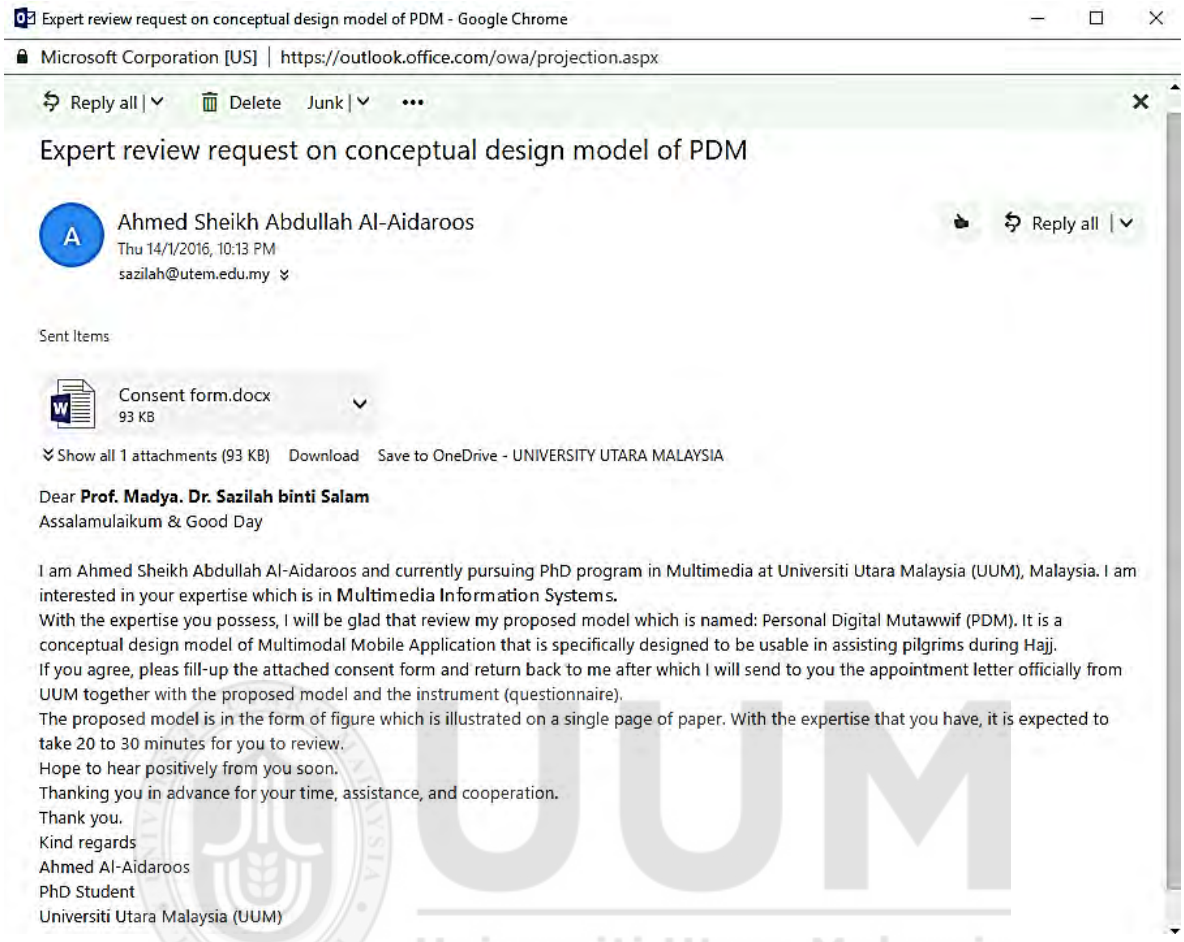
My Printed Name and Official Stamp

Date

Signature of the Researcher

For further information, please contact:
s94410@alumni.uum.edu.my / Mr.alaidaroos@Gmail.com /am.ariffin@uum.edu.my

Appendix F
Sample of Experts' Invitation Email and Response



Expert review request on conceptual design model of PDM - Google Chrome

Microsoft Corporation [US] | https://outlook.office.com/owa/projection.aspx

Reply all | Delete Junk | ...

Expert review request on conceptual design model of PDM

A Ahmed Sheikh Abdullah Al-Aidaroos
Thu 14/1/2016, 10:13 PM
sazilah@utem.edu.my

Reply all

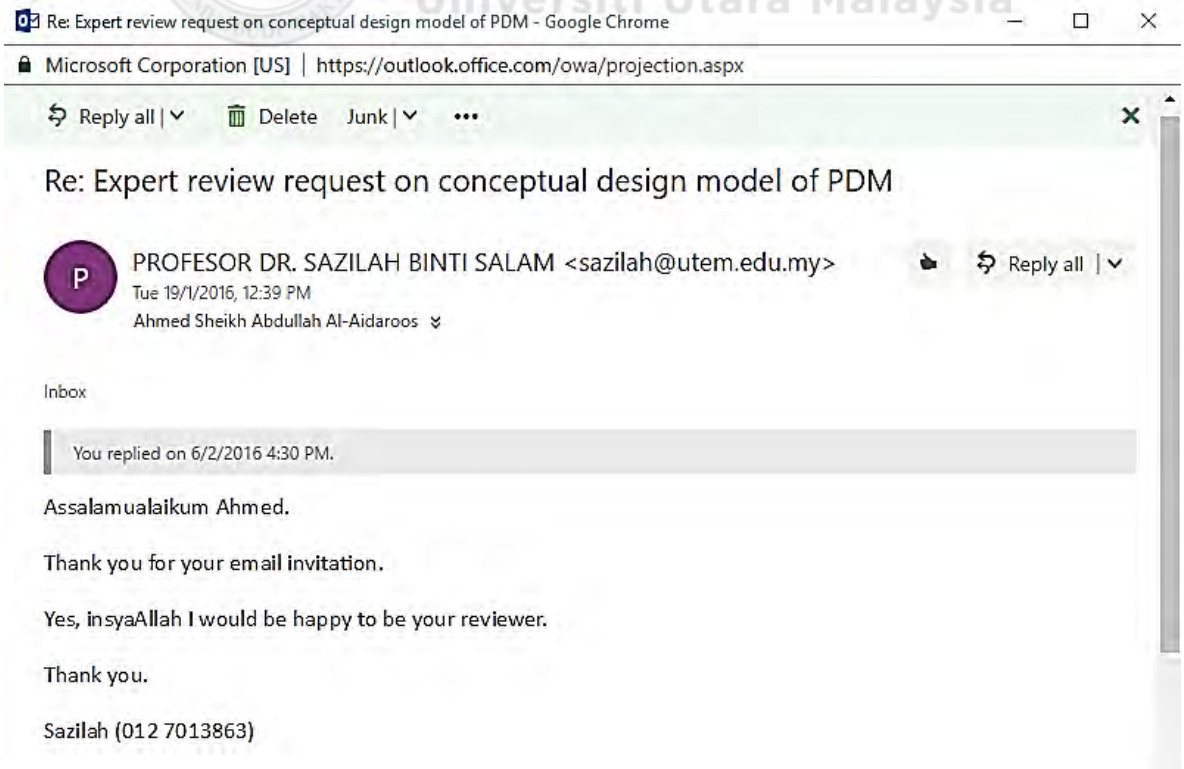
Sent Items

Consent form.docx
93 KB

Show all 1 attachments (93 KB) Download Save to OneDrive - UNIVERSITY UTARA MALAYSIA

