CONCEPTUAL MODEL OF MOBILE AUGMENTED REALITY FOR ENGAGING HEARING-IMPAIRED MUSEUM VISITORS

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Abstrak

Realiti Luasan Mudah alih (MAR) telah matang dengan ketara sepanjang dekad yang lalu sejak kelahiran sistem multimedia. Ia telah berkembang dari idea konseptual pengalaman realiti luasan kepada aplikasi praktikal sebenar yang digunakan pada telefon pintar. Para penyelidik (MAR) telah memutuskan untuk menggunakan konsep keterlibatan dalam merancang aplikasi MAR bagi menarik minat pengunjung muzium dan memastikan persekitaran pembelajaran yang lebih berkesan. Walau bagaimanapun, kebanyakan aplikasi MAR ini disesuaikan dengan pelawat pendengaran biasa manakala pelawat yang cacat pendengaran (HI) kurang disokong. Ini menjadikan pengunjung HI mengalami pengalaman yang tidak menyenangkan dan akhirnya tidak berpuas hati dengan lawatan mereka ke muzium. Kajian terhadap model konseptual bagi MAR untuk keterlibatan pelawat muzium HI juga adalah kurang. Oleh itu, kajian ini mencadangkan model konseptual bagi MAR untuk keterlibatan muzium bagi HI (MARHIME) dan akhirnya meningkatkan keterlibatan mereka semasa lawatan ke muzium. Bagi mencapai matlamat kajian ini, metodologi penyelidikan sains reka bentuk telah disesuaikan. Kajian ini menentukan unsur-unsur keterlibatan melalui kajian pakar, yang digunakan untuk mereka bentuk model konseptual untuk MARHIME. Di samping itu, prototaip MAR dibangunkan berdasarkan kepada model konseptual dan seni bina MARHIME. Prototaip MARHIME merangkumi model tiga dimensi, video, teks, dan imej untuk menyampaikan maklumat penting mengenai artefak kepada pengunjung muzium HI. Selain itu, aplikasi MARHIME hanya berfungsi di muzium dengan mengimbas persekitaran muzium kerana HI boleh menggunakan MAR sebagai panduan isyarat visual untuk menangkap isyarat aural yang hilang semasa lawatan mereka ke muzium. Kajian ini melibatkan 73 pengunjung museum HI sebagai peserta untuk menilai prototaip MARHIME mengenai pengalaman keterlibatan mereka. Dari hasil penilaian, didapati bahawa prototaip MARHIME dapat memberi keterlibatan kepada pelawat HI semasa lawatan mereka ke muzium. Oleh itu, kajian ini telah menentusahkan satu model konseptual keterlibatan dengan MAR bagi pelawat muzium HI. Model konsep MARHIME juga menyediakan garis panduan untuk membangunkan aplikasi realiti luasan mudah alih terutamanya untuk pengunjung muzium HI. Kajian ini menyumbang kepada keterlibatan pengunjung HI semasa lawatan ke muzium bagi memastikan keterangkuman orang kurang upaya dalam reka bentuk MAR.

Kata Kunci: Realiti luasan mudah alih, Keterlibatan, Cacat pendengaran, Pengunjung muzium.

Abstract

Mobile Augmented Reality (MAR) has matured significantly over the past decades since the birth of multimedia system. It has evolved from the conceptual idea of augmented reality experience to its actual practical applications in use on smartphones. Researchers in MAR have resolved to employ the concept of engagement in designing MAR applications to attract museum visitors' interest and ensure a more effective learning environment. However, most of these MAR applications are tailored to normal hearing visitors while the hearing-impaired (HI) visitors are less supported. This makes HI visitors to go through unpalatable experiences and eventually become dissatisfied with their visit to the museum. Also, there is lack of studies on the conceptual model of MAR for engaging the HI museum visitors. Therefore, this study proposes a conceptual model of MAR for the HI museum engagement (MARHIME) and eventually enhances their engagement during their museum visits. In achieving the aim of this study, design science research methodology was adapted. This study has determined engagement elements through expert review which were used to design the conceptual model of MARHIME. In addition, an MAR prototype was developed based on the MARHIME conceptual model and its architecture. The MARHIME prototype includes three-dimensional models, video, text, and images to deliver salient information of important artefacts to HI museum visitors. Moreover, the MARHIME application may only function in the museum by scanning the museum environment because the HI can use MAR as a visual signal guide in order to catch missing aural signals during their visit to the museums. The study involved 73 HI museum visitors as participants in order to evaluate the MARHIME prototype on their engagement experience. From the results of the evaluation, it was found that the MARHIME prototype was able to engage the HI visitors during their visit to the museum. Therefore, this study has validated a conceptual model on MAR for engaging the HI museum visitors. This conceptual model of MARHIME can be used as guidelines for researchers in understanding the elements of MAR in engaging the HI museum visitors and for developers in assisting the process of designing and developing MAR application for the HI museum visitors. This study contributes to the engagement of HI people during their museum visits to ensure the inclusiveness of disabled people in the MAR design.

Keywords: Mobile augmented reality, Engagement, Hearing Impaired Museum Visitors.

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List of Abbreviations

2D	2 Dimensional
3D	3 Dimensional
ALDs	Assistive Listening Devices
API	application programming interfaces
AR	Augmented Reality
ASL	American Sign Language
AV	Augmented Virtuality
BTE	Behind the Ear
CC	Closed Caption
D	Definitely not relevant
dB	Decibel
DSR	Design Science Research
EFA	Exploratory Factor Analysis
GB	Gigabyte
GHz	Gigahertz
GPS	Global Positioning System
GUI	Graphic User Interface
HCI	Human Computer Interaction
HI	Hearing Impaired
HMD	Head Mounted Display
Hz	Hertz
iTACITUS	Intelligent Tourism and Cultural Information through Ubiquitous Service
ITC	In the Canal
ITE	In the Ear
JPEG	Joint Photographic Experts Group
KMO	Kaiser-Meyer-Olken
M	Maybe not relevant
MAR	Mobile Augmented Reality
MARHIME	Mobile augmented reality for hearing impaired museum visitor engagement
MART	Mobile Augmented Reality Tour
MR	Mixed Reality
MUX	Museum User Experience
OS	Operating system

PCA	Principal Component Analysis
PNG	Portable Network Graphics
QR	Quick Response
R	Relevant
RAM	Random Access Memory
RFID	Radio Frequency Identification
SDH	Subtitle for Deaf and Hard-of-Hearing
SDK	software development kit
SPSS	Statistical Package for the Social Science
SSL	Sum of Squared Loadings
TTS	Text to Speech
TV	Television
UNWTO	United Nations World Tourism Organization
USA	United States of America
UX	User Experience
VR	Virtual Reality
VRC	Video Cassette Recorder

List of Publications

- Baker, E. J., Bakar, J. A. A., & Zulkifli, A. N. (2017). Mobile Augmented Reality Elements for Museum Hearing Impaired Visitors' Engagement. Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 9(2-12), 171-178.
- Baker, E. J., Bakar, J. A. A., & Zulkifli, A. N. Engagement Elements for Mobile Augmented Reality Application. International Journal of Engineering and Technology (IJET). ISSN : 2227-524X.(2018)
- Baker, E. J., Bakar, J. A. A., & Zulkifli, A. N. (2018, September). Mobile augmented reality for hearing impaired museum engagement (MARHIME): A conceptual model. In AIP Conference Proceedings (Vol. 2016, No. 1, p. 020031). AIP Publishing
- Baker, E. J., Bakar, J. A. A., & Zulkifli, A. N. (2017, October). Elements of museum mobile augmented reality for engaging hearing impaired visitors. In AIP Conference Proceedings (Vol. 1891, No. 1, p. 020033). AIP Publishing.
- Baker, E. J., Bakar, J. A. A., & Zulkifli, A. N. (2018, March). Conceptual Model Elements for Mobile Augmented Reality for Engaging Hearing-Impaired Museum Visitors. In SMMTC Postgraduate Symposium 2018 (p. 86).
- Baker, E. J., Bakar, J. A. A., & Zulkifli, A. N. (2018, September). Mobile augmented reality for hearing impaired museum engagement (MARHIME): A conceptual model. In AIP Conference Proceedings (Vol. 2016, No. 1, p. 020031). AIP Publishing.
- Baker, E. J., Bakar, J. A. A., Zulkifli, A. N., & Omar, A.,C. Development of the MARHIME App Embedding the Mobile Augmented Reality for Hearing-Impaired Museum Visitors Engagement Model. International Journal of Innovative Technology and Exploring Engineering, (IJITEE) ISSN: 2278-3075, Volume-8 Issue-8S, June 2019.

CHAPTER ONE
INTRODUCTION

1.1 Overview

Augmented reality (AR) is a multimedia system which involves the introduction of virtual objects into the real environment in order to obtain an augmented environment. This augmented environment is the direct superimposition of physical objects and computer-reproduced objects. The knowledge of AR systems is influencing human-computer interaction with today's proliferation of Mobile Augmented Reality (MAR) applications, and the provision of social support within many domains ranging from health care to tourism. MAR applications benefits include mobility, handy, wearability, environment-awareness, multi-modal, flexible usage, visual alerts and reminders which have been influencing social interaction positively (Olsson, Lagerstam, Kärkkäinen & Väänänen-Vainio-Mattila, 2013). Despite the fact that MAR applications have enormous benefits to human beings, both socially and industrially, however, there are still few technical limitations of these applications such as outdoor and portability use, depth perception, tracking and calibration, user experience, overload, and over-reliance (Van Krevelen & Poelman, 2010). Out of these limitations, many studies have focused on the user experience because it is believed to promote MAR social acceptance. This has made researchers such as Ali, Koleva, Bedwell, and Benford, (2018); Lindgren, Tscholl, Wang and Johnson (2016); Ibáñez, Di Serio and Villarán (2014); Di Serio, Ibáñez and Kloos (2013); Dede (2009) to investigate on ways to increase user engagement and learning in MAR. Engagement depicts the act of raising users' attract and interest in a pleasing manner in order to get their attention to performing activities at the museums (Di Serio et al., 2013). Nevertheless, there is still lack of study that explores MAR user engagement

among the Hearing-Impaired (HI) people, especially among HI museum visitors and tourists. It is unfortunate that the HI visitors are having huge difficulties not only with accessibility issues within the museum but also with engagement experience (Goss, Kollmann, Reich, & Iacovelli, 2015). Likewise, little is known about how people with HI can have an engaging experience within museums. It is found there is lack of studies focuses on engagement for HI people particularly during museum visits. Hence, this study aims to contribute a conceptual model of engagement with MAR for HI visitors in museums.

1.2 Museum Visit MAR and HI People

Previously, many studies have explored augmented reality (AR) such as He, Wu, and Li (2018); Tscheu and Buhalis (2016); Fiore, Mainetti, Manco and Marra (2014); Haugstvedt and Krogstie (2012). AR is a concept that supplements the real-world environment with computer-generated elements which create a live direct or indirect environment (Wu, Lee, Chang, & Liang, 2013). This environment is based on an idea known as mediated reality which makes use of graphics, sound, GPS and video. The concept has been used similarly in various domains such as advertising (Löchtefeld, Böhmer, Daiber, & Gehring, 2013), education (Wu et al., 2013), engineering (Côté, Trudel, Desbiens, Giguère, & Snyder, 2013), edutainment (Shuo, Kim, Choi, & Kim, 2015), industrial manufacturing (Nee, Ong, Chryssolouris, & Mourtzis, 2012) and medicine (Lee et al., 2013). These domain applications have produced supportive aids technologies and devices which enhance users' reality perceptive in order to make life better for them. In the nutshell, AR reproduces a real-world scenario with a simulated environment, conventionally real-time and semantic context.

Likewise, the concept has been implemented in many studies to provide support for disabled people as seen in the work of McMahon, Cihak and Wright (2015); Lin and Chang (2015); Lin et al. (2015); Tang et al. (2015); Colpani, Homem and Rodrigo (2015); Stuart, Christensen, Chen, Kim and Chen (2013). However, most of these studies focus on physical activities only. Also, none of these studies specifically explore AR as a support or guide in museums for HI people. Furthermore, it has been advocated that there is a need for AR content to replace and remedy the absent senses for some disabled individuals (Alkhamisi & Monowar, 2013). It is pointed out that MAR can be used to support disabled individuals as an alternative instrument to their senses. For instance, HI people can use MAR to enhance their visual abilities. On the other hand, the HI can use MAR as visual signals guide in order to catch missing aural signals during their visit to the museums (Carmigniani & Furht, 2011). In addition, it has been discovered in the literature that most museum MAR applications are not designed to support HI visitors (McLean, 2015; Harmon, Waelde, & Whatley, 2014; Pearn, Buhalis, & Darcy, 2011). Hence, this study aims to construct a conceptual model of engagement with MAR for HI people during their visits to the museums.

1.3 Problem Statement

There are many studies in the vast literature that investigated a conceptual model of users' engagement within technology domains such as E-Shopping, News Online (O'Brien and Toms, 2008); (O'Brien & Toms, 2010); (O'Brien, 2017), Multimedia (Webster & Ho, 1997), Games (Wiebe et al., 2014); (Permadi & Rafi, 2015); (Rutledge & Neal, 2012), but all these studied the usage by normal hearing people. There is a growing interest among MAR researchers to enhance museum visitors'

experiences in learning, engagement, enjoyment and personalized manners. This can be seen in previous studies of interactive museum MAR applications such as Jiang et al. (2017); Scarles, Casey and Treharne (2016); Pérez-Sanagustín, Parra, Verdugo, García-Galleguillos, and Nussbaum (2016); Chang et al. (2014); Wakkary et al. (2009); Roes, Stash, Wang, and Aroyo (2009); Szymanski et al. (2008). These aforementioned studies have indicated that museum MAR applications are capable of providing the needed support for visitor-driven guidance in order to access the museum in a learnable fashion. However, Chang et al. (2015); Pollalis, Fahnbulleh, Tynes, & Shaer, (2017); Pollalis et al. (2018) mentioned that most of the existing museum MAR applications were unable to adequately engage users. The issue of user engagement is an important concept in museum visits because engagement enhances user enjoyment, learning and acceptance (Hatala & Wakkary, 2005); (Bell, 2002); (Pollalis et al., 2018). There is lack of studies for HI in the museum especially using MAR, therefore, this study determines of engagement for HI at the museum.

In addition, most of the existing MAR applications are tailored for the usage of normal hearing people. These include Intrigue at the museum by Xhembulla, Rubino, Barberis and Malnati (2014); Domus by van der Vaart and Ray (2014); ARtLens by Pollalis et al. (2018) and ARtSENSE by Damala et al. (2012), whereas there are limited studies that explore HI user engagement within the vast literature. Thus, it is imperative to design MAR applications that may engage the HI people during their visit to the museums. This is because most of the HI visitors do not experience engagement at the museums due to the improper medium of information dissemination (Zajadacz & Szmal, 2017; Chikuta, Kabote, & Chikanya, 2017; Cranmer, Jung, Dieck, & Miller, 2016). The HI usually have the problem of comprehension at the museums due to their lack of audio senses which give them

unpalatable experiences (Chikuta et al., 2017; Lovelock, 2015; Vila, Darcy, & González, 2015).

Although few studies in the literature explored issues with museum HI visitors such as Jankowska et al. (2017); Zajadacz and Szmal (2017); McLean (2015); Pearn, Buhalis and Darcy (2011); Goodall (2006); Goodall, Pottinger, Dixon, and Russell (2004), many of these previous studies did not provide a supportive solution that can enhance the HI users' engaging experience in the museums. Most of these studies majorly focus on accessibility issues such as supports in terms of infrastructure inside the buildings, and movement accessibility in and around the sites. There is a need to explore MAR as a supportive and assistive platform that can engage HI visitors' during their visits to the museums in order to ensure a proper learning environment for all visitors (Chikuta et al., 2017; Angkananon, Wald, & Gilbert, 2016; Betsworth, Bowen, Robinson, & Jones, 2014). Also, these studies lack engagement elements that specifically support HI during their visit to the museums.

Therefore, there is a need to identify engagement elements to support HI visitors. This study identifies the engagement elements which are subsequently used to propose a conceptual model of engagement with MAR for HI museum visitors. These engagement elements would create AR supported aids and devices which will remedy the absence of hearing senses in HI individuals. Likewise, these elements may also enhance the MAR which will improve HI user experience during their visits to the museums.

1.4 Research Questions

From the above-discussed problem statement, the following questions will be used to guide this study:

i. What are the elements of MAR for engaging the HI museum visitors?

ii. How to develop the conceptual model of MAR for engaging the HI museum visitors based on the identified elements?

iii. How to validate the conceptual model of MAR for engaging the HI museum visitors through expert review and prototyping?

1.5 Research Objective

The main aim of this study is to propose a conceptual model of engagement with MAR for HI museum visitors. The main aim is subdivided into three objectives as follows:

i. To identify the elements of MAR for engaging the HI museum visitors.

ii. To develop a conceptual model of MAR for engaging the HI museum visitors based on the identified elements.

iii. To validate the conceptual model of MAR for engaging the HI museum visitors through expert review and prototyping.

1.6 Scope of Study

The domain of this study focuses on the construction of a conceptual model of MAR for engaging HI museum visitors. The conceptual model was constructed based on the identified elements of engagement of MAR which were adapted with two theories:

engagement and museum. Due to lack of studies focusing on engagement for HI people, particularly during their museum visits and also most of the HI visitors do not experience engagement at the museums because of the improper medium of information dissemination, thus the MARHIME prototype was developed utilizing MAR for engaging HI museum visitors.

Furthermore, the participants for this study consist of only the hearing loss group of the HI people. This is because this group that may be supported with hearing aids and assistive devices. Also, this study was conducted in one of the Iraq ancient museums. This museum is important because it contains many artefacts which reflect the history of Iraq and reflects the history of humanity in general.

Moreover, the MARHIME prototype may only function in the museum by scanning the museum environment because the HI can use MAR as a visual signal guide in order to catch missing aural signals during their visit to the museums. The MARHIME prototype was developed using Unity 3D, Vuforia software and C++ was used as the programming language. In addition, the Arabic language was used in the design and development of the MARHIME prototype since the evaluation was conducted in Iraq and the participants were HI Iraqis who use Arabic as the language of communication.

1.7 Operational Definition

Augmented Reality (AR): A computer science field which is a concept that supplements the real-world environment with computer-generated elements which create a live direct or indirect environment. This environment is based on an idea known as mediated reality which makes use of graphics, sound, Global Positioning System (GPS), and video

Mobile Augmented Reality (MAR): This is a type of AR whose platform is based on a smartphone or handheld devices.

Hearing Impaired (HI): An incident of loss of hearing ability which means not receiving acoustic sound by the ear.

Museum: A place of blend of tourism, culture, visit, history, and natural resources meant to preserve the rich knowledge and information of indigenous communities.

Engagement: A quality of user experience with technology which is measured using a multidimensional construct.

Conceptual Model: A conceptual model is the graphical application's representation that is expected to help researchers and developers to fully understand the unimagined systems of new technology better and to provide ideas for further research in this emerging field.

1.8 Thesis Organization

There are seven chapters within this thesis which provides the needed support for the study. The content of these chapters are as follows:

Chapter 1: Introduction

This chapter contains the introduction, which is followed by a brief understanding of issues confronting the HI during their visit to the museum. Likewise, the chapter presents the study's problem statement, research questions, research objectives and research scope. Furthermore, this chapter also provides the operational terminologies that are used in the study.

Chapter 2: Literature Review

This chapter reviews literature related to the HI, tourism, museum, MAR, engagement design principle. The underpinning theories and models that are used to pivot this study are also discussed in the chapter.

Chapter 3: Research Methodology

This chapter presents the research methodology used to achieve the three research questions that are formulated in this chapter. It covers the various study phases and its stepwise activities at each phase in order to explicitly achieve all the research objectives.

Chapter 4: Conceptual Model of Mobile Augmented Reality for Engaging Hearing-Impaired Museum Visitors

This chapter discusses the development of the proposed conceptual model of mobile augmented reality (MAR) for engaging HI museum visitors (MARHIME). It explains the development and validation phase of the conceptual model, which include focus group and expert review of the proposed elements for the conceptual model.

Chapter 5: Prototype Development and Evaluation of MAR for Engaging HI museum visitors

This chapter presents the development of the MARHIME prototype. It highlights the functional and technical requirements needed to be taken into consideration in developing the prototype. It also discusses the embedding elements from the conceptual model into the prototype.

Chapter 6: User Evaluation

This chapter discusses the results of the evaluation of MARHIME. A pilot study validation was conducted, to investigate the limitations of the research instrument prior to the main evaluation analysis. The findings from these analyses are discussed in this chapter.