Dear **Prof. Madya. Dr. Sazilah binti Salam**
Assalamulaikum & Good Day

I am Ahmed Sheikh Abdullah Al-Aidaroos and currently pursuing PhD program in Multimedia at Universiti Utara Malaysia (UUM), Malaysia. I am interested in your expertise which is in **Multimedia Information Systems.**
With the expertise you possess, I will be glad that review my proposed model which is named: Personal Digital Mutawwif (PDM). It is a conceptual design model of Multimodal Mobile Application that is specifically designed to be usable in assisting pilgrims during Hajj.
If you agree, pleas fill-up the attached consent form and return back to me after which I will send to you the appointment letter officially from UUM together with the proposed model and the instrument (questionnaire).
The proposed model is in the form of figure which is illustrated on a single page of paper. With the expertise that you have, it is expected to take 20 to 30 minutes for you to review.
Hope to hear positively from you soon.
Thanking you in advance for your time, assistance, and cooperation.
Thank you.
Kind regards
Ahmed Al-Aidaroos
PhD Student
Universiti Utara Malaysia (UUM)



Re: Expert review request on conceptual design model of PDM - Google Chrome

Microsoft Corporation [US] | https://outlook.office.com/owa/projection.aspx

Reply all | Delete Junk | ...

Re: Expert review request on conceptual design model of PDM

P PROFESOR DR. SAZILAH BINTI SALAM <sazilah@utem.edu.my>
Tue 19/1/2016, 12:39 PM
Ahmed Sheikh Abdullah Al-Aidaroos

Reply all

Inbox

You replied on 6/2/2016 4:30 PM.

Assalamualaikum Ahmed.

Thank you for your email invitation.

Yes, insyaAllah I would be happy to be your reviewer.

Thank you.

Sazilah (012 7013863)

Appendix G
Sample of Appointment Letter for Expert

PUSAT PENGAJIAN TEKNOLOGI MULTIMEDIA DAN KOMUNIKASI
SCHOOL OF MULTIMEDIA TECHNOLOGY AND COMMUNICATION
Universiti Utara Malaysia
06010 UUM SINTOK
KEDAH DARUL AMAN
MALAYSIA

Tel: 604-928 5801
Faks (Fax): 604-928 5804
Laman Web (Web): http://www.smmtc.uum.edu.my

KEDAH AMAN MAKMUR • BERSAMA MEMACU TRANSFORMASI

UUM/CAS(SMMTC)/P-30
18 January 2016

Dr. Murni Binti Mahmud,
Associate Professor,
Department of Information Systems,
Kulliyyah of Information and Communication Technology,
International Islamic University Malaysia
P.O. Box 10, 50728 Kuala Lumpur, Malaysia.
Tel: 603 6196 5647, 603 6196 5620

Madam,

APPOINTMENT AS EXPERT REVIEWER FOR CONCEPTUAL DESIGN MODEL OF MULTIMODAL MOBILE ASSISTANCE DURING HAJJ: PERSONAL DIGITAL MUTAWWIF (PDM)

Thank you for agreeing to involve as an expert in a PHD study, particularly for reviewing and evaluating a conceptual model with the following details:

Student Name	:	**Ahmed Sheikh Abdullah Al-Aidaroos**
No Matrik	:	**94410**
School	:	**School of Multimedia Technology and Communication, UUM**
Research Title	:	**Conceptual Model of Multi-Modal Usable Mobile Assistance during Hajj**
Supervisor	:	**Dr. Ariffin Abdul Mutalib**

For you information, the student will use the model for his research. Therefore, he needs your expertise to review the proposed model in a few dimensions as stated in the reviewing form.

Your cooperation, time, and assistance are greatly appreciated.

Thank you.

"ILMU BUDI BAKTI"

Sincerely yours,

DR. NORSIAH ABDUL HAMID
Dean
School of Multimedia Technology and Communication,
UUM College of Arts and Sciences
Universiti Utara Malaysia

Appendix H

The Instrument of Expert Review

INSTRUMENT FOR EXPERT REVIEW:

CONCEPTUAL DESIGN MODEL OF MULTIMODAL MOBILE ASSISTANCE DURING HAJJ: PERSONAL DIGITAL MUTAWWIF (PDM)

Dear Prof. / Dr. / Sir / Ma,

EXPERT REVIEW OF CONCEPTUAL DESIGN MODEL OF PDM

I am **Ahmed Sheikh Abdullah Al-Aidaroos** and currently pursuing PhD program in Multimedia at Universiti Utara Malaysia (UUM), Malaysia. I am delighted to inform you that you have been selected to participate in this research on the reason as follows:

1. Your qualifications either in Human Computer Interaction (HCI) or Mobile Applications or Multimedia or Software Engineering (SE) or Information Systems (IS) or Computer Science (CS) or any related areas, and/or
2. You have been researching/teaching in Multimedia or Usability or HCI or instructional design or IT or CS areas for at least five years.

My PhD research proposes **A CONCEPTUAL MODEL OF MULTI-MODAL USABLE MOBILE ASSISTANCE DURING HAJJ**. As part of this research, a conceptual design model which is named **Personal Digital Mutawwif (PDM)** has been designed. It is aimed to provide a conceptual design model of developing a multimodal mobile application that is specifically designed to be usable in assisting pilgrims during Hajj.

Therefore, as part of the prerequisite for this research, it is required that you evaluate the appropriateness of the proposed design strategies in the instrument listed in the review form below.

It would be greatly appreciated if you could complete this evaluation form.

The information supplied will be treated as confidential and will be used for the research purposes, which will be reported anonymously in academic publications.

Please feel free to contact me by e-mail: **Mr.Alaidaroos@gmail.com** in regard to any queries or my supervisor **am.ariffin@uum.edu.my**.

INSTRUCTIONS:

Please read and go through the **PDM** figure carefully. Once this is done, with the expertise you possess, please provide feedback for all questions in the provided spaces.

EXPERT/REVIEWER DETAILS

Name* **:**_____

Highest educational level* **:** _____ **Gender** **:** ☐ Male ☐ Female

Years of Experience* **:** _____ **Age** **:** _____

ITEMS TO REVIEW

Based on the proposed conceptual model (as depicted in the given handout), please tick (✓) your choice.

1.	**The proposed elements in the following components are relevant**	**All proposed components and elements are relevant**	**Some are definitely not relevant**	**Some may not be relevant**
	Structural			
	Content Composition			
	Design Principles			
	Technology			
	Development Approach			

2.	**The proposed design principles are understood**	**Needs very detailed explanation**	**Needs some explanation**	**It's easy to understand**
	Texts Formatting			
	Images			
	Graphics			
	Animations			
	Audios			
	Fusion and Fission			
	Instruction-Base			
	Organization			
	Labelling			
	Navigation Systems			
	Transitions			
	User Interface and Layout			

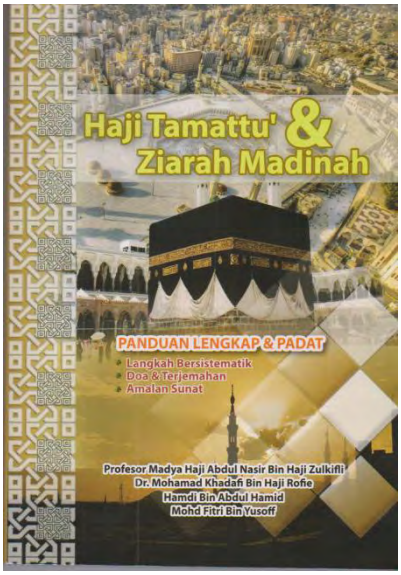
3.	**The following terminology**	**Needs very detailed explanation**	**Needs some explanation**	**It's easy to understand**
	Modalities			
	Fusion			
	Fission			
	Manual Mode			
	Oral Mode			
	Automatic Mode			
	Instruction-Base			

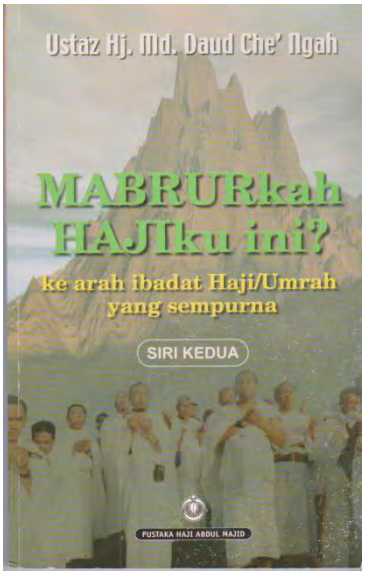
4. The connections and flows of all the components are logical? Yes [ ] No [ ]

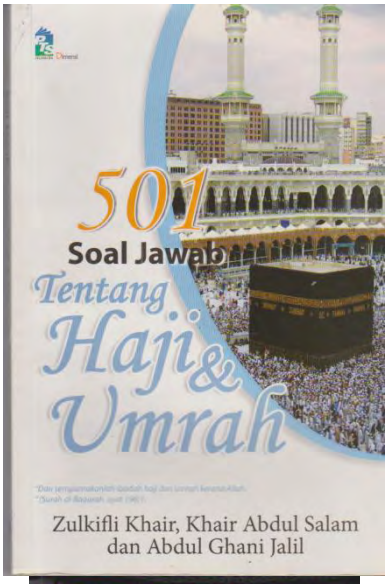
5. Overall, the production model is readable? Yes [ ] No [ ]

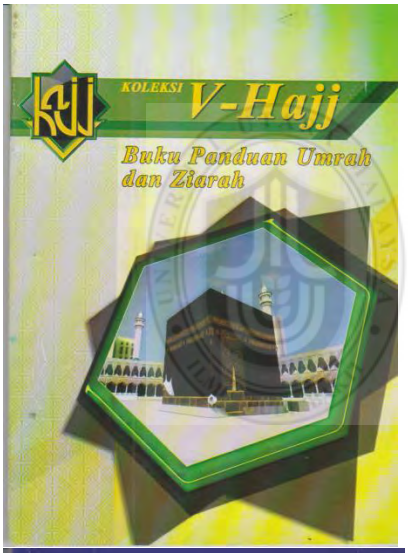
6. Please write your further comments below:----------

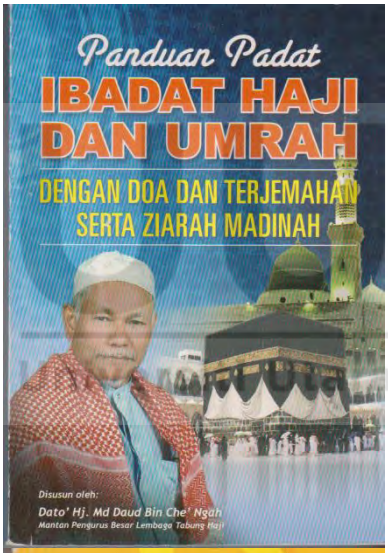
Appendix I
Books Cover Pictures (The Sources of Contents)

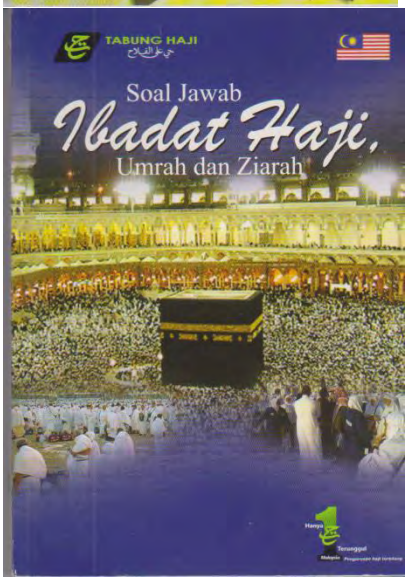


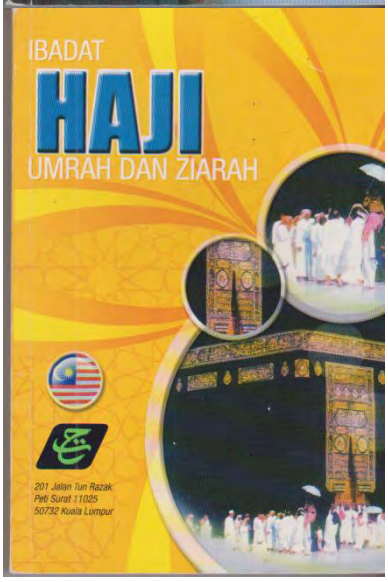


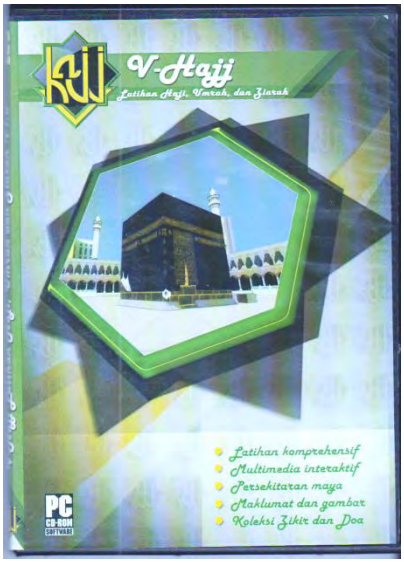












Appendix J
The First Draft of Q-U3MA

School of Multimedia Technology and Communication

College of Arts and Sciences

UNIVERSITI UTARA MALAYSIA

QUESTIONNAIRE

Measuring the Usability of Multi-Modal Mobile Applications (Q-U3MA)

Assalammu'alaikum and Good Day,

Dear respondents, we are delighted to inform you that you have been selected randomly to participate in our research (**CONCEPTUAL MODEL OF MULTI-MODAL USABLE MOBILE ASSISTANCE DURING HAJJ**). The aim of the questionnaire is to measure the usability of **Personal Digital Mutawwif (PDM)**.