Chapter 7: Conclusion

This chapter provides a conclusion for this study. It presents answers to the research questions and reviews the research objectives. In addition, the contributions, limitations and recommendations of this study are also presented.

1.9 Chapter Summary

From this chapter, the major issues and challenges facing the HI community were established which led to the problem statement, research questions, research objectives, research scope and summary of this research study. The next chapter will further strengthen the study by linking it with other previous studies in the related domains.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The main focus of this chapter is to review previous studies related to MAR for HI at the museum. This chapter begins with a discussion on AR and its various assistive technology applications, especially within Mobile Augmented Reality (MAR) at the museum and conceptual model for MAR. Users' experiences within the museum environment in relation to the concepts of engagement are also presented. It further discusses in detail the concept of engagement as related to mobile applications for Hearing-Impaired (HI). Description and issues surrounding HI community with various assistive technologies used by the community are also presented. Subsequently, this chapter debates the relevance of closed captioning and subtitle for HI with various assistive innovations developed to support and aid their concerns. Finally, this chapter provides a theoretical underpinning for this study which explores two different theories in order to better understand the study. A summary is presented in order to recap the literature review.

2.2 Augmented Reality (AR)

Augmented Reality (AR), a computer science field which is seen as a subfield of Mixed Reality concept. The study by Milgram and Kishino (1994) clarified many misconceptions on the definitions and classification of AR. In their study, definition and classification were evolved based on Reality-Virtuality Continuum which is shown in Figure 2.1.

Figure 2.1. Reality - Virtuality Continuum by Milgram and Kishino (1994)

On the far-left side of the continuum is the real environment which is the natural physical environment where human interacts with real and physical quantities within their natural space. On the far-right side of the continuum is the virtual environment which is the world of computer-generated images or unreal physical quantities interaction. The major difference in these two is that the virtual environment is the total immersion of computer-generated images, whereas real environment deals with non-computer-generated object interactions. In between these two worlds (real and virtual environments) are two distinct environments known as AR and Augmented Virtuality (AV). AV involves the introduction of real life into the virtual environment as pointed out in Ternier, Klemke, Kalz, & Specht (2012). On the other hand, AR involves the introduction of virtual objects into the real environment as used in Li et al. (2018); Fedosov et al. (2016); Rassweiler et al. (2015). These two environments (AV and AR) are known as Mixed Reality (MR) which is the mixture of virtuality and reality (a mixture of real and virtual objects). Based on this continuum, AR has been getting more attention within the last few years due to its nature (Li et al., 2018; Barsom, Graafland, & Schijven, 2016). Based on Figure 2.2 the 3D object is being displayed on the screen of the mobile device, whenever the camera scanned the marker in the AR environment. AR applications tend to run on mobile or wearable devices. A Smartphone consists of all hardware requirements of AR. This means that

the hardware required to implement an AR application is wearable (Theodorou, 2018).

Figure 2.2. Augmented Reality Environment View (Chavan, 2014)

AR is a simulated environment where physical (unreal and lifeless) and real-life entities are integrated (augmented) together with the aid of computer-generated sensory. It is similar to mediated reality which uses the concept of modification of real-life and enhanced by technology to produce the desired reality perceptions. The computer-generated virtual reality is real-time simulations and replaces the previous real-life scenarios. The integration of object recognition and computer vision into the simulated environment will make it interactive and digitally manipulative. In this study, AR is defined as the technology that overlays digital information in the forms of image, text, video, and 3D model into the real-time environment in order to enhance the user experiences.

There are two different types of optical tracking systems for AR; one is marker-based AR and the other is Markerless AR. Marker-based AR can be implied that a marker is used as a trigger while Markerless AR can be used without markers (Cheng, Chen & Chen, 2017). For marker-based AR, the marker can either a 2D image such as QR codes or barcodes to produce a result when it is sensed by a reader, typically a camera on a mobile phone with visual features that are easy to be extracted or natural objects directly in the real environment (Damala et al., 2008). Instead of tracking features of a marker, Markerless AR comprises of a general system that tracks the position and orientation of a camera observing a scene without visual markers such as GPS, radio frequency identification and sensor technology to control the relative position relationship between virtual objects and the real world as shown in Figure 2.3.

Figure 2.3. Markerless Augmented Reality Environment View (Abhishekh, Reddy, Kumar & Rajeswarappa, 2013)

Figure 2.4 shows the marker-based Augmented Reality (recognition based) where the camera displays the visual of the surroundings, and the software on the device

recognizes a particular marker which then triggers the software to provide an output. Simple outputs may be playing a short video, displaying a 3D model or an image file to showcase the AR animation tutorial with interactive visual effect (Cheng, Chen & Chen, 2017). Therefore, this study has used AR markers comprising of 2D images since the marker-based AR is suitable for indoor use (Damala et al., 2008). In addition, most museums normally have dim lighting condition which probably hinder the camera to recognize the object as markerless (Olwal & Henrysson, 2007). Therefore, in this study, marker-based AR has the advantage of providing faster response to the camera compared to markerless AR.

Figure 2.4. Marker of Augmented Reality Environment View (Theodorou, 2018)

2.2.1 Augmented Reality Applications

The application of AR is enormous within the vast literature. For instance, AR is used to provide a solution to the building of manufacturing and industrial prototypes. This is done to reduce the high cost of industrial prototypes or prevention of human exposition to the harmful situation during the prototype's testing. AR prototype saves companies considerable amount of time and money as prototypes would be able to be

changed quicker and created at a lower cost since they would no longer involve materials. Likewise, AR has been used in various domains like archaeology, tourism, gaming, education and others. Based on Figure 2.5 the AR in the tourism domain is a system that combines virtual content and real-world content that can provide the tourist with information in real time environment.

Figure 2.5. AR Application in the Tourism Domain (Haugstvedt & Krogstie, 2012)

Furthermore, AR has been used to reimagine archaeological landscapes and notation as presented in studies like Eve (2012); Swan and Gabbard (2005). It has also revolutionized the manner that architectural practices are implemented as discussed in Hill, MacIntyre, Gandy, Davidson, and Rouzati (2010); Webster, Feiner, MacIntyre, Massie, and Krueger (1996). Furthermore, AR application is vital for product previews, integration of print and video marketing in the commerce domain (Lu & Smith, 2007; Arrasvuori, 2006). Table 2.1 summarizes the various domains that AR applications exist.

Table 2.1

Summary of AR Application in Various Domains

No	Domain	Usage	References
1	Archaeology	AR is used in modern landscaping, enabling archaeologists to formulate conclusions about site placement and configuration.	Westin, Foka and Chapman (2018); Eve, (2012); Swan and Gabbard (2005)
2	Architecture	AR aids in visualizing building projects such as sight-seeing.	Hill, MacIntyre, Gandy, Davidson, and Rouzati (2010); Webster et al. (1996)
3	Commerce	Product previews, integration of print and video marketing.	Lu and Smith (2007); Arrasvuori (2006)
4	Construction	Visualize georeferenced construction sites, underground structures, cables and pipes.	Le et al. (2015); Wang, Truijens, Hou, Wang and Zhou, (2014)
5	Education	Complements curriculum by superimposing text, graphics, video and audio into students' real time environment.	Dunleavy and Dede (2014); Lee (2012); Lemole et al. (2007)
6	Emergency management or search and rescue	Useful in public safety situations - from super storms to suspects at large.	Tsai et al. (2012); Nevatia et al. (2008); Kamat and El-Tawil (2007)
7	Gaming	AR permits gamers to experience digital gameplay in a real-world environment.	Ortiz-Catalan et al. (2014); Nilsen, Linton and Looser (2004)
8	Industrial design	Permits industrial designer experience and operational testing.	Park, Lim, Seo, Jung, and Lee (2015); Ng, Wang, Ong, and Nee (2013); Nee, Ong, Chryssolouris and Mourtzis (2012)
9	Medical	AR provides the surgeon with information and virtual X-ray.	Barsom, Graafland, and Schijven (2016); Chaballout, Molloy, Vaughn, Brisson, and Shaw (2016); Vera, Russo, Mohsin, and Tsuda (2014)
10	Beauty	AR is implemented in a smartphone and tablet application for facial beauty such as Makeup Genius.	Rammon Oliveira De Almeida et al. (2015); Buchmann, Violich, Billinghurst, and Cockburn (2004)
11	Spatial immersion and interaction	Digitalize human presence in space and provide a computer-generated model.	Benko, Ofek, Zheng, and Wilson (2015); Park et al. (2015)

Table 2.1 Continued

No	Domain	Usage	References
12	Military	As a networked communication system that renders useful battlefield data, soldier's navigation and battlefield perspective.	Calhoun, Draper, Abernathy, Delgado, and Patzek (2005); Yeh and Wickens (2001)
13	Navigation	As effective navigation devices such as automobile's windshield, weather, terrain, road conditions and traffic information and alerts to potential hazards.	Lorenz et al. (2015); Dixon et al. (2013); Kolbe (2003)
14	Office workplace	Conferences with real and virtual participants.	Osorio-Gómez, Viganò, and Arbeláez (2016); Stafford et al. (2009)
15	Sports and entertainment	Provides see-through and overlay augmentation through tracked camera feeds for enhanced viewing by the audience.	Bala et al. (2015); Baudisch et al. (2014); Lee, Woo, and Lee (2005)
16	Television	Such as TV Weather visualizations and interactive TV.	Caldera-Serrano and León-Moreno (2015); Balcisoy and Thalmann (1997)
17	Translation	AR systems can interpret foreign text on signs and menus and in a user's augmented view, re-display the text in the user's language.	Rogowski, Wu and Clark (2015); Jain, Manweiler, and Roy Choudhury (2015); Lester (2013)
18	Tourism and sightseeing	To enhance tourists' real time experience displays location and its features with comments made previously by tourists. Simulate historical events, places, and objects.	Ali et al. (2018); Hassan and Jung (2016); Pendit, Zaibon, and Abubakar (2015); Chen, Chang, and Huang (2014); Guttentag (2010); Noh, Sunar, and Pan (2009)

Based on the above applications, it has been discovered that AR has been majorly deployed for the purpose of learning. Learning based AR applications cover various applications ranging from game, historical, cultural, museum guidance and sightseeing. Meanwhile, in the advent of smartphones and mobile devices, AR smartphone applications were developed known as MAR technology. The next section discusses more on the design and technology of MAR applications generally and MAR in museum particularly.

2.2.2 Museum MAR

MAR is a form of AR in portable platform which allows users to interact with the augmented environment without being distracted. It allows the MAR user to be in focus, movable and freely engage with the augmented environment to achieve the desired objective. This same scenario is intended for museum MAR because museum visitors need to be focused and moving in order to interact with the augmented environment. As pointed out by Kenteris, Gavalas and Economou (2011), there are four major classes of museum mobile technology namely: mobile phone navigational system, mobile guide applications, web-based applications and web-to-mobile applications. The first class is the mobile phone navigational systems which make use of maps to provide guidance for museum visitors using interactive platforms like tablet and phone (Lin & Chen, 2015). Similarly, mobile guide applications generally make use of mobile communication devices to provide museum visitors with information (Linge, Booth & Parsons, 2016; Wu, 2016). On the other hand, web-to-mobile applications utilize the website to provide museum visitors' information using a combination of website and mobile online applications (Othman, Young, & Aman, 2015). Web-based applications are similar to the web-to-mobile system, where the applications utilize only website browser and display the information on a mobile platform (like phones and tablets) (Sakkopoulos et al., 2015). Out of the four aforementioned museum mobile technologies, mobile guide applications are mostly used especially in AR environment. This class of technology is commonly used because of its interactive and movable nature that makes it easier for museum visitors to focus. This is why most museum applications are based on this class. Table 2.2 depicts the selected mobile applications in the museum domain.

Table 2.2

Selected Museum Applications

No	Model	Class	Reference	Description	Limitation
1	Museum Tourist Experience	Web-based application	Jung, Dieck, Lee, and Chung (2016)	Visitor's experience in a mixed environment by combining both VR and AR.	Focus only on economic factors
2	Service oriented MAR architecture for multiple applications	Web-based application	Rattanarungrot, White, and Jackson (2015)	Support for content acquisition and utilization of the third-party digital media contents on a real scene.	A web-based application that lacks interactive media.
3	Enjoyable Informal Learning MAR	Mobile guide application	Pendit, Zaibon, and Bakar (2014a)	Enjoyable Informal Learning Mobile augmented reality.	Focus on enjoyment and learning without providing assistive support to any target group.
4	Mobile Augmented Reality Tour (MART)	Web to mobile application	Yovcheva, Buhalis, and Gatzidis, (2013)	The application provides context-awareness and the information provision about the artefact in the museum.	Information awareness without interactive media and assistive support
5	TechCoolTour	Web to mobile application	Wachelka (2013)	Augmented 3D reconstruction, 3D virtual character, video, 360 degrees panorama with heritage site.	Non-interactive and engagement not considered
6	Framework and Data Flow of AR-based on-site Tour Guide	Mobile Phone Navigational System	Seo, Kim, and Park (2011)	Based on a framework that contains data flow of application which consists of two agents, the contextual management agent and map management agent.	The framework only provides tour guide flow and lack interactive media
7	Architecture System of Sutoon-Hoo Mobile Augmented Reality	Web-to-mobile app	Angelopoulou et al. (2011)	Uses architecture system and divided into two namely; initialization and object categorization by involving components such as object assignment, inventory, and museum database.	The content structure was not well defined and mainly performs as a tour guide.

Table 2.2 Continued

No	Model	Class	Reference	Description	Limitation
8	Intelligent Tourism and Cultural Information through Ubiquitous Service (iTACITUS)	Web-to-mobile application	Kim and Park (2011)	Superimposed environment annotated landscape, and spatial acoustic overlays to present the AR information on a smartphone platform.	Interactive but not assistive support
9	MobiAR	Mobile guide application	Marimon et al. (2010)	MobiAR is an Android service platform for tourist information based on AR, which allows users to browse information and multimedia content about a city through their own mobile devices.	Static application with no interaction platform
10	Mobile Guides Museum	Mobile Phone Navigational System	Damala, Cubaud, Bationo, Houlier, and Marchal (2008)	AR-enabled mobile multimedia museum guide designed and implemented for the Museum of Fine Arts in Rennes, France.	No interactive platform
11	AR guided systems in museums	Mobile guide application	Hammady & Temple (2017)	A communication model which would work as a roadmap building AR guidance system	Focused on AR with games elements in the museums to about educate visitors the history and the culture

Most of these mentioned studies addressed issues of formal and informal learning, however, little attention is given to user engagement which might be one of the rationales for failures of existing museum MAR applications (Chang, 2015). The issue of users' engagement is important in a museum visit because engagement enhances users' entertainment, learning, and acceptance which have a direct influence on the visitors' experiences (Hatala & Wakkary, 2005). Additionally, none of these studies specifically focus on the HI visitors while most of the studies in the vast literature majorly were targeted towards normal hearing people. Likewise, the most used museum mobile technology is the mobile guide application because it provides detail information and learning platform for users. Hence, this study explores the

MAR application as one possible way for HI visitors' engagement at the museum. Next section explores the concepts and issues related to the user experience during their visit to museum sites.

2.3 Conceptual model

A conceptual model is a high-level description of how a system is organized and operates (Johnson & Henderson, 2002). A conceptual model can be defined as an abstraction that outlines what the developer can do with an application or software and what concepts are needed to understand how to interact with it (Preece et al., 2007). The proposed conceptual model is the graphical application's representation that is expected to help researchers and developers to fully understand the unimagined systems of new technology better and to provide ideas for further research in this emerging field (Leppaniemi & Karjaluoto, 2005). The purpose of any conceptual model is the representation of the structure for the system entities (concepts) and the relationships among those entities (Ganga, 2009; Hendriks, Schiffelers, Hüfner & Sonntag, 2011; Rad & Jabbari, 2012). In other words, it shows a general representation of salient features with various applications.

2.3.1 Conceptual model of MAR

The previous section defines and elaborates the conceptual model. This section covers related studies pertaining to four MAR conceptual models. For instance, Pendit (2015) explores the conceptual model that has been proposed to guide the development of MARCHSTEIL as shown in Figure 2.6. The model consists of three main components: MAR technology, enjoyable informal learning, and the cultural heritage site.

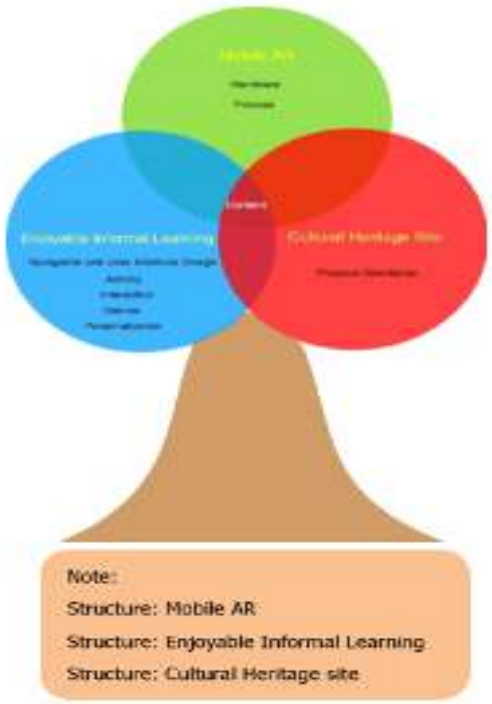


Figure 2.6. MARCHSTEIL Conceptual Model

The AR@Melaka prototype was designed as shown in Figure 2.7 to validate the conceptual model. The contents include profile, map, audio and multiple-choice quiz of the Melaka heritage sites.

Figure 2.7. Snapshot of AR@Melaka prototype

The results showed that MARCHSTEIL was easy, useful, fast and helpful to the visitors in gaining knowledge and supporting enjoyable informal learning. In addition, it helps the researchers to shape the background knowledge in the area. Unfortunately, with all the rich features that are provided by the MARCHSTEIL prototype, it does not provide engagement for the HI at the museum. Permadi and Rafi (2015), have proposed a conceptual model of the user engagement for MAR games as shown in Figure 2.8. The model comprises of eight attributes of user engagement for mobile-based augmented reality games that can be used by the game designers to design engaging MAR games for the industry and future AR engagement research.

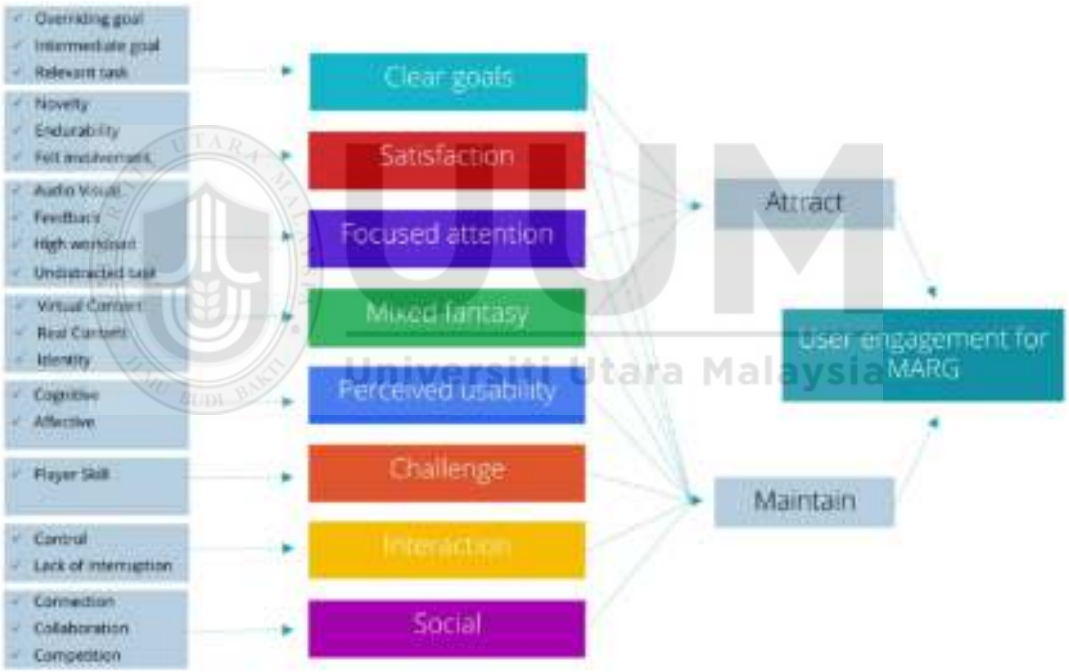


Figure 2.8. MARCHSTEIL Conceptual Model User Engagement Model for Mobile-based AR Game.