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publication.

It would be greatly appreciated is you could complete the questionnaire with honest and sincere. I would like to say thank you for your time and cooperation.

Yours Truly,

Ahmed Sheikh Al-Aidaroos

Section A: Respondent's Demographic

INSTRUCTION: Please tick (√) in the box [ ] and fill in the blank.

1. Gender: [ ] Male [ ] Female

2. Age: [ ] 10-25 years [ ] 26-40 years

[ ] 41-60 years [ ] 61 years and above

3. Education level: [ ] Primary School [ ] Secondary School

[ ] Diploma [ ] Bachelor Degree

[ ] Master Degree [ ] Doctorate Degree

4. Your experience on mobile applications*:* ---------- Months

5. Have you been to Makkah to perform Hajj or Umrah? [ ] Yes [ ] No

If yes how many times _____

Section B: PDM Usability Evaluation

INSTRUCTION: Please circle (O) on the scale of your choice.

Strongly Disagree	Disagree	Somehow Agree	Agree	Strongly Agree
1	2	3	4	5

	Effectiveness					
Usefulness						
1.	The information provided by PDM is enough and helpful.	1	2	3	4	5
2.	The information provided by PDM is effective in helping me complete the rituals of Hajj.	1	2	3	4	5
3.	Using PDM would enable me to accomplish the rituals of Hajj more quickly.	1	2	3	4	5
4.	Using PDM would enhance my effectiveness in performing the rituals of Hajj.	1	2	3	4	5
5.	Using PDM would make it easier to perform the rituals of Hajj.	1	2	3	4	5
6.	Using PDM would increase my productivity in performing the rituals of Hajj.	1	2	3	4	5
7.	PDM meets my needs and does everything I would expect.	1	2	3	4	5
8.	The voice instructions in PDM are clear and easy to understand.	1	2	3	4	5
9.	Sounds in PDM are sufficiently pure and not noisy.	1	2	3	4	5
10.	In PDM, the recitation speed of voice instructions is sufficiently moderate.	1	2	3	4	5
11.	I would find PDM useful in Hajj.	1	2	3	4	5
Errors						
1.	I think PDM prevents me from making errors.	1	2	3	4	5
2.	I can recover from mistakes quickly and easily while operating PDM.	1	2	3	4	5
3.	PDM has at some time stopped unexpectedly.	1	2	3	4	5
Simplicity						
1.	The operations of PDM are simple and uncomplicated.	1	2	3	4	5
2.	The organization of information on PDM is clear and easy to understand.	1	2	3	4	5
3.	I learned to use PDM quickly.	1	2	3	4	5
4.	I easily remember how to use PDM.	1	2	3	4	5
5.	The information provided by PDM is easy to understand.	1	2	3	4	5
6.	PDM is designed for all levels of users.	1	2	3	4	5
7.	I found PDM simple to use.	1	2	3	4	5
Reliability						
1.	PDM is reliable, dependable, and trustworthy.	1	2	3	4	5
2.	PDM is accurate in identifying my exact location.	1	2	3	4	5

3.	PDM is accurate in interpreting my voice commands.	1	2	3	4	5
4.	PDM has all the functions and capabilities I expect it to have.	1	2	3	4	5
	Efficiency					
Ease of Use						
1.	I can use PDM without written instructions.	1	2	3	4	5
2.	PDM requires the fewest steps possible to accomplish what I want to do.	1	2	3	4	5
3.	The speed of PDM is fast enough.	1	2	3	4	5
4.	It is easy to make PDM does exactly what I want.	1	2	3	4	5
5.	It would be easy for me to become skillful at using PDM.	1	2	3	4	5
6.	It is easy to learn PDM.	1	2	3	4	5
7.	I can use PDM successfully every time.	1	2	3	4	5
8.	Using PDM is effortless.	1	2	3	4	5
9.	Using PDM is sufficiently easy.	1	2	3	4	5
Safety						
1.	The highlighting on the PDM screens is helpful.	1	2	3	4	5
2.	It is sufficiently easy to operate PDM with one hand.	1	2	3	4	5
3.	PDM is safe to use without causing harm or difficulty.	1	2	3	4	5
4.	It is safe to use PDM while performing rituals of Hajj.	1	2	3	4	5
5.	PDM is suitable to use in a crowded environment like Hajj.	1	2	3	4	5
Flexibility						
1.	It is easy to move from one part of a task to another.	1	2	3	4	5
2.	I do not notice any inconsistency as I use PDM.	1	2	3	4	5
3.	All operations in PDM can be carried out in a systematically similar way.	1	2	3	4	5
4.	In PDM, the control matches user skills.	1	2	3	4	5
5.	The visual representation in PDM is consistent with familiar conventions.	1	2	3	4	5
6.	The wording in PDM is familiar.	1	2	3	4	5
7.	PDM provides zooming for display expansion.	1	2	3	4	5
8.	The interface of PDM is consistent with other products I have used.	1	2	3	4	5
Accessibility						
1.	It is easy to find the information I need in PDM.	1	2	3	4	5
2.	It is easy to navigate the PDM.	1	2	3	4	5
3.	The organization of the PDM menus is sufficiently logical.	1	2	3	4	5
4.	The buttons are sufficiently easy to locate.	1	2	3	4	5

5.	The amount of information displayed on the PDM screens is adequate.	1	2	3	4	5
6.	The characters on PDM screens are easy to read.	1	2	3	4	5
7.	The terminologies used in PDM are consistent and always related to the task.	1	2	3	4	5
8.	The sequence of PDM screens is clear and logical.	1	2	3	4	5
	Satisfaction					
Attitude						
1.	I feel I need to have PDM.	1	2	3	4	5
2.	I feel comfortable and confident using PDM.	1	2	3	4	5
3.	I feel excited when using PDM.	1	2	3	4	5
4.	I would recommend PDM to my friends.	1	2	3	4	5
Acceptability						
1.	The interface of PDM is attractive and pleasant.	1	2	3	4	5
2.	PDM is wonderful.	1	2	3	4	5
3.	Overall, I am satisfied with PDM.	1	2	3	4	5

END OF QUESTIONS

THANK YOU FOR PARTICIPATING!

Appendix K

The Instrument for Face and Content Validity of Q-U3MA

INSTRUMENT FOR CONTENT VALIDITY:

MEASURING THE USABILITY OF MULTI-MODAL MOBILE APPLICATIONS (Q-U3MA)

Guide for expert/ reviewer

You are selected to review this questionnaire on reasons as follows:

- You are PhD or master holder in either in Human Computer Interaction (HCI) or Usability or Mobile Applications or Multimedia or Software Engineering (SE) or Information Systems (IS) or Computer Science (CS) or any related areas, and/or
- You have a teaching background for five years or above in the above mentioned areas or any relevant area.

On top of that, you have at least five years studying/ researching/ teaching in the above mentioned areas or any relevant area.

Apparatus:

1. This sheet
2. The questionnaire of measuring the usability of multi-modal mobile applications (Q-U3MA)
3. Pen

Instructions:

- You are provided with the above listed apparatus.
- Read and understand the Q-U3MA carefully.
- Finally, with the expertise you have, it is expected that you could provide feedback for all questions in the provided spaces.

QUESTIONS FOR REVIEW

Section A: Effectiveness

Q1) Sub-measures relevancy?

Sub-Measures	Relevant	Not relevant
Usefulness		
Errors		
Simplicity		
Reliability		

Q2) Items representativeness and clarity?

Representativeness	Scale	Clarity
Item is not representative	**1**	Item is not clear
Item needs major revisions to be representative	**2**	Item needs major revisions to be clear
Item needs minor revisions to be representative	**3**	Item needs minor revisions to be clear
Item is representative	**4**	Item is clear

A) Usefulness Items		Representativeness				Clarity			
		1	2	3	4	1	2	3	4
1.	The information provided by PDM is enough and helpful.								
2.	The information provided by PDM is effective in helping me complete the rituals of Hajj.								
3.	Using PDM would enable me to accomplish the rituals of Hajj more quickly.								
4.	Using PDM would enhance my effectiveness in performing the rituals of Hajj.								
5.	Using PDM would make it easier to perform the rituals of Hajj.								
6.	Using PDM would increase my productivity in performing the rituals of Hajj.								
7.	PDM meets my needs and does everything I would expect.								
8.	The voice instructions in PDM are clear and easy to understand.								
9.	Sounds in PDM are sufficiently pure and not noisy.								
10.	In PDM, the recitation speed of voice instructions is sufficiently moderate.								
11.	I would find PDM useful in Hajj.								

B) Errors Items		Representativeness				Clarity			
		1	2	3	4	1	2	3	4
1.	I think PDM prevents me from making errors.								
2.	I can recover from mistakes quickly and easily while operating PDM.								
3.	PDM has at some time stopped unexpectedly.								

C) Simplicity Items		Representativeness				Clarity			
		1	2	3	4	1	2	3	4
1.	The operations of PDM are simple and uncomplicated.								
2.	The organization of information on PDM is clear and easy to understand.								
3.	I learned to use PDM quickly.								
4.	I easily remember how to use PDM.								
5.	The information provided by PDM is easy to understand.								
6.	PDM is designed for all levels of users.								
7.	I found PDM simple to use.								

D) Reliability Items		Representativeness				Clarity			
		1	2	3	4	1	2	3	4
1.	PDM is reliable, dependable, and trustworthy.								
2.	PDM is accurate in identifying my exact location.								
3.	PDM is accurate in interpreting my voice commands.								
4.	PDM has all the functions and capabilities I expect it to have.								

Section B: Efficiency

Q1) Sub-measures relevancy?

Sub-Measures	Relevant	Not relevant
Ease of use		
Safety		
Flexibility		
Accessibility		

Q2) Items representativeness and clarity?

Representativeness	Scale	Clarity
Item is not representative	**1**	Item is not clear
Item needs major revisions to be representative	**2**	Item needs major revisions to be clear
Item needs minor revisions to be representative	**3**	Item needs minor revisions to be clear
Item is representative	**4**	Item is clear

	A) Ease of Use Items	**Representativeness**				**Clarity**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1.	I can use PDM without written instructions.								
2.	PDM requires the fewest steps possible to accomplish what I want to do.								
3.	The speed of PDM is fast enough.								
4.	It is easy to make PDM does exactly what I want.								
5.	It would be easy for me to become skillful at using PDM.								
6.	It is easy to learn PDM.								
7.	I can use PDM successfully every time.								
8.	Using PDM is effortless.								
9.	Using PDM is sufficiently easy.								

	B) Safety Items	**Representativeness**				**Clarity**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1.	The highlighting on the PDM screens is helpful.								
2.	It is sufficiently easy to operate PDM with one hand.								
3.	PDM is safe to use without causing harm or difficulty.								
4.	It is safe to use PDM while performing rituals of Hajj.								
5.	PDM is suitable to use in a crowded environment like Hajj.								

	C) Flexibility Items	**Representativeness**				**Clarity**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1.	It is easy to move from one part of a task to another.								
2.	I do not notice any inconsistency as I use PDM.								
3.	All operations in PDM can be carried out in a systematically similar way.								
4.	In PDM, the control matches user skills.								
5.	The visual representation in PDM is consistent with familiar conventions.								
6.	The wording in PDM is familiar.								
7.	PDM provides zooming for display expansion.								
8.	The interface of PDM is consistent with other products I have used.								

	D) Accessibility Items	**Representativeness**				**Clarity**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1.	It is easy to find the information I need in PDM.								
2.	It is easy to navigate the PDM.								
3.	The organization of the PDM menus is sufficiently logical.								
4.	The buttons are sufficiently easy to locate.								

5.	The amount of information displayed on the PDM screens is adequate.								
6.	The characters on PDM screens are easy to read.								
7.	The terminologies used in PDM are consistent and always related to the task.								
8.	The sequence of PDM screens is clear and logical.								

Section C: Satisfaction

Q1) Sub-measures relevancy?

Sub-Measures	Relevant	Not relevant
Attitude		
Acceptability		

Q2) Items representativeness and clarity?

Representativeness	Scale	Clarity
Item is not representative	**1**	Item is not clear
Item needs major revisions to be representative	**2**	Item needs major revisions to be clear
Item needs minor revisions to be representative	**3**	Item needs minor revisions to be clear
Item is representative	**4**	Item is clear

	A) Attitude Items	**Representativeness**				**Clarity**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1.	I feel I need to have PDM.								
2.	I feel comfortable and confident using PDM.								
3.	I feel excited when using PDM.								
4.	I would recommend PDM to my friends.								

	B) Acceptability Items	**Representativeness**				**Clarity**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1.	The interface of PDM is attractive and pleasant.								
2.	PDM is wonderful.								
3.	Overall, I am satisfied with PDM.								