The application as shown in Figure 2.9 was developed to validate the conceptual model. The results showed that the five major elements that affected the user engagement were social, challenge, perceived usability, clear goals and satisfaction (Permadi & Rafi, 2016). Overall, the elements of engagement are useful for the

conceptual model despite it was designed for normal people and used for gaming. Nevertheless, the elements and contents were examined in constructing the proposed conceptual model for engaging the HI museum visitors.

Figure 2.9. Snapshot of User Engagement Model for Mobile-based AR Game application

Another major work that contributed to the proposed conceptual model of this study is the AR query-answering system (AR-QAS) (Lin & Chen, 2015). It was based on mobile cloud-computing in providing the natural language informational navigation services for MAR. Lin and Chen (2015) developed the AR-QAS model by combining the Technology Acceptance Model (TAM), media richness theory, and factors of self-efficacy that can be applied to relevant MAR research as shown in Figure 2.10.

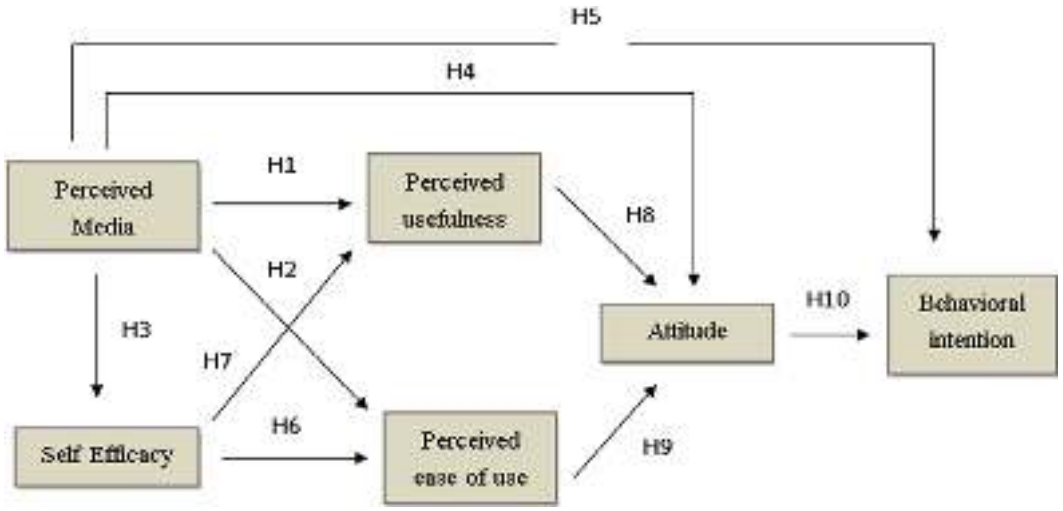


Figure 2.10. AR-QAS Conceptual Model

In validating the AR-QAS conceptual model, the results revealed that the average question classification accuracy of QAS, when combined with the artificial neural network, were found to be positively related to perceived usefulness, self-efficacy, ease of use, use intention and user attitude. Figure 2.11 shows a snapshot of the AR-QAS application.

Figure 2.11. Snapshot of the AR-QAS on the mobile phone.

Furthermore, this study reveals that before new systems are created, designers are suggested in improving the user attitudes during the use of new technologies. However, the contents for the MAR elements are for the normal people and do not present the engagement elements for the HI during the museum visit. However, the provided contents and features were also considered in creating the proposed conceptual model of this study.

Apart from these aforementioned studies, other notable studies that have contributed in validating the conceptual model for the MAR include; Awang et al. (2017) who proposed a conceptual model for designing MAR in learning basic numbers especially for LINUS students. This model consists of cognitive load theory, compensatory approach, intrinsic motivation approach and multimedia elements as an interactive learning method by using MAR system in learning the basic numbers for LINUS students. Figure 2.12 shows the conceptual model in enhancing learning and teaching for LINUS students.

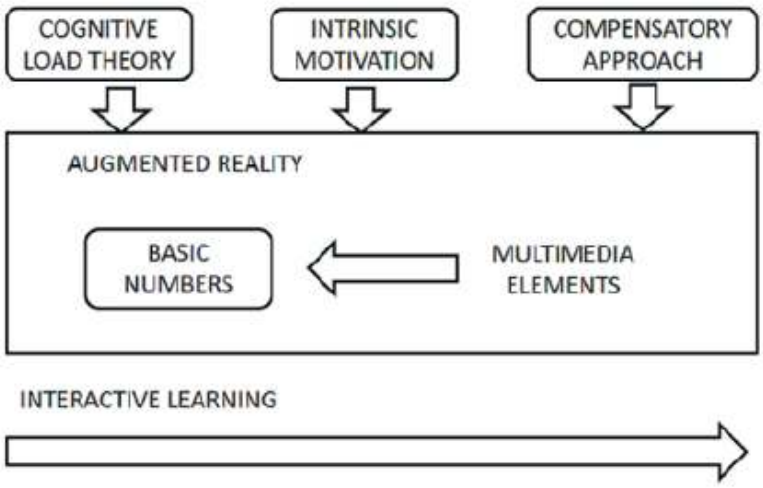


Figure 2.12. Conceptual Model for Designing MAR in Learning Basic Numbers

The conceptual model was validated using the ARBEST prototype as shown in Figure 2.13. It was concluded that the conceptual model was able to provide a more

enjoyable experience and good motivation in learning by using the MAR technology for normal people. Unfortunately, none of the components were related to the engagement elements.

Figure 2.13. Snapshots of the Interface of the ARBEST Prototype for Learning Numbers.

Previous conceptual models used MAR for many purposes such as game, culture, heritage, learning and information navigation without properly measuring the engagement in a museum visit. Furthermore, these conceptual models were developed for normal people. Therefore, there is a need to propose a conceptual model of MAR for engaging the HI museum visitors.

2.4 User Experience

User experience (UX) includes the engagement of user perception and reality with a given application, which depends on their assessment of the application quality, service, and usage (Pérez-Sanagustín et al., 2016). It refers to the users' deep

comprehension and feeling of the application which is rooted in if the application meets their needs, value, abilities, and expectation. This is what informs the users' interaction with the application and forms their decision to further use of the application. User engagement experience demands if they are satisfied with not alone the application design but also its efficiency. The issue of user engagement is very important for any application because it decides user satisfaction. According to Chung, Lee Kim and Koo (2017), the user should be satisfaction can be enhanced by application continuum. They believe the application available for them to meet their information requirements. Users of mobile application who have positive beliefs about its attributes are more likely to feel satisfied with the mobile application. Deng, Turner, Gehling, and Prince (2010) pointed out that, user satisfaction can be enhanced by application quality, information quality, connection quality and perceived usefulness. Besides, the users felt attracted and satisfied as this application triggers the users' curiosity towards unfamiliar or new experiences. Therefore, the users' continuous usage of the application which revolves around the values that derived from the application. This value is usually based on the users' perception and understanding towards the application in meeting their expectations and hence determine will their future recommendations to other users.

2.4.1 Museum User Experience

Based on UX concept, previous studies have equally explored the issue of Museum User Experience (MUX) because it has to do with museum visitors' personal experiences. This experience depicts the feelings and deep comprehension of users during their visit to the museum sites. Their feeling and experience on the museum

are based on factors which have been explored by previous studies. For instance, Lin (2016) explored the concept of user experience on the MAR hand puppet historical museum in Taiwan. Their study introduced iBeacon sensor AR device to improve the museum users' experience within the hand puppetry museum. The conclusion of their study shows that user experience is enhanced with the use of AR and technology generally. Their study pinpoints the need to gamifying museum environment and allows the museum to interact with users in an interesting manner. This same approach was implemented by Seppälä et al. (2016) on Finnish Luostarinmäki Handicrafts Museum. Their findings likewise supported Lin (2016) conclusion that gamification of museum MAR will make the application more interactive and improve MUX.

Similarly, Loy, Zhao and Jun (2015) study focused on improving Gansu Provincial Museum in China which was faced with low patronage of visitors. Their main focus was on how to use digital technology (like AR, MAR, interactive games) to engage users' experience during their visit to the museum. In their conclusion, they were able to implement museum MAR and museum interactive games which positively enhance users' experience and increase patronage of visits to the museum site. This same concept was implemented by Ta, Zhao and Loy (2015) in order to improve MUX in Inner Mongolia Museum China. They developed a mobile digital museum which received overwhelming responses from users because of its positive engagement and interactive factors.

Another major work that contributed to MUX was by Rubino, Barberis, Chio, Xhembulla, and Malnati (2014) which focused on improving UX of visitors to the Palazzo Madama-Museo Civico d'Arte Antica in Torino Italy. They explore on making Museum mobile applications to positively enhance visitors' experience within

the museum. Thus, the study results revealed that easy to use, interaction platform, information dissimilation and informative graphical interface are vital to MUX. Also, Cho, Choi, and Kim (2013) made a similar conclusion in their study on MUX in Gwacheon National Science Museum a national museum in Gwacheon South Korea. They concluded that museum interior design and multimedia applications are vital in emphasizing interaction museum design installation for MUX.

Apart from these studies, other notable studies that have contributed to MUX include Hsi and Fait (2005); Hsi (2003, 2002). For example, Hsi and Fait (2005) used Radio Frequency Identification (RFID) technology to positively enhance MUX beyond the museum walls. Their study was carried out at the Exploratorium museum (which is a hands-on science museum) in San Francisco. In their findings, it has been pinpointed that flexibility and interactive are the factors in enhancing MUX. Another study that had a similar finding and was equally carried out at the Exploratorium museum was conducted by Hsi (2003). The study explored the rationale to improve MUX using nomadic web content design. It was concluded that sense of isolation, integrating real-place and virtual contexts, explanations, exhibit history, social identity and enjoyable factors are vital in MUX. Likewise, Hsi (2002) developed The Electronic Guidebook which is a mobile web resource to improve MUX in Exploratorium museum San Francisco. It was identified that users' engagement and convenience are two important issues to ensure positive MUX. Also, Pollalis et al. (2018) presented ARtLens application in an African Art museum exhibit using AR application to enhance visitor's engagement and learn about artefacts in the museum while keeping the focus on the original artefact. This study provides guides to the visitors in exploring the original artefacts by supplying audio and visual information. In their conclusion, they were able to implement museum AR application to engage the visitors.

The studies mentioned above have shown that technologies have been deployed to enhance positive MUX. This is imperative in order to enable users to accomplish their intentions which include learning, information and fun. Hence, MUX is important to provide the needed guide and users' expectation during their visit to the museum sites. The MUX interaction platform for museum visitors is represented in Figure 2.14.

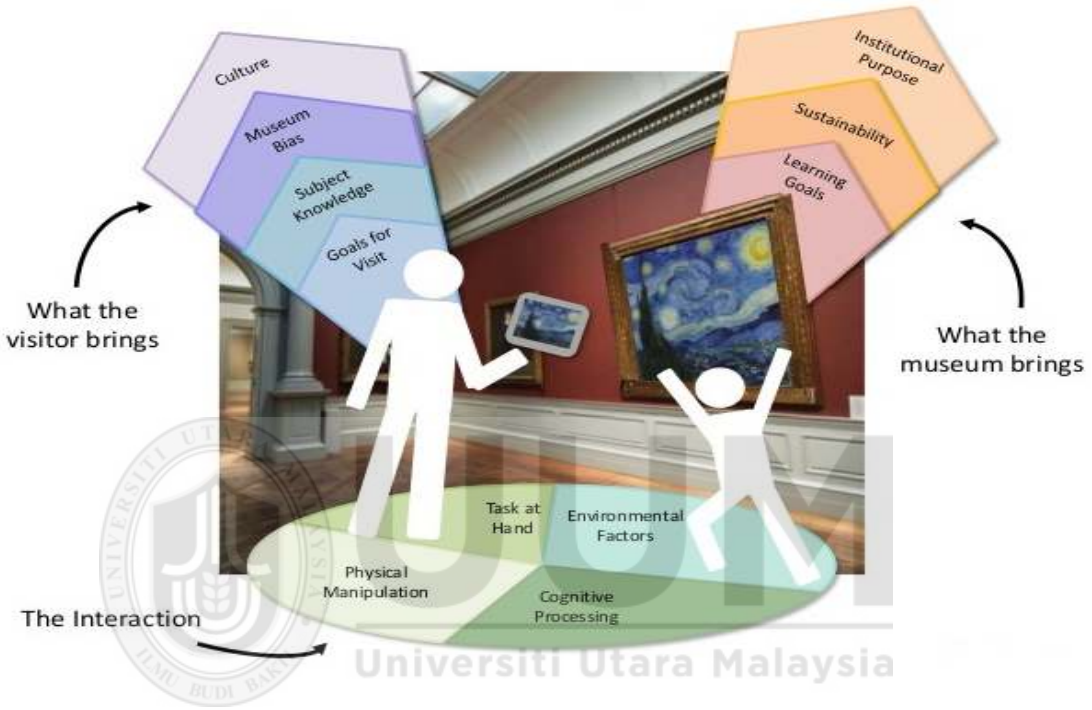


Figure 2.14. MUX Interactions Platform (Kaiser & Treptow, 2013)

The figure above depicts that on one hand, visitors (users) always have purposes behind their visit to a museum and these purposes mixed with their personalities form their expectations. Whereas on the other hand, the museum too has its selling points which are the major purposes of the museum. The point that these two major purposes (users and museum) merge is known as the interaction platform. This platform is very important because it determines the outcome of MUX, either positive or negative. This is why many studies emphasize on the need to reduce distractions, psychological reactance, dissatisfaction and users' information overload during their visit to the museums in order to ensure positive outcomes. Previous studies attempted to engage

users' using digital technology without proper measuring of engagement. Furthermore, the digital technology is developed for normal museum visitors. Therefore, there is a need to identify elements of engagement for museum users' MUX, especially for HI visitors.

2.5 User Engagement

The concept of engagement is widely used in person-centred practice research such as behavioural change intervention and user-centred studies. According to Kearsley and Shneiderman (1998), the concept of engagement involves the decision by the user to undertake tasks (as given by the mobile application) related to his/her interest and competence, practice it continuously by interacting immensely and deeply in order to continue the task with persistence and commitment because of the value attributed to the task. Chapman, Selvarajah, and Webster (1999); Chapman (1997) explained engagement in terms of multimedia perspective as a system that enables users' curiosity, motivation, attention focus, and intrinsic interest. In addition, O'Brien and Toms (2008) pointed out that engagement is the attribute that depicts the quality of user's value, experience and continuity with a technology. According to Permadi and Rafi (2015), the attributes of engagement for MAR games such as satisfaction, usability, and interaction are identified in order to increase user experience in engaging mobile AR games for the industry. Similarly, many scholars have explained mobile application engagement in terms of the users' attitude and behaviour (Du, Venkatakrishnan, Youngblood, Ram, & Pirolli, 2016); (Weston, Morrison, Yardley, & Van Kleek, 2015), long-term retention (Pavliscsak et al., 2016), user's impact (Kosinski et al., 2016), and users' measure of comprehension on an application (Kim, Kim, & Wachter, 2013). In the context of this study, engagement is defined as a

quality of user experience with technology which is measured using a multidimensional construct. In summary, it can be concluded that mobile application engagement is the number of users' encounter and interact continuously with an application.

2.5.1 Engagement Process

The implementation of engaging mobile applications has been the most difficult in the light of novelty, user-felt involvement and endurability. This is because most mobile applications are found not to be endurable which usually will not make users continue with their usage (Ribeiro & da Silva, 2012). In order to fully comprehend the rationale for this issue, there is a need to explore the various dimensions of the concept of engagement in mobile applications. As established in the previous section that engagement involves users' interest and competence the concepts of interest and competence are deeply rooted in the users' feelings and sense-making on the mobile application. The studies of Fredricks, Blumenfeld, and Paris (2004); O'Brien and Toms (2008) shed better light on the issue of engagement of mobile application when discussing the three major processes of engagement namely: behavioural, emotional and cognitive. Behavioural engagement is when the users show optimism, curiosity, passion and attention towards a mobile application which usually increase the motivation to learn. Emotional engagement is when users show affective tendencies such as sense of belonging and fun with the mobile application. Cognitive engagement is when users show critical thinking level by challenging themselves in the interaction with the mobile application. Table 2.3 summarizes the different outcomes in terms of positive engagement, non-engagement and negative engagement of the according to engagement process of behavioural, emotional and cognitive.

Table 2.3

Engagement Process with the Corresponding Outcomes

	Positive Engagement	Non-Engagement	Negative Engagement
Behavioural	Users interact with mobile application; enthusiasm	Users failed to complete interaction with the mobile application	Users skip continuous interaction with the mobile application
Emotional	Curiosity; Enjoyment	Boredom	Declined
Cognitive	Critical thinking	Incomprehensive	Disremember

In Table 2.3, the positive and negative engagement outcomes depict the forms of user engagement with the mobile applications. These outcomes reflect the users' reactions based on their interaction with the mobile application. It can be seen that outcomes within the three processes reflect in the form of reactions that will be obtained during the interaction. Similar reaction outcomes are obtained with the engagement of MAR whereas the resultant reaction can be positive, negative or non-engagement outcomes. However, this study focuses on the positive engagement outcomes. This is the process that depicts the MAR users' to be enthusiastic in their interaction and engagement with the system. The next subsection examines the concept of engagement within MAR.

2.5.2 MAR and Engagement Studies

Based on the on-going review and as established in the previous section, engagement of audience is a key issue in mobile application. As mentioned by Patel, Clawson, Voida, and Lyons (2009), researchers work hard and meticulously to design, develop and market mobile application, however, many of these products do not last in the market. It was reported that most previously developed applications failed to engage the users which usually leads to failure in users' retention and usage of these applications. It further concluded that user engagement is vital in order for users to

use the application over and over again. Likewise, a survey has shown that only around 24% of mobile applications are used by users once before discarding them (Ribeiro & da Silva, 2012) whereas these applications were intended for long-term users' engagement by the developers. There are many studies in the vast literature that investigated mobile applications users' engagement within the different domains such as healthcare, community development, decision support system, and human-centered computing as summarized in Table 2.4.

Table 2.4

Selected Mobile Apps and MAR with Engagement

Study	Study Purpose	Domain
Tang et al. (2016)	Interactive systems for patient-centred care to enhance patient engagement.	Healthcare
Du et al. (2016)	Mobile Application to Increase Adherence in Exercise and Nutrition Programs.	Healthcare
Kosinski et al. (2016).	Patient Engagement Rates Using a Mobile Application Platform.	Healthcare
Pugliese et al. (2016).	Mobile Patient Engagement Tool.	Healthcare
Pavliscsak et al. (2016)	Patient engagement with a mobile application among service members in transition.	Healthcare
Carter (2014)	Mobile Application Design to Encourage Civic Engagement.	Community Development
Han, Shih, Rosson, and Carroll (2014)	Enhancing community awareness and participation in the local heritage with a mobile application.	Community Development
Kim et al. (2013)	Mobile user engagement system.	Decision Support System
Denny (2013)	Virtual achievements on student engagement.	Human centered Computing
De Marsico, Galdi, Nappi, and Riccio (2014)	A facial and iris recognition for mobile engagement.	Human centered Computing
Huizenga, Admiraal, Akkerman and Dam (2009)	Mobile game enhancing engagement.	Human centered Computing
Permadi and Rafi (2015)	User engagement for MAR games.	Human centered Computing
Elwood (2018)	AR Guide for engaging learners in communities of Inquiry	Human centered Computing

From Table 2.4, it is evident that in the healthcare domain, engagement is required for effective and efficient patients' treatment and monitoring (Kosinski et al., 2016). MAR application has made patients to have an active role in their treatment decision making whereas they can collaborate, share information and receive treatment at their convenience. Thus, MAR provides patients with easier access to lab results, medical statement and other documentation. Likewise, MAR has been used successful to enhance the community development. Many applications such as Carter (2014) and Han, Shih, Rosson, and Carroll (2014) are developed to actively engage the community members in order to create awareness and participation. Similarly, MAR developments have been done in human centered computing domain such as De Marsico et al. (2014); Denny (2013) and Elwood (2018) where users' engagement has been explored. It can be seen that mobile applications have been implemented in various domains such as health interventions, education, games, human computing technology, behavioural changes and user experiences medium whereas the healthcare domain was found to be the most frequently applied domain in the vast literature (Barello et al., 2015). However, it has been discovered that majority of these studies focus on medical, decision support applications and others, whereas there is less focus on engagement of mobile applications for the HI. Hence, this study investigates MAR in engaging the HI users.

2.5.3 Engagement with MAR for HI

As discussed in the previous subsection, the majority of the studies within the vast literature focus more on engagement of mobile applications for normal hearing people whereas less attention is given to the engagement of mobile application for the HI users. Table 2.5 summarizes studies that explore MAR applications for the HI users.

Table 2.5

MAR for HI Users

Reference	Description	Remarks	Features	Target Audience	Limitation
Mirzaei, Ghorshi, and Mortazavi (2012)	A communication system for the deaf, disabled and ordinary people, the system to communicate with each other.	ASRAR can convert speech into readable text and show the text directly on the AR display.	Automatic Speech Recognition (ASR) and Text-to-Speech Synthesis (TTS)	Deaf and Disable	For Communication; neither museum setting nor engagement
Carmigniani and Furht (2011)	iHeAR is an interactive system for HI and deaf.	Use iPhone and iPad2 as the interaction and platform devices.	Speech recognition and language modelling.	HI and deaf	For Communication; neither museum setting nor engagement
Parton (2015)	Auras: Augmented Reality educational application.	Mobile Augmented Reality (MAR) application to facilitate Quick Response (QR) Codes for deaf children.	Quick Response (QR) Codes, sign language, 3D	Deaf	Focus on Teaching and learning; neither museum setting nor engagement elements
Luo Han, Liu, Chen, and Bai (2012)	Learning for HI students.	In-class hearing assisting for HI and deaf students.	Mixed reality and non-verbal communication	HI and deaf	Focus on HI learning but neither museum nor engagement elements
Parton (2017)	A google glass application for deaf students to engage in a classroom,	A Google Glass application that would enable deaf students to look at the QR code of an object in the classroom	Scan a QR code for an object and watch video.	Deaf	Learning neither museum setting nor engagement elements
Ahmad et al. (2018)	Identify the HI students learning behaviours in Quran learning.	Identify the interface attributes or criteria for the MAR application.	Texts, Colours, Images and SL	HI and Deaf	Learning neither museum setting nor engagement elements

Based on the above table, MAR has been used for HI communication, teaching and learning purposes. For instance, the studies of Mirzaei, Ghorshi and Mortazavi (2012); Carmigniani and Furht (2011) depict that MAR enhances speech narration and conversion into readable text which makes communication easier for the HI community. Similarly, the studies by Parton (2015); Luo et al. (2012); Parton (2017); Ahmad et al. (2018) reflect the usefulness of MAR for learning by the HI. These two studies depict that MAR provides a unique platform for the HI interaction and stimulation environment for learning. Nevertheless, it is seen that there are limited studies on MAR for the HI visitors. Therefore, this study will focus on the conceptual model of engagement of MAR for the HI visitors at the museum site. In view of this, the next section will examine the needs and issues surrounding the HI people whereas specific reviews will be made on the nature and classification of HI which will be used to guide this study.

2.5.4 Elements of Engagement with MAR

Previous subsection has discussed in general, engagement with MAR for the HI. This subsection specifically focuses on the elements of MAR engagement for the HI. As discussed in the previous subsections, mobile engagement defines the range of interaction among the MAR application and the user. This interaction is very important because it depicts the level of engagement. According to Mangold and Faulds (2009), the more persuasive the interaction, the more engaging the MAR application. Hence, it is imperative to consider the elements that will enhance the persuasive interaction and engagement between the MAR application and its users. Schmidt (2000) pointed out that mobile interactions take place in four contexts namely: the mobile application, the application content, third parties and assignment.

The mobile application refers to the movable personalized electronic device while the application content means the information on the mobile application. Third parties context means the ability for the user to relate to the contents in the application as a different entity while the assignment depicts the tasks that are needed to be completed in order to stay connected with the third parties in the mobile application. The utilization of these four channels produces an emotional commitment and involvement interaction between the application and the user. This emotional commitment and involvement interaction are defined by the engagement of MAR application. However, the rationale to comprehend this engagement is a major issue with many MAR applications especially for the HI. Table 2.6 presents a summary of elements of engagement of MAR in the vast literature.

Table 2.6

Summary of Engagement Elements of MAR

No	Elements	Description	Reference
1	Aesthetics	This is the concept of mixing the nature of beauty, art, and with the creation and appreciation of MAR.	O'Brien & Toms (2010); Wiebe, Lamb, Hardy, Sharek (2014); van Vugt et al. (2007); Banhawi, Ali, & Judi (2012); Lalmas, O'Brien, & Yom-Tov (2014); Huang & Liao (2015); Bolter et al. (2013); Lee, Chung, & Jung (2015); Chung, Lee, Kim, & Koo (2017); Pantano, Rese, & Baier (2017); Jung, Lee, Chung, & tom Dieck (2018)
2	Novelty	The concept of using mobile applications to teach new behaviour and knowledge for the user.	O'Brien & Toms (2008); Banhawi et al. (2012); Wiebe et al. (2014); Lalmas et al. (2014); Patzer, Smith & Keebler (2014); Olsson et al. (2013)
3	Usability	This is the concept of flexibility, ease of use, suitability and learnability of MAR.	Permadi & Rafi (2015); Rutledge & Neal (2012); O'Brien & Toms (2010); Banhawi et al. (2012); Wiebe et al. (2014); Huang & Liao (2015); Hector & Payel, (2014); Haugstvedt (2012); Olsson et al. (2013); Lee et al. (2015); Chung, Lee, Kim, & Koo (2017); Pantano et al. (2017); Leue & Jung (2014); Jung et al. (2018)
4	Feedback	Positive information that will enhance passionate reactions which will promote positive performance.	O'Brien and Toms (2008); Rutledge & Neal (2012); Hector & Payel (2014); Liu, Huot, Diehl, Mackay, & Beaudouin-Lafon (2012)
5	Motivation	An act which encourages action or target activity to be performed by a user.	O'Brien & Toms (2010); Chapman (1997); Szafir, & Mutlu, (2012); (Vreede, Nguyen, Vreede, & Boughzala, 2013); Yusoff, & Dahlan, (2013); (Lalmas et al., 2014); Kim et al. (2013); Gopalan, Zulkifli, & Aida (2016); Di Serio et al. (2013); Chang et al. (2015)
6	Attention	The ability to be involved and absorbed on a specific task by losing track of time without being distracted.	Rutledge & Neal (2012); O'Brien & Toms (2010); Webster & Ho (1997); Peters et al. (2009); Banhawi et al. (2012); Szafir & Mutlu (2012); Wiebe et al. (2014); Lalmas et al. (2014); Di Serio et al. (2013); Biocca, Tang, Owen, & Xiao (2006); Yusoff & Dahlan (2013)

Table 2.6 Continued

No	Elements	Description	Reference
7	Perceived Control	The act of dominating, commanding and regulating others, an activity, or a system	O'Brien & Toms (2008); Webster & Ho (1997); Hector & Payel (2014)
8	Curiosity	This is when the human mind yearns for knowledge by investigating an environment, object, or situation in search of the knowledge.	Webster & Ho (1997); O'Brien & Toms (2010); Chapman (1997); Litman & Spielberger (2003); Reychav, Zhu & Wu (2017); Ciolfi & Bannon (2002)
9	Enjoyment	The user experiencing fun, enjoy, and entertainment with the usage of the application.	Ma (2012); Rutledge & Neal (2012); O'Brien & Toms (2006); Bressler & Bodzin (2013); Lalmas et al. (2014); Pendit et al. (2014b); Lee et al. (2015); Chung et al. (2017); Pantano et al. (2017); Jung et al. (2018); Shernoff, Csikszentmihalyi, Schneider & Shernoff (2014).
10	Social skill	Ability to facilitate interaction and communication with others.	Rutledge & Neal (2012); Permadi & Rafi (2015); Escobedo et al. (2012)
11	Self-efficacy	Confident in one's belief in one's ability to succeed in specific situations or accomplish a task.	Rutledge & Neal (2012); Glasgow et al. (2011); Sirakaya & Kilic Cakmak (2018); Lin & Chen (2015); Sharek & Wiebe (2015); Wiebe et al. (2014)
12	Felt Involvement	The users feeling involve during interaction with MAR application	O'Brien and Toms (2008); Wiebe et al. (2014); Permadi & Rafi (2015)
13	Endurability	The likelihood of the user to return back to the usage of the application.	O'Brien & Toms (2010); Wiebe et al. (2014); Banhawi et al. (2012); Lalmas et al. (2014); Conley (2013)
14	Interest	This when an object or system attracts attention, provokes thought, intrigues, and fascinates a user.	Webster & Ho (1997); O'Brien & Toms (2010); Chapman (1997); Peters et al. (2009); Vreede et al. (2013); Yusoff & Dahlan (2013); Nachairit & Srisawasdi (2015); Nincarean, Alia, Halim, & Rahman (2013); Shernoff et al. (2014).

Table 2.6 Continued

No	Elements	Description	Reference
15	Immersion	The application should be able to cause deep mental involvement for the users.	Permadi & Rafi (2015); Chen et al. (2005); Sweetser & Wyeth (2005); Kim (2013)
16	Challenge	The application should be able to provoke users to action.	Webster & Ho (1997); O'Brien & Toms (2010); Bressler & Bodzin (2013)
17	Satisfaction	This is an act of being content and fond with an application.	Rutledge & Neal (2012); Permadi & Rafi (2015); O'Brien & Toms (2013); van Vugt et al. (2007); Wiebe et al. (2014); Kim et al. (2013); Nachairit & Srisawasdi (2015); Chou & Chanlin (2014); Chung et al. (2017); Leue & Jung (2014)
18	Collaboration	The action or power of focusing the user attention on the action with the application.	Rutledge & Neal (2012); Shernoff et al. (2014); Permadi & Rafi (2015)
19	Trust	Users must have confident in the workability of the application.	Lalmas et al. (2014); Hussein (2016); Sillence et al. (2006); Gurak & Antonijević (2009); Nilsson & Johansson (2007); Yeh & Wickens (2000); Wang (2010)
20	Interaction	Aware of being in control towards the application whereby interactivity, information and feedback are given upon an action.	Permadi & Rafi (2015); Rutledge & Neal (2012); O'Brien & Toms (2010); Pantano et al. (2017); Hatala, Kalantari, Wakkary, & Newby (2004)

Based on the literature review, twenty (20) elements have been identified as the elements of engagement of MAR from the vast literature. This implies that each of the elements trigger engagement in MAR. The following subsections discuss each of these elements in detail.

2.5.4.1 Aesthetics

This is the concept of visual beauty or the study of natural and appealing mobile environment (O'Brien & Toms, 2010). This concept implies that the theory of beauty is introduced into the MAR so that the mobile users can appreciate the expression and representation of the message that the MAR application is conveying. Also, Aesthetics element is suitable for the HI because it depends on the users' visual senses. Therefore, it is considered as the proposed element for this study. In a major study by O'Brien and Toms (2010); Wiebe et al. (2014), the concept of aesthetics is identified as an evaluation and measurement factor for engagement. This study follows the definition of O'Brien and Toms (2010) which defines aesthetics as visual beauty or the study of natural and appealing mobile environments.

2.5.4.2 Novelty

This concept depicts the usage of MAR to teach and learn new behaviour and knowledge for the user. The concept ensures that the conveying messages of the mobile application are based on the principle of quality, originality and newness in order to achieve the target behaviour of the application. This concept has been implemented in studies such as O'Brien and Toms (2008); Patzer et al. (2014); Assaker, Vinzi, and O'Connor (2011) where it is argued that novelty enhances engagement. These studies pinpoint that when users know that an application is

teaching a new behaviour then their curiosity to explore the application will increase which will make them to be engaged to the application. Thus, the novelty element is suitable for the HI people because it depends on the HI in learning the new behaviour and knowledge. Therefore, it is considered as the proposed element for this study.

2.5.4.3 Usability

This is the measurement of the flexibility, ease of use, suitability and learnability of MAR as perceived by the users' (Sauro, 2015) and (Hussain, Abubakar, & Hashim, 2015). Ease of use of a system is one of the measuring tools for evaluating mobile applications. Similar concept has been implemented in studies like Hector and Payel (2014), Pribeanu (2014); O'Brien and Toms (2010); Huang and Liao (2015); Nilsson and Johansson (2007); Haugstvedt (2012) where it is maintained that usability promotes users' engagement and satisfaction with the MAR. Thus, the usability element is suitable for the HI people because it refers to the ease of use application. Therefore, it is considered as the proposed element for this study. Therefore, this study follows the definition of Othman, Petrie, and Power (2011) which defines usability as the measurement of consistency of information and ease of use application functionality as perceived by the users.

2.5.4.4 Feedback

This is the concept of users' response and reaction to obtain modification in order to promote positive performance. Mouratidis, Vansteenkiste, Lens, & Sideridis, (2008); Rutledge & Neal, (2012) argues that when users perceive that their input and contribution to a system is vital then their engagement with the system will increase. This further support Hector and Payel, (2014) position that positive feedback

information enhances passionate reactions and promotes positive performance. Thus, the feedback element is suitable for the HI people because they may need to receive feedback from use of the technology.

2.5.4.5 Motivation

Motivation defines an act which encourages action or target activity to be performed by a user (Alqahtani & Mohammad, 2015; Chapman, 1997). A study by Di Serio et al. (2013) has shown that users usually get engaged to the applications that they perceived to inspire or motivate them towards excellence. Thus, the motivation element is suitable for the HI because motivation may encourage the HI to continue using the MAR to do some activities during the museum visit. Therefore, it is considered as the proposed element for this study. Therefore, this study follows the definition of Gopalan et al. (2016); Chapman, (1997); Fogg (2009) which defined motivation as an act which encourages action or target activity to be performed by a user.

2.5.4.6 Attention

Attention is the ability to be involved and absorbed on a specific task by losing track of time without being distracted (Rutledge & Neal, 2012; O'Brien & Toms, 2010; Webster & Ho, 1997). Banhawi et al. (2012); O'Brien and Toms (2008); Rutledge & Neal (2012) implemented this concept in their studies. These studies concluded that the applications which are able to gain attention of users will successfully engage the users. Thus, attention is suitable for the HI because they may not be distracted from the use of the technology. Therefore, it is considered as the proposed element for this study.

2.5.4.7 Perceived Control

It is a belief that users feel that they are in control of the event or situation within an application. It is a state that users have the understanding that they determine the internal situation and event within an application. This state becomes more intense when users belief they have more control and influence on the application environment and/or bring about the desired outcomes. This concept has been used in studies such as Boberg, Karapanos, Holopainen, and Lucero (2015); Webster & Ho (1997); Hector & Payel (2014) where it is noted that users perceived control on the application promotes their engagement. Thus, there is probably a need for the HI to control situation within an application. Therefore, it is considered as the proposed element for this study.

2.5.4.8 Curiosity

Curiosity is a state when the human mind yearns for knowledge by investigating an environment, object, or situation in search of the knowledge. This describes the quality of inquisitive thinking which will push the users to internal exploration and investigation. This concept promotes informal learning while the users learn through investigation and exploration. The concept has been implemented in studies by Reychav et al. (2017); Olsson (2017); Boberg et al. (2015); Ciolfi & Bannon (2002) where it has been discovered that the applications that increase user curiosity can successfully engage the users in a learning environment. The HI may be eager to search for knowledge using application at the museum visit. Therefore, it is considered as the proposed element for this study.

2.5.4.9 Enjoyment

The concept of enjoyment implies the feeling of being benefiting to the conveying message of the application. This concept involves users experiencing fun, joy, and entertained based on their interaction with the MAR applications MA, L. E. (2012); Bressler and Bodzin (2013); MäNtymäKi and Salo (2011); Pendit et al. (2014b); Nysveen, Pedersen, Thorbjørnsen, (2005). The HI may need to feel enjoy, fun and entertained with the application during the museum visit. Therefore, it is considered as the proposed element for this study. Therefore, this study follows the definition of MäNtymäKi and Salo (2011); Nysveen et al. (2005) which states that enjoyment is when the user experiencing fun, joy and entertained with the usage of the application.

2.5.4.10 Social skill

This is the ability to facilitate communication, relationship and interaction with others within the same social circle. Studies by Escobedo et al. (2012); Rutledge and Neal, (2012) have highlighted that any application that facilitates social ability and skill enhances users' engagement. Social skill concept implies that users are able to connect with others by forming bonds and circle. The HI probably needs relationship and interaction with others by using the application. Therefore, it is considered as the proposed element for this study.

2.5.4.11 Self-efficacy

Self-efficacy defines confidence in users' belief in their ability to succeed in specific situations or accomplish a task. Based on the studies by Mun and Hwang (2003); Rutledge and Neal (2012), any application that enhances the users' self-efficacy will

also engage them. It is considered as the proposed element for this study because the HI may need to accomplish a task with the application during the museum visit.

2.5.4.12 Felt Involvement

This is the concept of how much feeling users involve during interaction with MAR application and how drawn in they were able to become. This concept has been implemented in studies such as O'Brien and Toms (2008); Wiebe et al. (2014) where it is argued that when felt involvement increases users will get more engaged to the application. The concept ensures that the conveying messages of the mobile application are based on the quality of the HI interactions with the application. The quality of the HI interaction depends on the degree of challenges in achieving a specific task, the skills users possess in meeting those challenges, and the participants control over the interaction.

2.5.4.13 Endurability

This is the ability for users to bear and tolerate instructions from the application in order to perform the target action or behaviour. This concept defines the likelihood of the user to return back to the usage of the application, and this has been explored in studies such as Wiebe et al. (2014); O'Brien and Toms (2010). Thus, the HI may need to bear instructions from the application in order to perform the target action.

2.5.4.14 Interest

The concept of interest is when an object or system attracts attention, provokes thought, intrigues, and fascinates a user. This implies that interest is the gaining of users' awareness and concern in order to get them involved and participate in

predefined action or behaviour. Many studies such as Schraw, Bruning & Svoboda (1995); Yusoff and Dahlan (2013); Webster and Ho (1997) have argued that users' engagement is succeeded when the users are interested in the applications' message. Also, interest element is suitable for the HI when an object or system attracts the attention of the HI. Therefore, it is considered as the proposed element for this study.

2.5.4.15 Immersion

The concept of immersion defines the state of deep mental involvement of users based on their interaction with an application. This concept implies that the user is able to experience deep thinking as a result of the application's interaction. This concept is well explained in the studies by Chen, Kolko, Cuddihy, and Medina, (2005); Permadi & Rafi (2015); Di Serio et al. (2013) where the element of immersion is associated with engagement. The HI may need deep mental involvement based on their interaction with an application. Therefore, it is considered as the proposed element for this study.

2.5.4.16 Challenge

The concept of challenge involves a provocation to action or summons to compete and contest. Thus, an engaged application should be able to dare and persuade the HI to perform the target action and behaviour. This concept has been implemented and explained in the previous studies (Permadi & Rafi, 2015; Chou & Chanlin, 2014) as a determinant of engagement.

2.5.4.17 Satisfaction

This is an act of being content and fond with the MAR applications which is usually by users fulfilling their expectations on the application. This concept pinpoints that every HI usually has a predefined target in exploring an application and if this target is not met then they will disengage with the application. On the other hand, if the target is met then they will become more engaged with the application (Permadi & Rafi, 2015; Nachairit & Srisawasdi, 2015; Chou & Chanlin, 2014). This study follows the definition of Alqahtani and Mohammad (2015); Rutledge and Neal (2012) which states that satisfaction as an act of being content and fond with an application

2.5.4.18 Collaboration

Concentration is the action or power of focusing the user attention on the action with the application. Rutledge & Neal (2012); Shernoff et al. (2014); Permadi & Rafi (2015) implemented this concept in their studies. These studies concluded that the applications which are able to gain the concentration of users, will successfully engaged the users. Thus, the HI may need focusing on the action with the application.

2.5.4.19 Trust

The concept of trust defines the users' confidence in the workability of the application to achieve its defined objective and aim. The concept is vital because without trust it will be impossible for the users to follow the instruction of the application. This concept has been implemented in studies such as Lalmas et al. (2014); Hussein, (2016); Nilsson and Johansson (2007) whereby it is established that a trustful application will be more engaging to the users. Thus, the HI may need confidence in the workability of the application to feel engaged.

2.5.4.20 Interaction

Interaction depicts the way and manner that users and application connects. This is important because the platform and nature of the application communication will affect users' engagement with the application (Rutledge & Neal, 2012; Permadi & Rafi, 2015). Thus, the ability to connect between the HI and the application is critical to engagement (Haugstvedt, 2012; Othman et al., 2011). This study follows the definition of (Othman et al., 2011) which states interaction as aware of being in control towards the application whereby interactivity, information and feedback are given-up on an action.