Section D: General Comments *(Please specify the item):*

END OF QUESTIONS

Thank you for participating

Appendix L
Reliability Test Results

1- Usefulness (2 Items Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.875	**.893**	**11**

Reliability Statistics After FA

Cronbach's Alpha	N of Items
.934	**9**

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
43.6286	57.476	7.58127	11

Item Statistics

	Mean	Std. Deviation	N
USF1	4.1429	.80961	35
USF2	4.2571	.85209	35
USF3	4.1143	.90005	35
USF4	3.0286	1.50461	35
USF5	4.3714	.97274	35
USF6	3.2286	1.05957	35
USF7	4.1429	1.03307	35
USF8	4.0857	.98134	35
USF9	4.1714	.92309	35
USF10	3.9429	1.05560	35
USF11	4.1429	1.11521	35

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
USF1	39.4857	47.669	.819	.826	.852
USF2	39.3714	48.240	.719	.611	.857
USF3	39.5143	49.257	.586	.768	.864
USF4	**40.6000**	**50.071**	**.241**	**.445**	**.900**
USF5	39.2571	46.432	.762	.753	.852
USF6	**40.4000**	**57.541**	**-.074**	**.447**	**.906**
USF7	39.4857	46.139	.732	.807	.853
USF8	39.5429	46.491	.749	.794	.853
USF9	39.4571	47.079	.753	.801	.854
USF10	39.6857	45.634	.752	.761	.852
USF11	39.4857	44.492	.789	.862	.848

2- Errors Rate (No Item Deleted)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.848	**.851**	**4**

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
15.8000	9.988	3.16042	4

Item Statistics

	Mean	Std. Deviation	N
ERR1	4.1429	.91210	35
ERR2	3.9143	.88688	35
ERR3	4.0857	.95090	35
ERR4	3.6571	1.05560	35

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ERR1	11.6571	5.997	.707	.559	.798
ERR2	11.8857	5.810	.793	.694	.764
ERR3	11.7143	6.328	.576	.355	.852
ERR4	12.1429	5.479	.687	.580	.809

3- Simplicity (1 Item Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.891	**.912**	**7**

Reliability Statistics After FA

Cronbach's Alpha	N of Items
.943	**6**

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
27.5143	36.022	6.00182	7

Item Statistics

	Mean	Std. Deviation	N
SIM1	4.0571	1.05560	35
SIM2	4.0571	1.02736	35
SIM3	4.2000	1.02326	35
SIM4	4.2000	1.02326	35
SIM5	4.0571	1.02736	35
SIM6	2.8286	1.50461	35
SIM7	4.1143	.96319	35

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SIM1	23.4571	27.197	.700	.601	.874
SIM2	23.4571	26.197	.834	.837	.858
SIM3	23.3143	26.869	.764	.709	.867
SIM4	23.3143	26.222	.835	.826	.858
SIM5	23.4571	25.844	.873	.871	.854
SIM6	**24.6857**	**29.222**	**.279**	**.177**	**.943**
SIM7	23.4000	27.071	.801	.787	.864

4- Reliability (No Item Deleted)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.901	**.904**	**4**

Item Statistics

	Mean	Std. Deviation	N
REL1	4.0857	.98134	35
REL2	3.9714	1.01419	35
REL3	3.8857	.93215	35
REL4	4.0000	1.13759	35

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
15.9429	12.820	3.58053	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
REL1	11.8571	7.420	.830	.692	.855
REL2	11.9714	7.440	.786	.626	.870
REL3	12.0571	7.879	.778	.624	.874
REL4	11.9429	7.055	.740	.555	.892

5- Ease Of Use (1 Item Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.896	**.909**	**7**

Item Statistics

	Mean	Std. Deviation	N
EOU1	4.0857	1.01087	35
EOU2	2.9429	1.37076	35
EOU3	4.0286	.92309	35
EOU4	3.7714	1.05957	35
EOU5	3.9429	1.16171	35
EOU6	4.1143	1.02244	35
EOU7	4.1143	.99325	35

Reliability Statistics After FA

Cronbach's Alpha	N of Items
.929	**6**

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
27.0000	35.529	5.96066	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
EOU1	22.9143	25.669	.863	.793	.862
EOU2	**24.0571**	**28.291**	**.368**	**.295**	**.929**
EOU3	22.9714	26.852	.818	.754	.869
EOU4	23.2286	26.534	.721	.697	.877
EOU5	23.0571	25.879	.702	.569	.880
EOU6	22.8857	26.398	.770	.801	.872
EOU7	22.8857	26.281	.811	.784	.868

6- Safety (No Item Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.916	**.915**	**4**

Item Statistics

	Mean	Std. Deviation	N
SAF1	4.0571	.96841	35
SAF2	3.9429	.96841	35
SAF3	4.1143	1.02244	35
SAF4	3.8857	.99325	35

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
16.0000	12.471	3.53137	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SAF1	11.9429	7.585	.740	.550	.913
SAF2	12.0571	7.232	.826	.724	.884
SAF3	11.8857	6.751	.880	.797	.864
SAF4	12.1143	7.281	.784	.648	.898

7- Flexibility (No Item Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.951	**.951**	**7**

Item Statistics

	Mean	Std. Deviation	N
FLE1	4.0286	.98476	35
FLE2	3.8857	1.05081	35
FLE3	4.0286	1.07062	35
FLE4	3.8000	.99410	35
FLE5	4.0571	.96841	35
FLE6	4.0571	.99832	35
FLE7	4.0286	.98476	35

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
27.8857	38.457	6.20138	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
FLE1	23.8571	28.891	.812	.694	.945
FLE2	24.0000	28.176	.823	.791	.944
FLE3	23.8571	27.538	.870	.829	.940
FLE4	24.0857	28.787	.814	.699	.945
FLE5	23.8286	28.793	.840	.736	.943
FLE6	23.8286	28.264	.866	.777	.940
FLE7	23.8571	28.950	.806	.702	.945

8- Accessibility (1 Items Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.910	**.931**	**8**

Item Statistics

	Mean	Std. Deviation	N
ACS1	4.0857	.98134	35
ACS2	3.9714	.95442	35
ACS3	3.8571	1.06116	35
ACS4	4.0286	1.01419	35
ACS5	3.8286	.98476	35
ACS6	3.9143	1.01087	35
ACS7	2.5143	1.54104	35

Reliability Statistics After FA

Cronbach's Alpha	N of Items
.961	**7**

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
30.2286	46.182	6.79570	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ACS1	26.1429	35.185	.862	.877	.886
ACS2	26.2571	36.197	.790	.716	.892
ACS3	26.3714	34.770	.822	.866	.888
ACS4	26.2000	35.400	.808	.795	.890
ACS5	26.4000	35.482	.829	.761	.889
ACS6	26.3143	35.045	.845	.812	.887
ACS7	**27.7143**	**39.916**	**.200**	**.168**	**.961**

9- Attitude (No Items Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.923	**.923**	**5**