All the twenty (20) elements discussed above are considered as the major MAR engagement elements that are needed for the design of an efficient MAR application. Out of twenty (20) elements, eleven (11) elements of engagement have been considered related to the museum based on the focus group. The eleven (11) elements are listed in Table 2.7.

Table 2.7

Engagement Elements of MAR Related to the Museum and cultural heritage

No	Elements	References
1	Aesthetic	Lee et al. (2015); Chung et al. (2017); Jung et al. (2018)
2	Satisfaction	Chung et al. (2017); Leue & Jung (2014); Moreno Gil & Ritchie (2009)
3	Enjoyment	Lee et al. (2015); Chung et al. (2017); Cesário, Radeta, Matos, & Nisi (2017); Chang et al. (2015); Van Dijk, Lingnau, & Kockelkorn (2012); Sylaiou, Mania, Karoulis, & White (2010); Jung et al. (2018)
4	Self-efficacy	Lin & Chen (2015); Sylaiou et al. (2014)
5	Usability	Lee et al. (2015); Jung et al. (2018); Leue & Jung (2014); Alzua-Sorzabal, Linaza, & Abad (2007); Damala et al. (2008)
6	Interaction	Vaz, Fernandes, & Veiga (2016); Sandifer (2003); Hatala et al. (2004); Kwan, et al. (2016); Li & Liew (2015)
7	Motivation	Moreno Gil & Ritchie (2009); Kim, Chiang, & Tang (2017); Cesário, Matos, Radeta, & Nisi (2017); Chang et al. (2015)

Table 2.7 Continued

No	Elements	References
8	Interest	Hatala et al. (2004); Chang et al. (2015)
9	Focused attention	Sandifer (2003); Chang et al. (2014); Bitgood (2010); Damala et al. (2008)
10	Curiosity	Ciolfi & Bannon (2002)
11	Perceived control	Baktash, Nair, Subramonian, & Ragavan (2016)

From the above summation, these eleven (11) elements are vital to the museum studies and cultural heritage and thus, have been considered to be used in this study. There are limited previous studies on MAR for HI as shown in Table 2.5 page (40). However, there is a need to consider the well-being of the HI due to the overwhelming of the elements of MAR for engagement. Thus, chapter 4 discusses in detail the focus group discussion that has been conducted and the elements that have been selected for this study.

2.6 The Hearing-Impaired People

The HI people account for over 5% of the world's populace which is about 360 million people (Kožuh, Hintermair, Holzinger, Volčič, & Debevc, 2015). Out of this populace, 124 million people are affected with moderate to severe HI while 108 million from this 124 million live in low and middle-income countries like Eastern Asia, South Asia, Asia-Pacific and sub-Saharan Africa. From this populace, 328 million are adults where around 33% of these are over 65 years old (Zazove, Meador, Reed, & Gorenflo, 2013). HI children are approximately 32 million worldwide while 65 million individuals were affected by hearing loss from childhood. Generally, hearing disability which is also known as HI or loss occurs when an individual threshold is above 40 decibels (dB) for adults and 30 dB for children (Pollard, Sutter, & Cerulli, 2013). This leads to little or no hearing abilities which might occur in one

or both ears. Generally, HI people have difficulties in learning and understanding languages which when not managed properly can result in loneliness, low esteem, and depression (Batten, Oakes, & Alexander, 2013; Lesar & Vitulic, 2013; Chuan et al., 2017).

2.6.1 Hearing Disability

Hearing disability occurs when sounds sensitivity is reduced below or above the normal rate of 40 decibels (dB) for adults while 30 dB for children (Jiang, Yin, & Wilkinson, 2015). The categorization of hearing disabilities is done based on severity to sense sound in the speech frequencies which is usually based on the increase in volume above the usual level necessary before the listener can detect it. Studies of Meinzen-Derr et al. (2014); Alexander, Kopun, and Stelmachowicz, (2013); Smith, Bale, and White (2005); Clark (1981) categorized hearing loss to be slight, mild, moderate, moderately severe, severe or profound as summarized in Table 2.8.

Table 2.8

Categorization of Hearing Disability

Categorize	**Minimum (dB HL)**	**Maximum (dB HL)**
Slight	16	25
Mild (Adult)	26	40
Mild (Children)	20	40
Moderate	41	54
Moderately Severe	55	70
Severe	71	90
Profound	91	<91

For humans, the frequency is from 20-200,000Hz while the amplitude is from 0-130dB. According to Vedurmudi et al. (2016), the 0dB amplitude does not mean there

is the absence of sound; however, it is soft which implies that an average unimpaired person's ear can hear it. Even, some individuals can hear down to -10dB however, the 130dB amplitude is known as the threshold of pain. Roy, Jiradejvong, Carver, and Limb (2012) pointed out that the human ear cannot hear equally various frequencies and concluded that sensitivity peaks for the human ear are at 3000 Hz. Based on studies by Vreeken et al. (2014); Bainbridge and Wallhagen (2014); Furness et al. (2013), hearing loss has been identified to be sensory which has a lot of signs and symptoms. These signs and symptoms can be grouped into primary and secondary. Primary signs and symptoms include pain or pressure in the ears and blocked feeling while secondary symptoms are hyperacusis (pain to certain frequencies and volume of sound), vertigo, disequilibrium and trypanophobia (case of hearing one's respiratory or voice sounds). Additionally, the studies by Hefeneider and McCoy (2015); Kujawa and Liberman (2009) gave some examples of hearing loss problems which were tagged as acoustic insults. Examples of such problem includes difficulty in speech comprehension, telephone usage, problem with speech discrimination against background noise (which is known as cocktail party effect), lack of directionality of sound and speech or sounds attenuation or muffled (which usually makes people to increase television, radio, music and other audio sources volumes carelessly).

These identified signs and symptoms have led researchers to investigate the root causes of hearing loss in humans. Examples of such studies that investigate hearing loss causes includes Azaiez et al. (2014); Smith, Shearer, Hildebrand, and Van Camp, (2014); Schoen, Burmeister, and Lesperance (2013); and Von Ameln et al. (2012). Multiple causes for hearing loss have been identified namely; genetics, ageing perinatal difficulties and developed causes like disease and environmental noises. Out of these identified causes in the vast literature, Basner et al. (2014); Yamasoba et al.

(2013) have pinpointed ageing, genetics and environmental noises as the most frequent root cause of hearing loss in humans. For instance, Arehart, Souza, Baca, and Kates (2013) mentioned that ageing is the greatest single reason for hearing loss which creates as an aftereffect of getting more seasoned regularly and is known as age-related hearing loss or presbycusis. Huang, Kantardzhieva, Scheffer, Liberman, and Chen, (2013) study emphasise that many individuals lose their hearing from around 40 years old which increase as one age or get more seasoned. It was concluded that by the age of 80, many people will have huge hearing issues. This finding was supported by Stevens et al. (2013) finding that as hearing break down, high-recurrence sounds occurs, for example, female or kids' voices might get to be hard to listen. It might likewise be harder to hear consonants, for example, "s", "f" and "th". Likewise, the studies of Sliwinska-Kowalska and Pawelczyk (2013); Sliwinska-Kowalska and Davis (2012) maintained that environmental noise is the second most common cause of hearing loss after ageing. This hearing loss occurs as a result of damage to the ear from repeated exposure to loud noises over time. This is known as noise-induced hearing loss, and it occurs when the sensitive hair cells inside the cochlea become damaged. In the words of Fonseca et al. (2016), hearing loss causes usually makes understanding difficult and this has been of great challenge to researchers generally.

2.6.2 Forms of Hearing Disability

Based on the identified causes of hearing loss mentioned in the subsection above, literature has been able to group hearing disabilities into four forms namely; conductive, sensorineural, mixed and central (Kuenburg, Fellinger, & Fellinger, 2016). The first form of hearing loss is conductive which occurs as a result of

blockage or infections to the outer or middle part of the ear which will hinder the propagation of sound wave to the ear (Kesser, Krook, & Gray, 2013). It happens when sound is not led proficiently through the external ear trench to the eardrum and the modest bones (ossicles) of the centre ear. It includes a diminishment in sound level or the capacity to hear faint sounds. This sort of hearing loss can regularly be amended therapeutically or surgically. This occurrence leads to both slight and mild hearing loss classes because there will be a reduction in sound frequencies to the ear. This form of hearing loss is corrected by medication and the use of hearing aids (Nelissen, Mylanus, Cremers, Hol, & Snik, 2015; Hill-Feltham, Roberts, & Gladdis, 2014).

The second form is the sensorineural hearing loss which occurs as a result of a problem within the inner ear. The term can be subdivided into two parts namely; sensory and neural (Dispenza, De Stefano, Costantino, Marchese, & Riggio, 2013). These two words permit more clarity in defining this sort of hearing loss. The exhaustive audiometric appraisal and supplemental tests can yield the data expected to separate between a sensory and a neural hearing loss, despite the fact that these can exist together in the same ear. Neural hearing loss is another name for retro-cochlear hearing loss. This form of hearing loss results from the internal ear or sound-related nerve brokenness (Raghunandhan et al., 2013). The sensory part might be from harm to the organ of corti or a failure of the hair cells to invigorate the nerves of hearing or a metabolic issue in the liquid of the internal ear. The neural or retro-cochlear part can be the consequence of serious harm to the organ of corti that causes the nerves of hearing to deteriorate or it can be a failure of the hearing nerves themselves to pass on neurochemical data through the focal sound-related pathways (Cho, Kwak, Kwak, & Lopez, 2015). The purpose behind sensorineural hearing loss sometimes cannot be resolved. It does not normally react positively to restorative treatment and it is

regularly depicted as an irreversible, perpetual condition. Like conductive hearing loss, sensorineural hearing loss lessens the force of sound, however, it may likewise bring a component of twisting into what is heard, bringing about sounds that are vague notwithstanding when they are sufficiently uproarious (Kujawa & Liberman, 2015). Once any restoratively treatable conditions have been precluded, the treatment for sensorineural hearing loss is intensification through hearing guides. The classes of moderate and moderate-severe hearing losses are in this form where sound frequencies are distorted even with the use of hearing aids (Tharpe & Gustafson, 2015).

The third form is the mixed hearing disability which is the mixture of both conductive and sensorineural (Bevans, Chen, & Crawford, 2013). This occurs when there is a problem in both inner and outer or middle parts of the ear (Vyskocil et al., 2014). Along these lines, notwithstanding some irreversible hearing loss brought on by an internal ear or sound-related nerve issue, there is additionally a brokenness of the centre ear system that exacerbates the hearing than the sensorineural loss alone. The conductive part might be agreeable to therapeutic treatment and inversion of the related hearing loss; however, the sensorineural segment will in all likelihood be changeless. Mixed hearing can be treated with hearing aids but, the choice of treatment will depend on the patient's state. The last form of hearing loss is the central which occurs due to damage to the central nervous system and has a great distortion on sound frequencies to the ear (Lee, 2013; Humes et al., 2012). Both mixed and central hearing loss belong to the profound and severe hearing loss classes (Smith et al., 2014).

2.7 Communication Methods for the Hearing-Impaired

The previous section has explained who the HI person is and their challenges generally. This section will show efforts from the research community on how to improve the communication and lifestyle of HI with the design of various assistive technologies (Stokoe, 2005). Specifically, this section will reflect on contributions from linguistic research domain on the HI communication methods. Based on this review, the term communication methods imply the ways and medium that an HI person interacts and communicates with others within the larger society (both normal hearing and HI people). There are four communication methods for the HI based on linguistic literature which includes sign language, lip reading, subtitle and closed caption (Marschark, Shaver, Nagle, & Newman, 2015). Although, any one of these four methods is mostly used for communication and interaction by the HI, however, the combination of these methods together is likewise possible. For instance, the case where only one method is used is known as singelingual, while bilingual is where two methods are combined and trilingual is where three methods are combined. The next subsection will discuss in detail the four methods as applicable to the HI.

2.7.1 Sign Language

Based on linguistic research domain, there are over 70 million HI individuals using sign language as their native or first language (Debevc, Kosec, & Holzinger, 2010). Sign language has been considered as the principal language and first language to numerous hearing loss individuals and HI (material sign languages). Although, there may be variation in sign language semantic depending on countries, albeit distinctive sign languages can have the same etymological roots similarly as spoken languages do.

This does not imply that sign language is not a global language for the HI but rather there are all inclusive elements in sign languages. Sign language is not a straightforward gestural code speaking to encompassing spoken language (Rogers et al., 2016). The adaptation and modification nature of sign language in various countries makes it a feasible and global language to be easily comprehended by people compared with other spoken languages in the world (Lederberg, Schick, & Spencer, 2013). Sign language is usually referred to as international sign and it is normally depicted with slashed ear symbol as shown in Figure 2.15.

Figure 2.15. International Symbol for HI (Clason, 2014)

However, there are many issues, pains, and criticism with sign language. For instance, Rautakoski and Martikainen (2014) mentioned the concerns in communication arts of the dissimilarities in spoken and sign languages. It was emphasized that this dissimilarity in the two languages (spoken and sign) usually cause a lot of misperception and lack of comprehension between both communities. Rosen, Turtletaub, Delouise, and Drake (2015) in their study on learning and usage of sign

language concluded that the language takes many years to learn and mastered. This makes it exceedingly limited especially among adults that lost their hearing abilities in their old years. The population of HI does not always devote the time required to learn and master sign language. Similarly, Ong and Ranganath (2005) reported that the variation in sign language creates numerous systems for HI communication which leads to confusion and misperceptions. For instance, British and USA sign Languages are greatly different despite both countries speak English which make systems created from both cannot be interchangeably used. In addition, Haug and Mann (2008) criticized the strenuous nature of sign language that second distraction may cause misunderstanding and inaccurate comprehension.

These issues and criticism have made scholars like Debevc, Milošević, and Kožuh (2015); de Araújo et al. (2013); Marschark et al. (2006) to argue that subtitling and closed captioning are more advantageous and engaging compared with sign language for the HI. This is supported by statistics from the USA where just 10% of the 24,000,000 hearing loss people prefer sign language while the remaining 90% prefer subtitling and closed captioning (Karchmer and Mitchell, 2004). This is because people nowadays prefer interactive and engagement medium of communication. Subtitling and closed captioning are preferred because they are displayed on the screen as many as three lines at a time in order for the audience to catch up if they become distracted, and more importantly can focus their attention to improve comprehension and understanding.

2.7.2 Lip Movement

Apart from sign language, lip movement is another method of communication for HI and it is also called lip-reading or speech-reading which involves the understanding of

the movement of the face, lip and tongue during conversation. This method is not easy because it relies on good knowledge of the spoken language and concentration in order to fathom the interpretation and comprehension. However, the method is an important skill to tackle isolation especially for HI and does not require much training. According to Kyle, Campbell, Mohammed, Coleman, and MacSweeney (2013), HI are identified as good lip-readers than normal hearing people because they can be more focused and possess high level of concentration (reduced distraction either from the environment or within their mind). This is the rationale why HI individuals are usually considered as the best lip-reading forensic professionals.

Likewise, it has been seen that lip movement increases literacy capability among the HI community (Tye-Murray, Hale, Spehar, Myerson, & Sommers, 2014). This is because HI children that are trained in lip-movement must acquire other language knowledge and skills in order to be able to fathom and comprehend the method. Although lip movement is very useful and beneficial for HI however, it is a difficult skill to master and has various interpretation with misinterpretation. This implies that there are no unique ways to it and different individuals can give diverse interpretations. Likewise, recognition of lip-movement is between 30% to 40% of speech, whereas 70% of the skill is based on guesswork (Ronnberg, 1993). Another issue is that for HI to be able to use lip-movement effectively then they must master the spoken language (depending on the country). This is a very difficult task because not all HI are knowledgeable in other natural languages and there are variations in these natural languages too (Plass, Guzman-Martinez, Ortega, Grabowecky, & Suzuki, 2014). Thus, these limitations have given the choice to explore other methods of interaction and communication among HI. The next discussion of this review will shed more light on subtitle and closed caption communication methods for HI.

2.7.3 Subtitle for Deaf and Hard-of-Hearing (SDH)

The concept of SDH as explained by Caimi (2006) is the display of spoken language on screen in order to bridge the communication gap between the two communities (spoken and sign languages). In this concept, the subtitling is done to believe that the target audience cannot hear the speaker nor the non-dialogue audio sound effects and speaker identification of the spoken words. This is done by translating the spoken language into screen understandable language in order to aid the HI comprehension (Straetz et al., 2004). This implies that subtitles describe what is going on/off screen for the comprehension of the HI that cannot hear the audio part of the screen (for example the explosion scene in movies). Subtitles can be helpful when a speaker is talking amid a minute with a lot of encompassing clamour. Figure 2.16 shows the international symbol for SDH.

Figure 2.16. SDH International Symbol (Wikipedia, 2018)

Now and again, the subtitles will be shown as a packed rendition of what is being said on screen or will be composed marginally distinctively to what is really said. These events are moderately rare and for the most part, do not hamper the comprehension of the spoken words. Likewise, the SDH has been used in a game where dialogues that are difficult to speak or hear are shown for audience comprehension. This has been

done to comprehend telephone conversation, explosions, enemies conspiring distance and others. It permits the audience to gain more insights and understanding on the spoken language which foster mutual comprehension to both HI community and spoken word community.

2.7.4 Closed Captioning (CC)

Similar to SDH, CC is also a text displaying media for words and expressions that are spoken and acted respectfully. Both SDH and CC are used to describe expression, convey a message and inform HI audience. However, there are lots of differences with both SDH and CC. CC is mainly used with special elements and signs that are not included in SDH. The communication of CC includes all audio information such as speaker identification, sound effects, and non-speech elements. CC elements are written in HI understandable language and are included in the video source language which is not done for SDH. This implies that CC is more detailed in information and comprehension for HI and the international symbol is shown in Figure 2.17.

Figure 2.17. Closed Captioning International Symbol (Clason, 2014)

CC has been used in many different applications for learning, reading and difficult audio environment where muting or low sound is needed. It can be used in a situation where audience simply wants to read a transcript along with audio. According to Ohene-Djan, Wright, and Combie-Smith (2007) there were over 7.5 million people using closed captioning while 6 million have no hearing impairment in the United Kingdom. It is also designed to be used in public environments where background noise usually disturbs such as in restaurants and bars. Nowadays, many television manufacturers are setting their products to automatically turn captioning on when the volume is muted. In comparison with SDH and normal subtitling medium, Table 2.9 summarizes the major differences of Normal Subtitling, SDH, and CC.

Table 2.9

Differences between Normal Subtitling, SDH, and CC

Characteristic	Normal Subtitling	SDH	CC
Sound effects	X	X	X
Synched with video	X	X	X
In source language		X	X
Speaker Identification		X	X
Can be turned on/off		X	X
Onscreen placement	Centred lower bottom third	Centred lower bottom third	Varies
Text appearance	Varies	Varies	Usually white text on black background
Encoding	Supported through HDMI (Blu-ray or HD DVD)	Supported through HDMI (Blu-ray or HD DVD)	Not supported through HDMI (Blu-ray or HD DVD)

It can be seen that the advantages of CC are enormous compared to other mediums as summarized in Table 2.9. The benefits gain from its application is not only to the HI community but also to the spoken community. Notwithstanding, few issues were

identified with CC. For instance, Kim, Han, Choi, and Jung (2015) pointed that CC made used of few text or words whereby most sentences are not usually captured in CC. White and Cansler (2014) mentioned the issue with multiple standards in CC which usually cause dialog misconception. Additionally, Salim, Haider, Conlan, Luz, and Campbell (2015); Blanco, Morales, and Silvestri (2015) studies emphasized the need to improve HI engagement, retention and overall users' experience with CC. This implies that issues like engagement, interaction, comprehension and retention are still limited with CC.

The application of CC is enormous which has created lots of advantageous competing technologies for the improvement of human lifestyle generally and HI specifically. It ranges from internet video streaming, movie, theatre, stadium, public speaking presentation, video game, telephone conversation, media monitoring service and television. For instance, television CC application has offered a real-time captioning with lots of benefits to both the HI and normal hearing audiences. According to Brooke (2015); Koskinen, Wilson, and Jensema (1985) studies which focused on television CC as a new tool for reading instruction, possess certain advantageous of television CC namely:

i. It enhances persuasive vocabularies and on time display for HI audiences because, in television, the audio (volume) can be silent in order to empower closed captioning.
ii. It empowers video streaming by giving more explanations to scenes with the help of CC and can be used by both HI and non-HI people.
iii. It can be used selectively which implies the CC can be switched off or on.
iv. It allows video and scenes search in television CC application

v. It provides better comprehension and read-along culture which is of huge benefit to both HI and non-HI people.

vi. It aids easy translation into other foreign languages.

vii. Helps in teaching sound English language to an audience which can be in the form of verbal structure to advance expression, verbal stating, and elocution of audiences.

viii. It protects against interruption and disturbance during video streaming whereby audiences can easily capture previous scenes.