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
20.4571	19.903	4.46122	5

Item Statistics

	Mean	Std. Deviation	N
ATT1	4.1429	1.00419	35
ATT2	4.0000	1.00000	35
ATT3	3.8857	1.02244	35
ATT4	4.1143	1.02244	35
ATT5	4.3143	1.05081	35

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ATT1	16.3143	13.104	.796	.724	.907
ATT2	16.4571	13.020	.815	.704	.903
ATT3	16.5714	13.429	.724	.619	.920
ATT4	16.3429	12.820	.825	.733	.901
ATT5	16.1429	12.538	.841	.744	.897

10- Acceptability (No Items Deleted)

Reliability Statistics Before FA

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.900	**.900**	**4**

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
16.1714	13.205	3.63387	4

Item Statistics

	Mean	Std. Deviation	N
ACP1	4.0571	.96841	35
ACP2	3.7714	1.05957	35
ACP3	4.2000	1.05161	35
ACP4	4.1429	1.06116	35

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ACP1	12.1143	8.104	.755	.619	.879
ACP2	12.4000	7.482	.794	.693	.865
ACP3	11.9714	7.676	.759	.619	.877
ACP4	12.0286	7.440	.801	.702	.862

Appendix M

The Final Version of Q-U3MA

School of Multimedia Technology and Communication

College of Arts and Sciences

UNIVERSITI UTARA MALAYSIA

QUESTIONNAIRE

BORANG SOAL SELIDIK

Measuring the Usability of Multi-Modal Mobile Applications (Q-U3MA)

Mengukur Kebolehgunaan Aplikasi Multi-Modal Mobile (Q-U3MA)

Assalammu'alaikum and Good Day,

Assalammu"alaikum dan Salam Sejahtera,

Dear respondents, we are delighted to inform you that you have been selected randomly to participate in our research (CONCEPTUAL MODEL OF MULTI-MODAL USABLE MOBILE ASSISTANCE DURING HAJJ). The aim of the questionnaire is to measure the usability of Personal Digital Mutawwif (PDM).
Responden yang dihormati, kami gembira untuk memberitahu anda bahawa anda telah dipilih secara rawak untuk mengambil bahagian dalam penyelidikan kami (MODEL KONSEPTUAL BANTUAN MULTI-MODAL MENGGUNAKAN MOBILE SEMASA HAJJ). Tujuan soal selidik ini adalah untuk mengukur kebolehgunaan Personal Digital Mutawwif (PDM).

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publication.
Maklumat yang dibekalkan akan dianggap sebagai sulit dan akan digunakan untuk tujuan penyelidikan yang boleh dilaporkan tanpa nama dalam penerbitan akademik.

It would be greatly appreciated is you could complete the questionnaire with honest and sincere. I would like to say thank you for your time and cooperation.
Adalah amat di hargai sekiranya anda dapat melengkapkan soal selidik dengan jujur dan ikhlas. Saya ingin mengucapkan terima kasih untuk masa dan kerjasama anda.

Yours Truly (*Ikhlas*),

Ahmed Sheikh Al-Aidaroos

Section A: Respondent's Demographic

Bahagian A: *Responden Demografi*

INSTRUCTION: Please tick (√) in the box [ ] and fill in the blank.

ARAHAN: *Sila tandakan (√) pada kotak yang disediakan [ ] dan isi tempat kosong.*

1. Gender/ *Jantina*: [ ] Male/ *Lelaki* [ ] Female / *Wanita*

2. Age/ *Umur*: [ ] 25 years and below / 25 *tahun dan ke bawah*
[ ] 26-40 years/ *26-40 tahun*
[ ] 41-55 years/ *41-55 tahun*
[ ] Over 55 Years/ *Lebih 55 tahun*

3. Education level /*Tahap Pendid*: [ ] Pre-Bachelor Degree/ *Pra-Ijazah Sarjana Muda*
[ ] Bachelor Degree/ *Ijazah Sarjana Muda*
[ ] Post Bachelor Degree/ *Post Ijazah Sarjana Muda*
[ ] None of the Above/ *Tiada di atas*

4. Your experience on mobile applications/ *Pengalaman anda pada aplikasi mudah alih:*
[ ] One year or Less/ *Satu tahun atau kurang*
[ ] More than one year/ *Lebih daripada satu tahun*

5. Have you been to Makkah to perform Hajj or Umrah
Pernah ke Makkah untuk mengerjakan Haji atau Umrah:
[ ] No / *Tidak*
[ ] Yes/ *Ya*

Section B: PDM Usability Evaluation
Section B: *PDM Penilaian Kebolehgunaan*

INSTRUCTION: Please circle (O) on the scale of your choice.
ARAHAN*: bulatan Sila (O) pada skala pilihan anda.*

Strongly Disagree	Disagree	Somehow Agree	Agree	Strongly Agree
1	2	3	4	5
Sangat tak setuju	*Tidak Setuju*	*Mungkin Setuju*	*Setuju*	*Sangat Setuju*

	EFFECTIVENESS/ *KEBERKESANAN*					
Usefulness/ Kegunaan						
1.	The information provided by PDM is helpful enough. *Maklumat yang diberikan oleh PDM cukup membantu.*	1	2	3	4	5
2.	The information provided by PDM is effective in helping me to complete the rituals of Hajj/Umrah. *Maklumat yang diberikan oleh PDM berkesan dalam membantu saya untuk melengkapkan ritual Haji / Umrah.*	1	2	3	4	5
3.	Using PDM would enable me to accomplish the rituals of Hajj/ Umrah contentedly. *Menggunakan PDM akan membolehkan saya untuk mencapai ibadat Haji / Umrah dengan puas hati.*	1	2	3	4	5
4.	Using PDM would make it easier to perform the rituals of Hajj/Umrah. *Menggunakan PDM akan membuat ia lebih mudah untuk melaksanakan manasik haji / umrah.*	1	2	3	4	5
5.	PDM meets my needs and expectation. *PDM memenuhi keperluan dan jangkaan saya.*	1	2	3	4	5
6.	The voice instructions in PDM are easy to understand. *Arahan suara dalam PDM mudah difahami.*	1	2	3	4	5
7.	Sounds in PDM are free of noise. *Bunyi di PDM adalah bebas daripada bunyi bising.*	1	2	3	4	5
8.	In PDM, the recitation speed of voice instructions is sufficiently moderate. *Dalam PDM, kelajuan bacaan arahan suara cukup sederhana.*	1	2	3	4	5
9.	I would find PDM useful in performing Hajj/Umrah. *Saya akan mencari PDM berguna dalam menunaikan Haji / Umrah.*	1	2	3	4	5
Errors Rate/ *Kadar Kesilapan*						
1.	PDM prevents me from making errors. PD*M menghalang saya daripada membuat kesilapan.*	1	2	3	4	5
2.	In PDM, I can recover from mistakes quickly. *Dalam PDM, saya boleh pulih daripada kesilapan dengan cepat.*	1	2	3	4	5
3.	In PDM, the error messages effective in assisting me to fix problems. *Dalam PDM, mesej ralat yang berkesan dalam membantu saya untuk menyelesaikan masalah.*	1	2	3	4	5
4.	PDM rarely stopped unexpectedly. *PDM jarang berhenti tiba-tiba.*	1	2	3	4	5
Simplicity/ *Kemudahan*						
1.	The operations of PDM are simple/ *Operasi PDM adalah mudah.*	1	2	3	4	5
2.	The organization of information on PDM is clear. *Penganjuran maklumat mengenai PDM jelas.*	1	2	3	4	5
3.	It is easy to learn PDM/ *Ia adalah mudah untuk belajar PDM.*	1	2	3	4	5

4.	I easily remember how to use PDM. *Saya mudah ingat bagaimana untuk menggunakan PDM.*	1	2	3	4	5
5.	The information provided by PDM is easy to understand. *Maklumat yang diberikan oleh PDM adalah mudah difahami.*	1	2	3	4	5
6.	I found PDM simple to use. *Saya mendapati PDM mudah untuk digunakan.*	1	2	3	4	5
Reliability/ *Kebolehpercayaan*						
1.	PDM is trustworthy /*PDM boleh dipercayai.*	1	2	3	4	5
2.	PDM is accurate in identifying my exact location. *PDM adalah tepat dalam mengenal pasti lokasi sebenar saya.*	1	2	3	4	5
3.	PDM is accurate in interpreting my voice commands. *PDM adalah tepat dalam menafsirkan arahan suara saya.*	1	2	3	4	5
4.	PDM has all the functions I expect it to have. *PDM mempunyai segala fungsi yang saya mengharapkan ia mempunyai*	1	2	3	4	5
EFFICIENCY/ *KECEKAPAN*						
Ease of Use/ *Kemudahan Penggunaan*						
1.	I can use PDM without written instructions. *Saya boleh menggunakan PDM tanpa arahan bertulis.*	1	2	3	4	5
2.	It is easy to make PDM does exactly what I want. *Mudah untuk membuat PDM tidak betul-betul apa yang saya mahu.*	1	2	3	4	5
3.	It would be easy for me to become skillful at using PDM. *Ia akan menjadi mudah bagi saya untuk menjadi mahir dengan menggunakan PDM.*	1	2	3	4	5
4.	I can use PDM successfully every time. *Saya boleh menggunakan PDM berjaya setiap kali.*	1	2	3	4	5
5.	Using PDM is effortless. *Menggunakan PDM adalah tanpa tenaga.*	1	2	3	4	5
6.	Using PDM is sufficiently easy. *Menggunakan PDM cukup mudah.*	1	2	3	4	5
Safety/ *Keselamatan*						
1.	It is sufficiently easy to operate PDM with one hand. *Cukup mudah untuk beroperasi PDM dengan satu tangan.*	1	2	3	4	5
2.	PDM is safe to use without causing harm. *PDM adalah selamat untuk digunakan tanpa menyebabkan kemudaratan.*	1	2	3	4	5
3.	It is safe to use PDM while performing rituals of Hajj. *Ia adalah selamat untuk digunakan PDM ketika melaksanakan manasik haji.*	1	2	3	4	5
4.	PDM is suitable to use in a crowded environment like Hajj. *PDM adalah sesuai untuk digunakan dalam persekitaran yang sesak seperti haji.*	1	2	3	4	5
Flexibility/ *Fleksibiliti*						
1.	It is easy to move from one part of a task to another. *Ia adalah mudah untuk bergerak dari satu bahagian satu tugas yang lain.*	1	2	3	4	5
2.	I do not notice any inconsistency as I use PDM. *Saya tidak melihat apa-apa yang tidak konsisten seperti yang saya gunakan PDM.*	1	2	3	4	5

3.	The interface of PDM is consistent with other products I have used. *Antara muka PDM adalah konsisten dengan produk-produk lain yang saya telah digunakan.*	1	2	3	4	5
4.	In PDM, the control matches user skills. *Dalam PDM, kawalan perlawanan kemahiran pengguna.*	1	2	3	4	5
5.	The visual representation in PDM is consistent with familiar conventions *Perwakilan visual di PDM adalah selaras dengan konvensyen biasa.*	1	2	3	4	5
6.	The wording in PDM is familiar. *Susunan kata dalam PDM biasa.*	1	2	3	4	5
7.	PDM provides zooming for display expansion. *PDM menyediakan zoom untuk pengembangan paparan.*	1	2	3	4	5
Accessibility/ *Kebolehan Mencapai*						
1.	It is easy to find the information I need in PDM. *Mudah untuk mencari maklumat yang saya perlukan di PDM.*	1	2	3	4	5
2.	It is easy to navigate the PDM. *Mudah untuk mengemudi PDM itu.*	1	2	3	4	5
3.	The organization of the PDM menus is sufficiently logical. *Penganjuran menu PDM adalah cukup logik.*	1	2	3	4	5
4.	The buttons are sufficiently easy to locate. *Butang yang cukup mudah untuk mencari.*	1	2	3	4	5
5.	The sequence of PDM screens is clear and logical. *Rentetan skrin PDM adalah jelas dan logik.*	1	2	3	4	5
6.	The characters on PDM screens are easy to read. *Watak-watak di skrin PDM adalah mudah untuk dibaca.*	1	2	3	4	5
7.	The terminologies used in PDM are always related to the task. *Istilah yang digunakan dalam PDM sentiasa berkaitan dengan tugas.*	1	2	3	4	5
SATISFACTION/ *KEPUASAN*						
Attitude/ *Sifat*						
1.	I feel I need to have PDM / *Saya rasa saya perlu mempunyai PDM.*	1	2	3	4	5
2.	I feel comfortable using PDM/ *Saya berasa selesa menggunakan PDM.*	1	2	3	4	5
3.	I feel confident using PDM/ *Saya merasa yakin menggunakan PDM.*	1	2	3	4	5
4.	I feel excited when using PDM/ *Saya rasa teruja apabila menggunakan PDM.*	1	2	3	4	5
5.	I would recommend PDM to my friends/ *Saya akan mengesyorkan PDM kepada rakan-rakan saya.*	1	2	3	4	5
Acceptability						
1.	The interface of PDM is attractive/ *Antara muka PDM adalah menari*	1	2	3	4	5
2.	PDM is pleasant to use/ *PDM adalah senang untuk digunakan*	1	2	3	4	5
3.	PDM is wonderful/ *PDM adalah indah.*	1	2	3	4	5
4.	Overall, I am satisfied with PDM/ *Secara keseluruhan, saya berpuas hati dengan PDM.*	1	2	3	4	5

END OF QUESTIONS /*TAMAT SOALAN*

THANK YOU FOR PARTICIPATING! /*TERIMA KASIH KERANA MENYERTAI!*