In another major study by Blanco, Morales, and Silvestri (2015), the authors proposed IntoNow, a mobile application that gives a second-screen experience to TV audiences. The mobile application utilizes the microphone of the mobile device to sample the sound originating from the TV set and analyses it against a database of TV shows with a specific end goal to recognize the project being viewed. Figure 2.18 presents the IntoNow user interface.

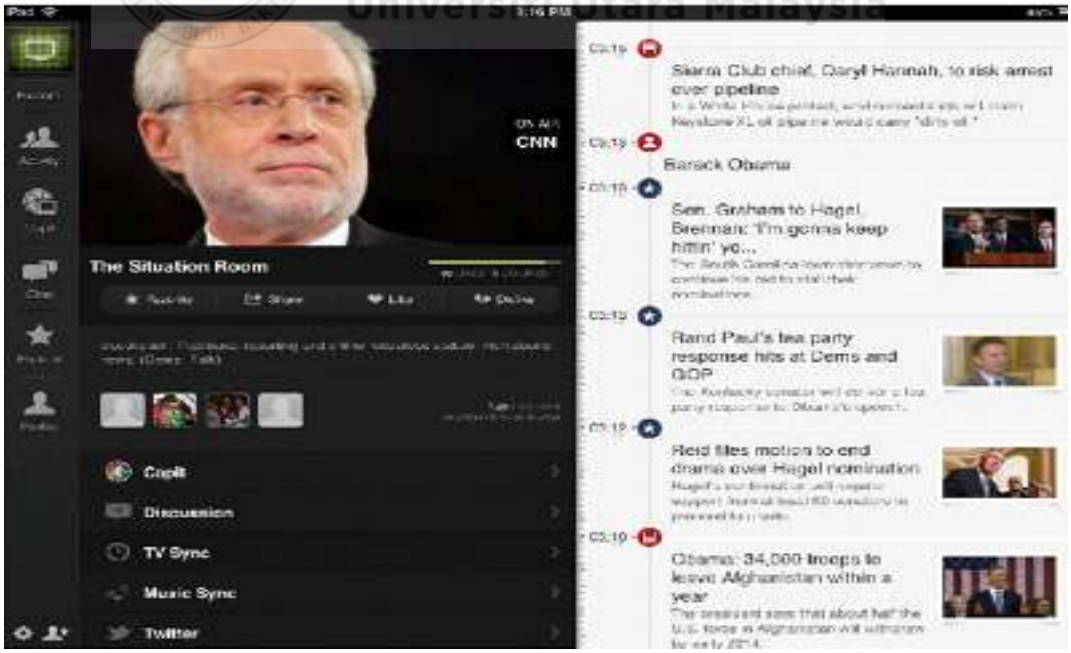


Figure 2.18. IntoNow User interface display featuring closed caption application on the right window (Blanco, Morales, & Silvestri, 2015)

IntoNow retrieves identified data by comparing the signal coming from the TV with TV shows' database to identify the show that being watched. By using closed caption, the system retrieves the information related to the TV show that the user is watching which is provided by the TV signal broadcaster.

The same concept has been implemented by White, Lartigue, and Dutton (2013) developed eScribe, a note-taking system augmented with multimedia content and designed to work in real time with collaborative input and annotation by users utilizing mobile devices. The mobile application integrates concept from CC and lecture environment such as multimedia, notes, and others into an indexed time-coded record of the lecture that is suitable for archiving. Similarly, Lochrie and Coulton (2012) studied information extraction in real time using CC on the Twitter platform. Their study has been identified to have enormous potential for reinvigorating live TV of audience interaction. Although, these applications are well functional for their design purposes however, there are still concerns among researchers such as Kim, Han, Choi, and Jung (2015); Shiver and Wolfe (2015); Lekakos, Chambel, and Knoche (2013) on how to improve CC and text to be more interactive and captivating to most audiences especially the HI. Additionally, van Rooij and Zirkle (2016); Salim, Haider, Conlan, Luz, and Campbell (2015); Varonis (2015) have pointed out the need to make the text and CC more engaging and attractive in order for the audiences not to be bored when interacting with the applications. Hence, this present study will make use of mobile augmented reality engagement elements to design an engaging application for the HI.

2.7.5 The Implication of the Communication Methods to This Study

The previous subsections discussed four communication methods for the HI. This subsection discusses the implication of these communication methods. Firstly, Sign language has been considered as the principal language and first language to numerous hearing loss individuals, although, there may be variation in sign language semantic depending on countries. However, there are many issues, pains, and criticism with sign language. Rautakoski and Martikainen (2014) mentioned the concerns in communication arts of the dissimilarities in spoken and sign languages. Rosen, Turtletaub, Delouise, and Drake (2015), in their study on learning and usage of sign language concluded that the language takes many years to learn and mastered. This makes it exceedingly limited especially among adults that lost their hearing abilities in their old years. Similarly, Ong and Ranganath (2005) reported that the variation in sign language creates numerous systems for the HI communication which leads to confusion and misperceptions. These issues and criticism have made scholars like Debevc, Milošević, and Kožuh (2015); de Araújo et al. (2013) to argue that subtitling is more advantageous and engaging compared to the sign language for the HI. Secondly, lip movement is another method of communication for the HI. This method is not easy because it relies on good knowledge of the spoken language and concentration in order to fathom the interpretation and comprehension. Although lip movement is beneficial for the HI, however, it is a difficult skill to master and has various interpretations with misinterpretations. Thus, these limitations have given the choice to explore other methods of interaction and communication among the HI. Thirdly, the CC is also designed to be used in public environments where background noise usually disturbs and needs special devices. Kim, Han, Choi, and Jung (2015) pointed that CC made used of few text or words whereby most sentences are not

usually captured in CC. White and Cansler (2014) mentioned the issue with multiple standards in CC which usually cause dialog misconception. Additionally, Salim, Haider, Conlan, Luz, and Campbell (2015); Blanco, Morales, and Silvestri (2015) studies emphasized the need to improve the HI engagement, retention and overall users' experience with the CC. This implies that issues like engagement, interaction, comprehension and retention are still limited with CC. Fourthly, in this concept; the subtitling is done to believe that the target audience cannot hear the speaker nor the non-dialogue audio sound effects and speaker identification of the spoken words. The subtitles will be shown as a packed rendition of what is being said on screen or will be composed marginally distinctively to what is really said. These events are moderately rare and for the most part, do not hamper the comprehension of the spoken words. It permits the audience to gain more insights and understanding on the spoken language which foster mutual comprehension to the HI community. Therefore, in this study the text of subtitling is preferred because they are displayed at the bottom of the screen in order to improve comprehension and understanding. Additionally, van Rooij and Zirkle (2016); Varonis (2015) pointed out the need to make the text more engaging and attractive in order for the audiences not to be bored when interacting with the application.

2.8 Hearing-Impaired and Museum Visit

Previous sections have shown that lots of efforts have been geared generally towards helping and improving the lifestyles of the HI. This is evident in the numerous applications and designs in the vast literature. The study of disabled people experiences can be dated back to 1990s (Poria, Reichel, and Brandt, 2010). This has led to the United Nations World Tourism Organization (UNWTO) in 2005 to

acknowledge the need for tourism for all tagged “accessible tourism for all”. This became imperative because disabilities and aged people represent a growing cluster of consumers of museum worldwide. This demonstrates museums turning into a fundamental right and vital for human improvement. It is a method for social improvement of incapacitated nationals and welfare of the general public upon tourism economy. This huge right ought to be bolstered by administrative arrangement and should be suggested as a regulation for museum administrations. There is a solid endeavour for the museum administrations availability for all visitors. Encouraging access as far as foundation and museum administrations for impaired individuals is the piece of accessible museum (Alén, Domínguez, and Losada, 2012). In this appreciation, exercises with innovation upgraded environment are pivotal for the accessible museum.

Accessible museum covers an assortment of exercises inside of spare time to museum. It depends on making individuals with confined limits and completely coordinates their useful and mental contemplations and activities for the individual fulfilment and social advancement (Alén, Domínguez, and Losada, 2012). Those accessible exercises and innovation upgraded administrations give incorporation and socialization which are huge advancement pointers for incapacitated individuals. Accessible museum is a type of tourism that includes communitarian forms between partners that empower individuals with access prerequisites, including portability, vision, hearing and subjective measurements of access to work autonomously and with value and pride through the conveyance of generally composed museum items, administrations and situations (Buhalis and Darcy, 2010). However, a group that has been precluded from the accessible museum are the HI or hearing loss. This is because the group has received little attention within the research literature whereas

most museum studies have focused mainly on accessibility museum and little is being done on enjoyable and informative museum for this group (Small & Darcy, 2010; Darcy & Taylor, 2009; Darcy & Dickson, 2009; Shaw, Veitch, & Coles, 2005; Goodall et al., 2004).

In the museum, there are many methods that are used to interact with the HI visitors which include the following; Assistive Listening Devices (ALDs), Real-Time Closed Captioning and Sign language interpretation. The ALDs are used in live broadcasts of events within the museum which for rear-window captioning and audio-description. In similar manner, Real-Time Closed Captioning is used in live broadcasts of events within the museum to enhance audio description to the HI visitors. Likewise, sign language interpretation is implemented as scheduled tours guide for HI visitors to the museum sites. Table 2.10 summarizes selected museum hearing aid application for the HI visitors based on Kenneth Berger Hearing Aid Museum and Archives (Curran & Galster, 2013).

Table 2.10

Summary of Museum hearing aid application

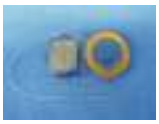
No	Application	Description	Benefit	Reference
1	Med-El Opus 2 Audio Processor 	This cochlear implant audio processor worked with the implanted Sonata. It consists of three parts—the behind-the-ear microphone/audio processor, the transmitting coil and the "FineTuner" remote control.	The thinnest and lightest processor, *OPUS 2* has children's and body-worn with 6-channel acoustic fitting	Müller et al. (2012); Seebens & Diller, (2011)
2	Med-El Sonata Cochlear Implant 	This cochlear implant module works with the Opus Audio Processors. It consists of an electronic module (centre), receiving coil (right) and long electrode array (left and bottom).	Offers up to 60 hours of hearing with two size 675 zinc air batteries	Gifford, Dorman, Shallop, & Sydlowski, (2010)

Table 2.10 Continued

No	Application	Description	Benefit	Reference
3	Med-El Pulsar Cochlear Implant 	This cochlear implant module works with the Tempo+ Audio Processor. It consists of an electronic module with receiving coil (left), a ground electrode (top and right), and a long electrode array (right and bottom).	High reliability with audio software for processing high quality sound.	Gifford, Dorman, Shallop, & Sydlowski, (2010)
4	Med-El Tempo+ Audio Processor 	This cochlear implant audio processor works with the Pulsar or earlier Combi 40+ cochlear implants. The Tempo+ consists of two parts, behind-the-ear microphone/audio processor and the transmitting coil.	It aids audio mixing which refines the quality of the sound.	Lorens, Zgoda, Obrycka, & Skarżynski, (2010)
5	Nucleus Freedom Speech Processor 	The external parts consist of the circular headpiece coil (left) and the behind-the-ear (BTE) speech processor/controller (right).	Aid with advanced speech coding, and streamlined speech processor	Spriet et al. (2007)
6	Nucleus SPrint Speech Processor 	The external parts consist of the circular headpiece coil (left), behind-the-ear (BTE) HS8A microphone (center) and body-worn speech processor (right).	Ear level processors are less flexible than the body-worn Sprint processor	Brown et al. (2000)
7	Nucleus ESPrit 3G  Speech Processor	The external parts consist of the circular transmitting coil (bottom) and the behind-the-ear (BTE) speech processor (top).	Built-in telecoil provides recipients with wireless access to the telephone without the need for additional adapters or cables	Santarelli et al. (2009)
8	Radio-based hearing aid system 	FM system where sound is wirelessly transmitted by radio waves.	Uses harmless radio waves which can be used at any environment	Hall (2001)
9	Vibraphone 	It consists of silver chambers in an "L" shaped design. Inside the larger chamber were small metal reeds that vibrate with the sound. It is doubtful that they would have helped anyone, even with a mild hearing loss. Sounds enter the Vibraphones through a ring hole in the bottom of the large chamber (right).	Two pieces of devices use at the same time on the two ears. It sizable and used to improve hearing quality	Marutake, Fukutome, & Asami, (1991)
10	Celluloid ear trumpet 	Two-section collapsible Metal "Pipe" Trumpet known as ear horn.	It is mostly used by ladies because of its multi-colours and fashion	Torick, DiMattia, Staruk Jr & Milner, (1975)

Most of these applications and techniques majorly focus on supportive hearing aids whereas, there is a need to explore engagement hearing aids which can make the HI have inspiring learning experience during their visits to the museum sites (Angkananon, Wald, & Gilbert, 2016; Betsworth, Bowen, Robinson, & Jones, 2014). These kinds of experiences are vital because it will provide the HI museum visitors with satisfaction in order to create a more social acceptance and make them to be able to come back for visits to the museum again. Hence, this study focuses on MAR engagement applications for the HI during their visits to the museums.

2.9 Underpinning Theories

This study will make use of one model and a theory to pivot its theoretical implications namely: museum experience model and engagement theory. The following subsections explain more about them and their relationship to this study.

2.9.1 Museum Experience Model

Museum experience model explores the rationale of not only visitors' visit to the museum but also their passion and expectation during their visit. The model reflects the inner motivation and drive that make people to visit the museum. Based on Falk and Storksdieck (2005), this model contains a rule of setting which impacts museum visitors experience and expectations. It was pointed out that there are three major factors that motivate museum visitors' experiences namely: their personal experience, social experience, and physical setting.

The first factor is visitors' personal experience which relates to the inner value of the visitors and is expressed in four dimensions.

i. Visitor' expectations and motivations: Most of the time, the rationale for visiting the museum is entertainment and learning, thus, this expectation and motivations must be met for satisfaction to be reached. When it is reached then it enhances the visitors' emotional experience which will always be remembered and marked by the visitors.

ii. Visitor' knowledgeable experience: Another form of experience that the visitors wish to have at museum sites is acquiring of new knowledge. New knowledge can be derived from old knowledge of objects in the museum which create the passion for learning.

iii. Visitors' beliefs: Another way of acquiring of new knowledge is by exploring on visitors' beliefs during their visit to the museum sites.

iv. Visitors' choices and control: The factors of choices and control enhance the museum visitors to acquiring of new knowledge by creating the passion for learning.

The second factor is visitors' social experiences which implies the social bonding and connection that visitors can have during their visit. Positive social bonding and attachment gives positive experience. The social experience is referred to social interaction among other visitors, museum staff and other social elements that can positively impact the visitors during their visits. On the other hand, the third factor which is physical setting refers to the feelings and influence that the museum building, artefacts and other non-living objects within the museum environment can have over the visitors (Selvakumar & Storksdieck, 2013; Lanir et al., 2013). The study by Pendit et al. (2015) has implemented the museum theory of MAR in the cultural heritage sites for normal hearing people. Thus, this theory would explain the HI behaviours in the museum during this study. It helps in the selection of the

engagement elements and their items during the development of the conceptual model of this study.

2.9.2 Engagement Theory

Due to the fact that this study develops a conceptual model of engagement of MAR for the HI then it will be wise to pivot it with the engagement theory. Based on Kearsley and Shneiderman (1998), the engagement theory stipulates the processes involved in technology-based learning where users are engaged with the technology in an active learning platform. According to Shneiderman (1994); Kearsley (1997), the engagement theory is defined as the process of establishing teamwork (collaboration) in order to achieve set objectives. Teamwork in the light of this study implies the interaction between the mobile application and the user, while the set objective is for satisfactory user experiences at the museum site. The theory pinpoints three factors namely; Relate-Create-Donate which can be summarized as follows:

i. The first factor 'Relate' depicts the act of forming a team with a technology which involves social skills. This depicts a case of collaborative learning between the technology and users which increases the motivation of users to learn within the platform.

ii. The second factor 'Create' implies the platform, where the interaction platform among the technology and users is purposeful and creative in nature. It should give the user a good sense of control over the technology in order to activate confidence in the interaction.

iii. The third factor 'Donate' depicts the value or benefit achieved during the interaction. It means that the interaction should be rewarding and efficient in order for users to have a continuous interest in the technology.

It can be seen that the theory promotes interactive learning whereas the outcome of the interaction depends largely on the technology (mobile application). However, it is important to note the difference between engagement and interactivity. The theory has been able to show that the technology (mobile application) is a source of critical thinking which provides the learning platform known as engagement. On the other hand, interactivity is the platform for the technology communication tools in the form of media delivery platform. Thus, engagement theory emphasises on the provision of a meaningful platform for learning based on the users and the technology (mobile applications) interactions. For instance, Kearsley and Shneiderman (1998) used the engagement theory to develop a technology-based teaching and learning framework. Their study implemented the three core components of engagement theory namely; collaboration, focus and project orientation to depict how students' engagement can be achieved in learning activities. Also, Herrington, Oliver, and Reeves (2002) implemented the engagement theory in the usage of authentic activities within the online learning platform in order for the students to willingly deflect their disbelief to fully engage in the learning scenarios on authentic tasks. The work by Permadi and Rafi (2016) displayed the use of the theory in MAR application where a conceptual model of user engagement for MAR game was developed. However, the usage of the engagement theory in MAR for the HI in the literature is still limited.

In a study based on the theory of engagement, O'Brien and Toms (2008) have constructed and evaluated a multidimensional scale to measure user engagement. Figure 2.19 shows the output of this study showing the four stages of engagement and their respective attributes. The first stage is the point of engagement which occurs when the user delves beyond the routine or the mechanistic level and then invests him/her self in the interaction. This stage shows the role of the interface of the

application to display novel information in an aesthetically pleasing way to capture the users' motivation and interest in the application which eventually make them interact with it.

In the second stage, the user is engaged with the application. The users' attention must be maintained with the feeling that they are part of the interaction process. The user therefore understands what to do with the application and control be able to it. These attributes vary according to the users' expectations and experience with the technology as well as the surrounding environment and the technology used.

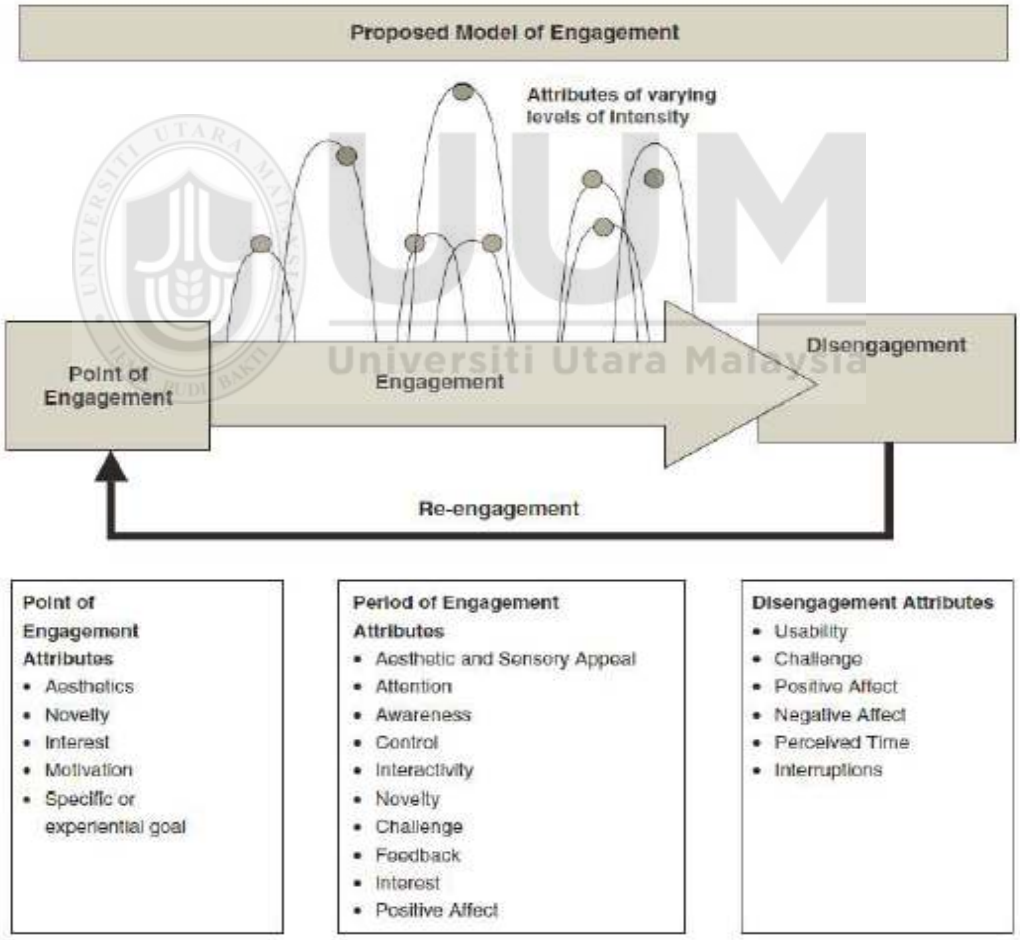


Figure 2.19. Stages of engagement (O'Brien & Toms, 2008)

Disengagement is the third stage whenever the user stops the task voluntarily or for internal reasons. Therefore, the user either feels positive feelings such as user's sense of success or negative feelings such as frustration and dissatisfaction. At the last stage, the user feels either success in the performance of the mission (positive feeling) or failure (negative emotions) or loss of interest and motivation. The Re-engagement stage is important because the user moves between stages during the single session. Therefore, the re-engagement stage is an integral part of the model. Engagement theory can be used in this study to explore users' perception of being engaged with the mobile application. In addition, this theory is vital in understanding users' requirements and needs in order to feel engaged within the mobile environment. However, the usage of the engagement theory in MAR for the HI in the literature is still limited. Thus, these are the reasons for this study to explore the engagement theory for the conceptual model of engagement of MAR for the HI visitors at the museum site.

2.10 Chapter Summary

This review has explored definitions and understanding of MAR with its application and issues surrounding the HI at the museum sites. Thus, this chapter provides a theoretical understanding on the conceptual model of engagement of MAR that can be developed for the HI at the museum site as summarized in Figure 2.20. The theoretical framework for this study comprises of five main headings namely; User Experience (UX), Augmented Reality (AR), the HI people, Communication methods for the HI and Under Planning Theories. The subheadings include; Museum User Experience, the Concept of Engagement which bisects from the main heading of User Experience. While Museum MAR and MAR Applications bisect from the main

heading Augmented Reality. Also, Hearing Disability, a Form of Hearing Disability and HI and Museum Visit bisect from main heading the HI people. While the main heading Communication Methods of the HI bisects from the Sub-headlines subtitle for Deaf and Hard-of-hearing (SDH), CC of HI, Lip Movement and SL for HI. In addition, this framework comprises of two theories that are adaptive to this study, that include; Museum Experience, and Engagement theory. The sub-subheading from the concept of engagement include; Engagement Process, Engagement MAR, HI and Engagement MAR. The next chapter will explore the research methodology for the study purpose.

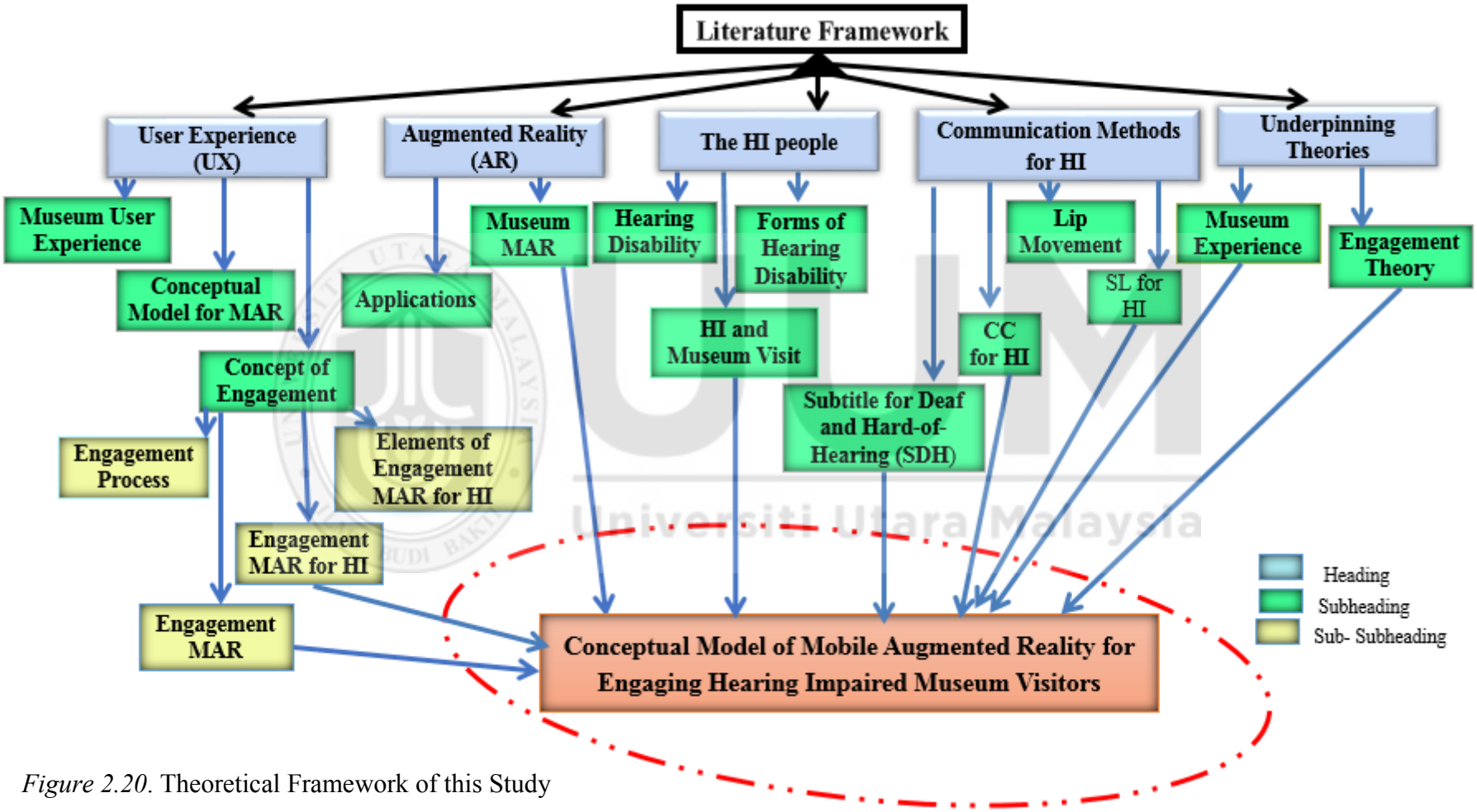


Figure 2.20. Theoretical Framework of this Study

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

Chapter 2 presents the literature review in the domains of AR, engagement, HI and museum. This chapter has provided the fundamental foundation into the research objectives as stated in Chapter 1. Meanwhile, chapter 3 describes the methodology that was used in answering the three research questions. The chapter starts with the research study paradigm and subsequently presents the research design and framework as a reference for this study. The other subsequent sections reflect the provide stages taken in answering all of the research questions. Then, details on the communication of the study and considerations that are implemented in the study are presented. Finally, the chapter recaps with a brief summary of the research methodology.

3.2 Research Design

Design Science Research (DSR) methodology has been identified as the most suitable method to provide answers to the research questions as stated in Chapter 1. This methodology was selected because it is fundamentally a problem-solving paradigm as mentioned by Peffers, Tuunanen, Rothenberger, and Chatterjee, (2008); Peffers, Rothenberger, Tuunanen, and Vaezi, (2012); Alturki, (2015); Vaishnavi and Kuechler (2015). It consists of six stages namely: problem identification, proposed solutions, model design, development, evaluation, and communication. Also, there are three major rationales for selecting the DSR methodology for this study which include:

i. DSR is more concerned with the end product such as artefact for implementation of the study.

ii. DSR is found to be suitable for this study since the study domain is related to the information system which provides flexible possible platform for MAR prototype development.

iii. This study will produce a prototype design in order to validate the proposed conceptual model.

Figure 3.1 summarises the stages, activities and outcomes that were implemented in this study based on the DSR methodology. Further elaborations will be made on each of the research frameworks in the following subsections.

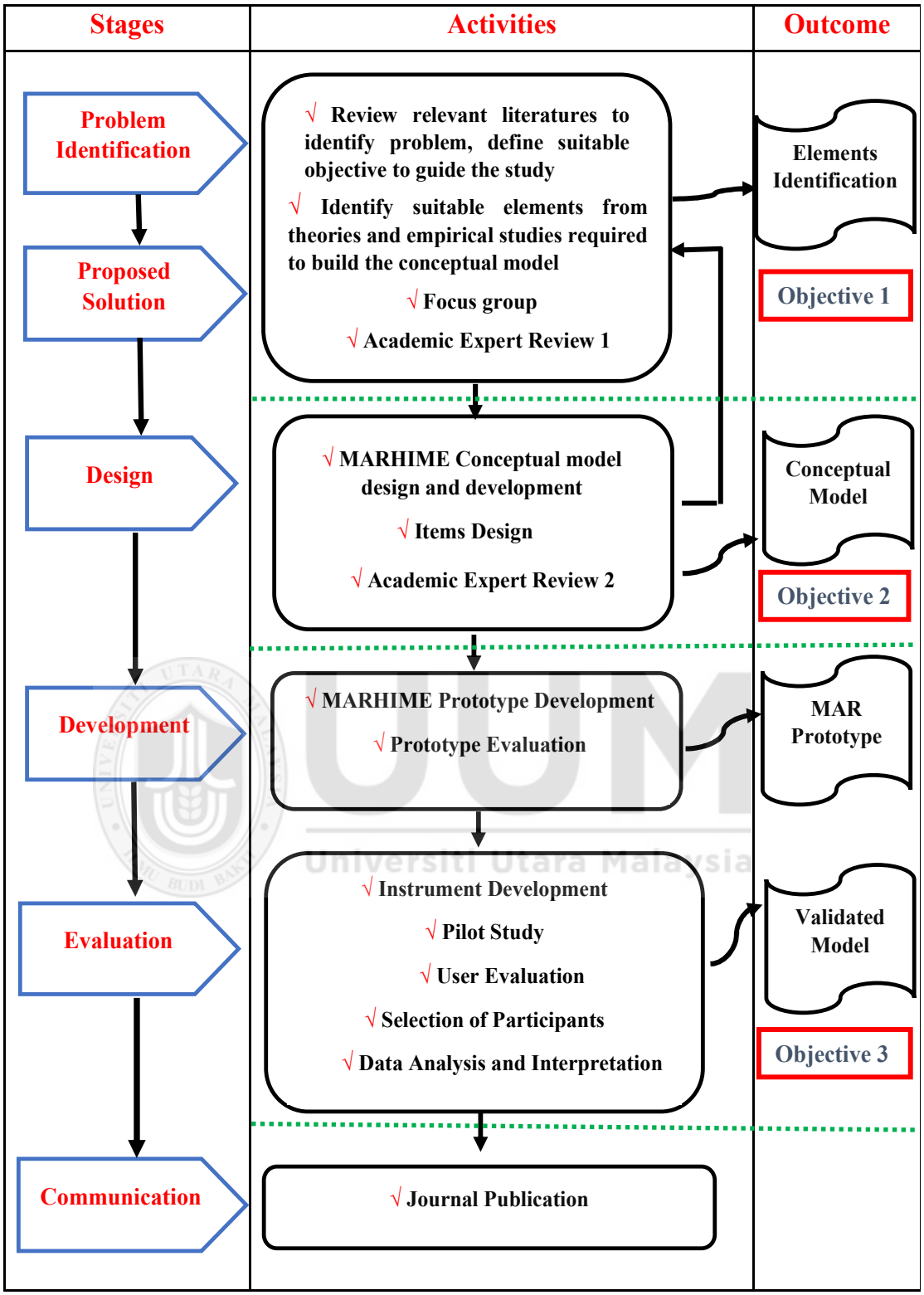


Figure 3.1. Research Methodology

In the vast literature, there are varieties of research methods available to provide solutions to any research problem. In fact, Gravetter and Forzano (2018); March and Smith (1995); Vaishnavi and Kuechler (2015); Shiratuddin and Hassan (2013); Peffers, Tuunanen, Rothenberger, and Chatterjee, (2008); Peffers, Rothenberger, Tuunanen, and Vaezi, (2012) pointed out that research methods can be classified into eight primary classes. Obviously, not all of these eight research methods can be suitable and comprehensively provide an adequate solution to every study. Hence, it is imperative to select the most suitable and comprehensively adequate literature to provide the needed solution to this present research. Considering the nature of the study which has to do with the development of a conceptual model and a prototype for the HI, DSR method was considered appropriate. This is because the DSR method is found to provide stages which lead to the artefact design which is rigorously demonstrated through well-executed validation processes.

3.3 Stage 1: Problem Identification

This first phase is where the foundation of the study was created. It involves the definition of the research objectives based on the problems identified in the vast literature. Literatures within the domains of AR, MAR, engagement, HI, museum, and heritage cultural site were reviewed to identify and examine the problems and issues related to the study. The conceptual model of MAR is also discussed. These problems and issues were used to formulate the research objectives for the study.

3.4 Stage 2: Proposed Solution

The literatures on AR, MAR, engagement, HI, museum, and heritage cultural site were used to identify the elements of MAR conceptual model for the HI. The

elements are related to the theories, models and empirical studies within these domains. This is based on Oxman and Guyatt (1988) suggestions to search for multiple bibliographic databases, reference list of previous eligible reviews, contacting scholars, conference proceedings, key journals and seminar articles related to these domains. The outcome of this phase provides the answer to the first research objective as stated in Chapter 1. For clarity, the following two subsections explain the procedure involved in the literature review and identification of elements, and the third subsection explains the focus group. Details of academic expert review phase 1 are available in stage 3 (iii).

i. Review of Relevant Literature

This study reviews existing literatures on engagement, MAR, HI, museum and other related domains and topics around the four main topics. This study also reviewed the conceptual model of MAR. The reviews were taken from books, journals, dissertations, and conference proceedings. Moreover, it also analysed the content from video, text, image that are related to the topic.

ii. Identify Suitable Elements

In order to identify the suitable elements of engagement for this study, an investigation of the existing engagement models was conducted to identify the elements from previous studies. It was found that existing engagement models are focusing much on engagement for websites, multimedia, games, and MAR for normal hearing people. At the end of Chapter 2, the 20 elements of engagement with MAR were listed and considered for the HI due to the differences in users' needs, and expectations in the digital environment (O'Brien, 2017). More light is

shed in the next subsection when these elements were presented to the focus group.

iii. Focus Group

Focus group is a small group (6 to 12 participants) of specific target group which responses to certain things like emotional response to a specific subject; questions are asked about their perceptions, attitudes, expectations, beliefs, opinion or their desire (Churchill, 1979; Escalada & Heong, 2011; Folch-Lyon & Trost, 1981). The purpose of focus group is to identify and describe matters in depth that are not clear or known enough to the researchers (Asbury, 1995; Goldman & McDonald, 1987). According to Balch and Mertens (1999), the focus group with HI can be highly productive, even the highly sensitive situations within socioeconomic, and different ethnic if they have common interests and way of communications. Thus, the aim of the focus group session in this study was to provide the participants with the twenty (20) elements so that they were able to select the most appropriate engagement elements according to the needs and expectations of the HI. Altogether, the focus group consisted of eleven (11) participants: five (5) were HI, two (2) were counselors, three (3) were HI teachers and one (1) was a museum staff. The session lasted about two hours with a break of fifteen (15) minutes. The participants were given a piece of paper listing all the twenty (20) elements including the definitions for each of the elements. They were required to answer Yes or No and provide remarks to the needs and expectations of the elements to be included in the MAR prototype for the HI museum visitors. In order to explain the definitions and procedures especially to the HI participants, an HI teacher helped to communicate the idea as presented in Appendix A and its back to back translation in Arabic as in Appendix B. In this

session, the participants were able to interact and discuss with each other, and these helped to reduce the feeling of shyness and confusion. They shared their ideas among themselves and this helped in developing their confidence and not being marginalized. In addition, this increased their motivation and speed up their acceptance of the information. In this study, the frequency analysis was used (Shelena, 2017). The results obtained from the focus group session were used to construct the proposed initial conceptual model of MAR for engagement of the HI at the museum sites. Details of focus group results were discussed in Chapter 4.

3.5 Stage 3: Design

In the design stage, the identified elements from the outcome of stage 2 were used to develop the conceptual model. The relationships between each element are determined based on related theories, models, and empirical studies within these domains. The integration of these elements was forwarded to a panel of experts for review purposes in order to validate the proposed conceptual model. In order to better comprehend the design of the conceptual model from the identified elements, the following subsections explain the activities in detail.

i. Conceptual Model Design and Development

The identified elements from the literature review and previous studies were further analysed to determine the items for each element. This activity provides details on suitable items for each element while maintaining its relationships to engagement, MAR, museum, and HI. Once all the elements were identified, the elements were integrated to form the proposed conceptual model. This activity was based on their relationship as depicted in the literature and previous studies.

The conceptual model was constructed based on the identified elements from previous stages with corresponding relationships. Figure 3.2 summarises the various activities involved in the validation of the conceptual model. The proposed conceptual model started with gathering of the twenty (20) engagement elements from the literature reviews. These elements are related to the theories, models and empirical studies within the user engagement with the technology and MAR domains. The focus group session was conducted to select eleven (11) most suitable elements for the HI according to their needs and expectations; as well as to disregard any element that does not meet those needs and expectations. Next, the proposed elements and the initial model from the focus group have been sent for Expert Review Phase 1 in order to validate and select the most suitable elements. The results from expert review phase 1 consisting of six (6) elements were then sent for expert review phase 2 for validation purpose. Eventually, the final version of the MAR for engaging the HI museum visitors' conceptual model was then refined accordingly based on the findings from the expert reviews.

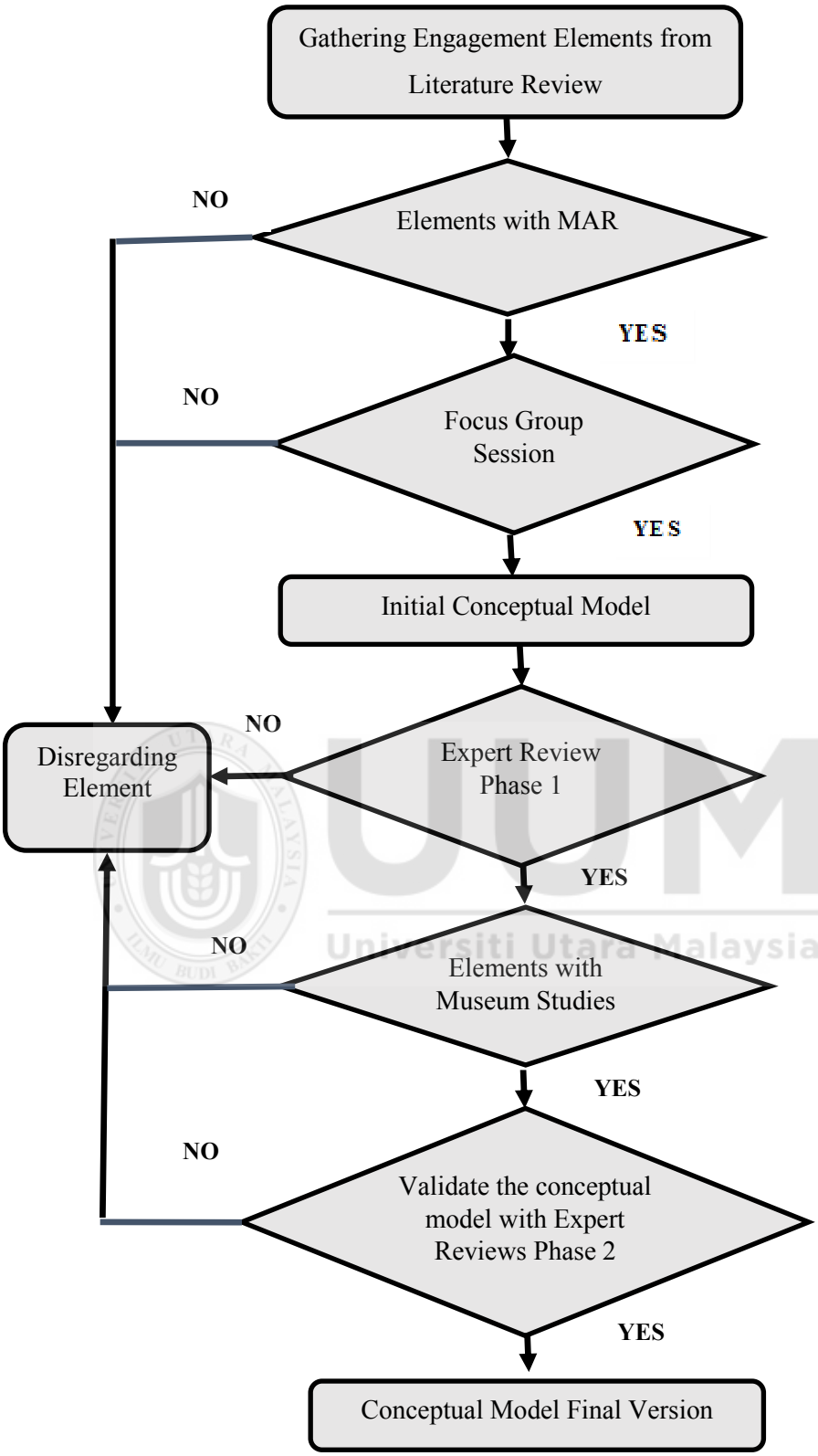


Figure 3.2. The Conceptual Model Validation Activities

ii. Selection of Items

In this study, the items for each element were adapted from the existing literatures. The items were validated through an expert review conducted by academic specialists in the field of MAR, HCI, Multimedia, Museum and HI. The experts have selected the proposed items based on their relevancy to the element. One of the experts has corrected some linguistic errors and some of them gave recommendations in enhancing the items. More on this procedure is available in chapter 4. In addition, this study used the pilot study to ascertain the appropriateness of those items before the evaluation session. Details on the pilot study will be discussed in stage 5 (ii).

iii. Academic Expert Review

Once the conceptual model has been constructed, the experts were asked to validate the model through an expert review. The results from the review were used to construct the proposed conceptual model of engagement of MAR for HI museum visitors. The experts involved in this study have various backgrounds including multimedia, museum, HI, HCI, and MAR from various countries. In this study, the elements were presented to eight (8) experts in review phase 1. The aim of review phase 1 was to select the most suitable elements based on the recommendations and suggestions from the focus group. Then review phase 2 involving five experts was conducted to validate the items for every element of the conceptual model. Moreover, these experts also determined whether the conceptual model is applicable to the HI and able to engage them for satisfactory at the museums.

In the review phase 1, based on the recommendations through focus group, eleven (11) elements were sent to the eight (8) experts. The acceptance criterion of the elements is subjected to 100 percent approval by all experts on the relevancy of those elements. After the review, only six elements fulfilled the criterion and were selected. Expert review is conducted to determine the reliability of components of the conceptual model before developing the model. This is discussed in the next section with further discussion in Chapter 4.

The academic expert review involved at least in one phase: either in Phase 1 or Phase 2 only or both Phase 1 and Phase 2. The list of academic experts' profiles is available in Chapter 4.4.

3.6 Stage 4: Development

The conceptual model from stage 3 was used to develop a prototype in order to validate the proposed conceptual model of engagement of MAR for HI museum visitors. The prototype development was employed based on the evolutionary approach from Forward, Badreddin, Lethbridge, and Solano (2012). This approach was used in order to keep or retain all the design conceptual model elements which will produce the final or finished application. Figure 3.3 summarises the various activities involved in the development of the prototype.

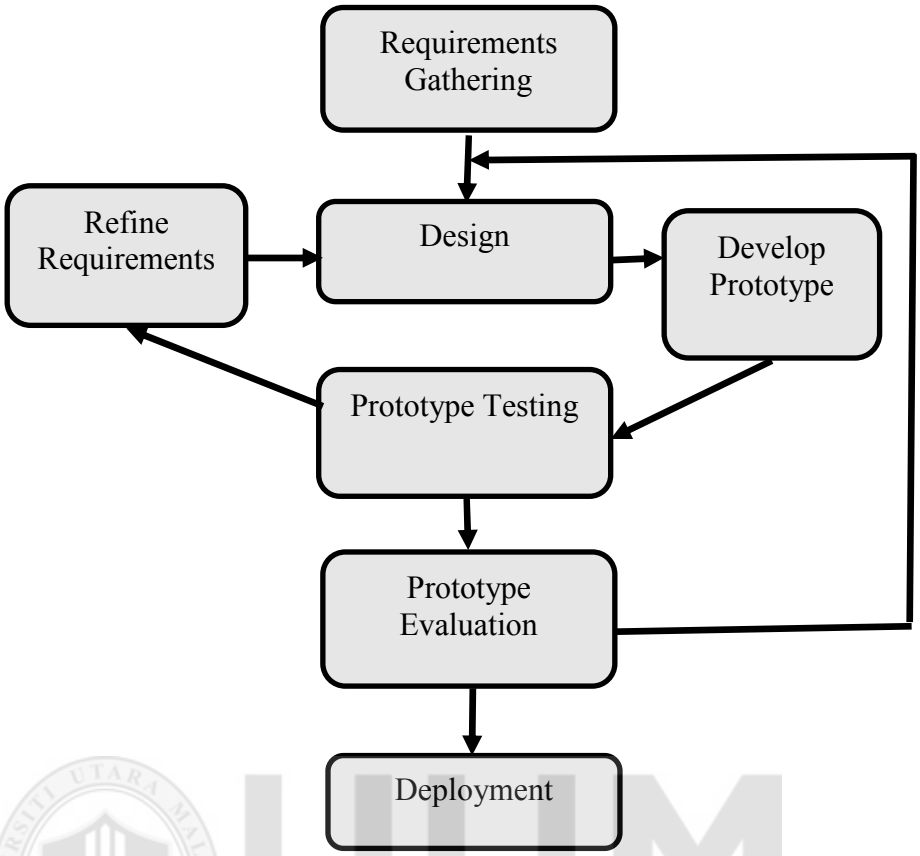


Figure 3.3. Prototype Development Activities

The proposed prototype development starts with the requirements gathering which was done based on the proposed conceptual model and previous studies. This information was used to develop the prototype using Vuforia and Unity 3D programs with the inclusion of C++ programming language. The following subsections explain the activities in detail.

i. Prototype Design

The proposed conceptual model was used as a guideline to design the MARHIME prototype. This activity was conducted to validate the developed conceptual model. The prototype design went through several refining and evaluation sessions which were based on the predefined objectives. The

prototype has to possess the necessary features in order to achieve these objectives. Details of the development activities are available in Chapter 5.

ii. Prototype Evaluation

This review was conducted to validate the developed MARHIME prototype. The outcome of this refinement and evaluation produced significant modifications to the prototype. The prototype was tested by performing evaluation sessions with HI teachers, and museum staff. Feedbacks received from the participants were used to further refine the prototype before it was finally deployed in this study. In addition, the final version of the prototype was subjected to expert review consisting of AR, multimedia and museum experts in order to ensure the functionality and interface of the prototype. Necessary adjustments and modifications were carried out on the proposed prototype based on these evaluations and review which produced the final version of the prototype deployed in this study. This prototype was used in the validation stage of the proposed conceptual model. Details of review activities are available in Chapter 5.

3.7 Stage 5: Evaluation

The evaluation stage aims to validate the proposed model and the process ensures that the conceptual description of the model is correctly implemented. The developed prototype acts as a validation tool for the conceptual model since it is one of the stages in DSR (Shiratuddin & Hassan, 2013). This approach also gives extensive attention to users' wants, needs and requirements during the design process (Kourouthanassis, Boletsis, & Lekakos, 2015). This is very important since the participants targeted in this study are the HI. It afforded the opportunity to fathom

their views and perceptions of the prototype and tools that can be of use to them. The validation took place at a museum in Iraq on a predetermined date. The validation was done by engaging the participants to use the developed prototype and answer the corresponding questionnaire. The questionnaire was translated from English to Arabic by using back-to-back translation. The results of the validation were analysed using descriptive analysis which interpreted the conceptual model. The details of these steps are discussed in the following subsections in order to provide clarity on the subject matter.

i. Instrument Development

The instrument used to evaluate the developed prototype was based on Wiebe et al. (2014); O'Brien and Toms (2010); Othman et al. (2011). Similarly, the required items for all the elements are shown in Table 4.3 in Chapter 4. These instruments were adapted for efficient validation result. The procedure used in developing the research instrument is depicted in Figure 3.4.

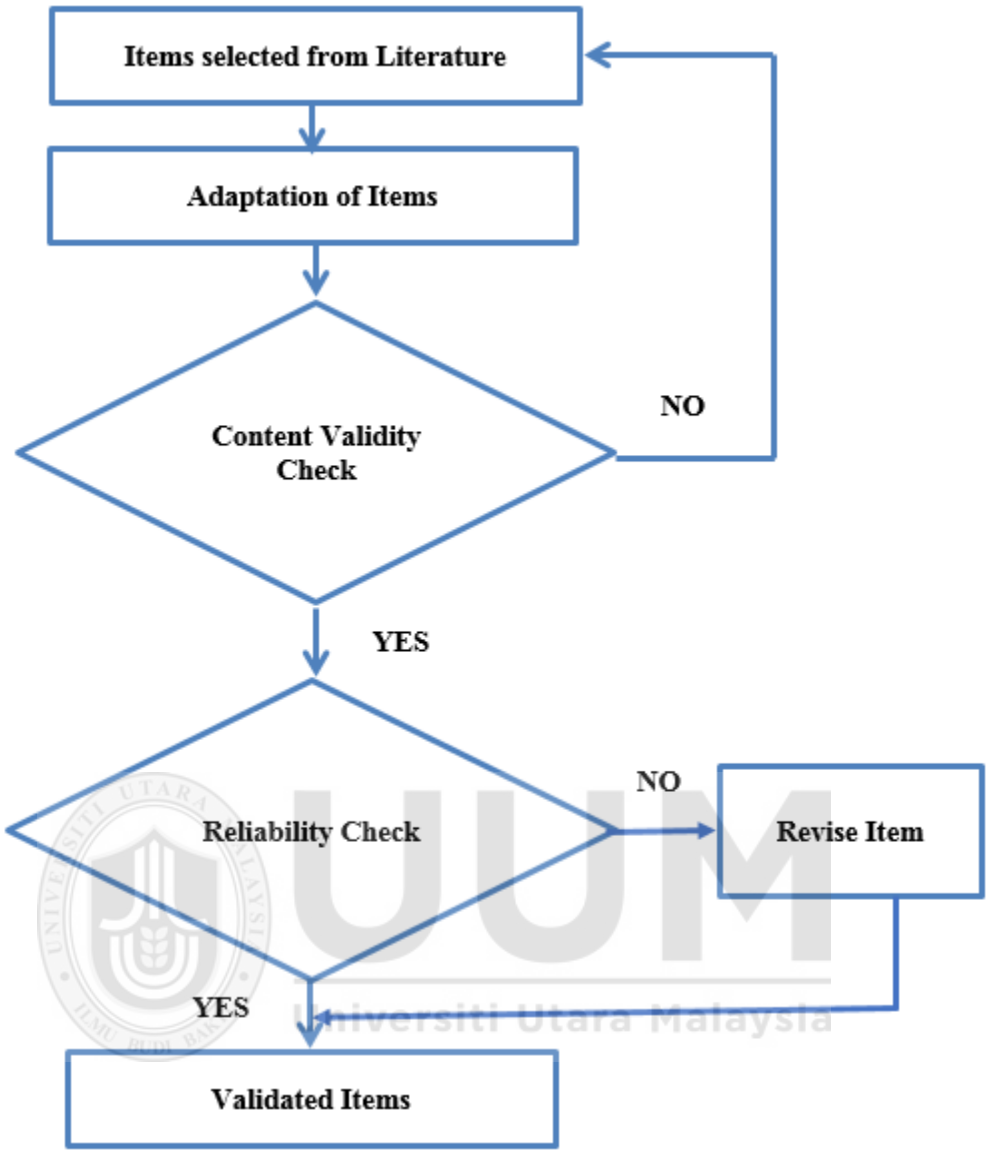


Figure 3.4. Instrument Development Procedure

The process of formulating the study instrument started with the selection of items based on related studies. The instrument was designed to measure the participants' perceptions. The instrument was then validated in terms of content validity.

Validity refers to the accuracy of a measure or the extent to which a score truthfully represents a concept (Zikmund, Babin, Carr, & Griffin, 2013). In this

study, two types of validity will be conducted: content validity and construct validity. Content validity refer to the degree to which the content of the items represents the appropriate universe of all relevant items under study, in this study (Cooper & Schindler, 2014) and it can be verified by three types of experts: academic experts, experts in instrument construction and HI. Construct validity means measuring the extent to which the measure fits theoretical expectations (De Vaus, 2002). Construct validity can be verified through factor analysis (Fabrigar & Wegener, 2012; Thompson, 2004). The results obtained provide a revised instrument which was suitable to measure and validate the developed prototype. The level of reliability of the instrument scale was determined to ensure the reliability of the elements. The variable for interpreting the reliability of the instrument is the Cronbach's alpha which was used for the pilot study conducted for validity purposes in this study. Details of the analyses and results are available in Chapter 6.

ii. Pilot Study

Pilot study is a small study of the main study which aims to provide useful information to improve the scale of the study and determine the level of reliability of the scale (Bordens & Abbott, 2011). Since the current study has adapted items from different sources, pilot study or pre-testing should be carried out on the part of the population to ascertain the appropriateness of those items (Hair, Black, Babin, Anderson, & Tatham, 2010). In addition, apart from ensuring the clarity of the items, the pilot study would also reveal on the correct formulation and arrangement of items based on the participants' satisfaction or

uneasiness while answering the questionnaire (Adams, Khan, Raeside, & White, 2007; Bell, 2005; Creswell, 2012). Cronbach's alpha was used in this study because it assesses whether the item measures the same thing that was set for it (DeVellis, 2016).

In the pilot study, 16 HI visitors were selected as participants. According to Sheatsley (1983), the number of sample size ranging from 12 to 25 is sufficient to provide the necessary information on the weaknesses in the pilot study. The participants were specifically selected with the highest level of education to ensure the accuracy of their responses. Questionnaires were distributed to all the participants. Consequently, some unclear wordings that have been identified during the pilot study were modified to increase the HI understanding in the real evaluation. More details on the results of the pilot study are available in chapter 6.

iii. User Evaluation

The experiment procedure is based on Lazar, Feng and Hochheiser (2017); Pendit (2015); Zainuddin, Zaman, and Ahmad (2010) where all the phases are properly implemented to ensure correctness. The first phase involved fixing of the experiment date and selection of a suitable room to conduct the experiment based on the suggestion by Guest, Bunce, and Johnson (2006). The experiment room was to ensure privacy and comfort for the participants of the study. Next was the selection of the participants following the discussion in Subsection (iv). The selected participants were required to read and sign the consent letter which was to seek their approval to take part in the study. This was to ensure that all

the participants were selected on the voluntary basis. Once the participants' selection was completed, a set of questionnaires was distributed to get information on the background of the participants. Once the background information has been obtained, the participants were allowed to interact with the prototype in a manner as suggested by Lazar, Feng and Hochheiser (2017); Hong, Wang, Yan, and Chua, (2010); Pendit (2015); and Shiver and Wolfe (2015). This was to ensure that the proper procedures have been followed and maintained in this study. Figure 3.5 summarizes the protocol followed in this study in a flowchart.

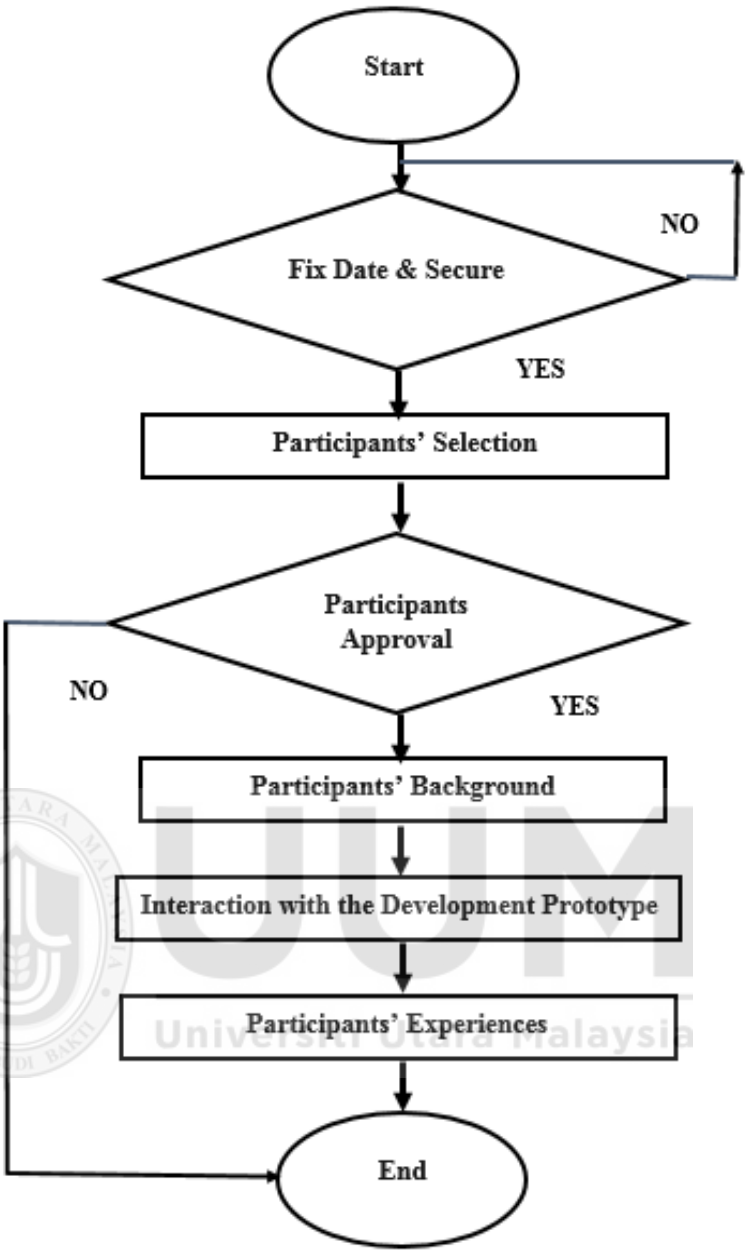


Figure 3.5. Flow Chart of the User Evaluation

The experiment protocol flow chart shows that at each decision phases, there are steps to be followed. For instance, at the participants' approval phase, the participants were expected to make voluntary decision. In case some of these participants were unable to make this decision then it marked the end of the procedure for such participants, whereas those were able to make the decision have to proceed with the protocol.

iv. Selection of Participants

For this study, seventy-three (73) HI were selected as participants for experiment based on Mitzner and Dijkstra (2016); Abdul Mutalib et al. (2015); Witteman et al. (2015); Zainuddin, Zaman, and Ahmad (2010) studies which recommend the use of small number of participants due to special case dealing with HI. In determining the choice for the sample size, the rule of thumb by Roscoe (1975) suggests that sample sizes larger than 30 and less than 500 are appropriate for most research. The selection of the participants was based on purposive and snowball sampling method (Mauk, 2017) when involving the HI community. Purposive sampling was conducted by the researcher by applying own criteria when defining the sample. In this case, the researcher selected own individuals as part of the study. This liberty exercised by the researcher was justified by Hair, Celsi, Money, Samouel, and Page (2016) which states that a researcher can make decisions that are influenced by the nature of the concept. The concept of considering the HI community which does not comprise a large percentage of the population is the reason behind the researcher making this decision. For the same reason, the snowball sampling was also utilized based on Mauk (2017) since the target audiences were the HI. It was implemented in such a way so that the participants would be able to recommend additional potential participants for the evaluation. Therefore, students and even families of the HI participated in the study. These methods were used to ensure that only suitable participants were selected for the study. The selected participants from the HI community have the right to voluntary consent to ensure confidentiality over their information. In addition, the selected HI community was able to read and write.

v. Data Analysis and Interpretation

The developed prototype was used in the experiment involving 73 selected participants. The instrument was used to evaluate the participants' perceptions pertaining to their engagement with the prototype which generated data for the study. The data were analysed using SPSS version 24. Descriptive analysis was used to interpret the collected data. It describes the results by summarising the responses in specific patterns (De Vaus, 2002). The mean value indicates the participants' satisfaction. If the item score is 4 and greater, it shows a high satisfaction of the participants. This study was used the level of reliability to ensure the reliability of the elements. Reliability can be measured using the Cronbach's Alpha (Cronbach, 1951; Cronbach & Meehl, 1955).

This study utilised the exploratory factor analysis for the six elements of engagement. It was used because the measurements were adapted from previous studies and validity of these items is required. Another analysis is Correlation & Multicoliniarity test which is used to explore the relationships between the elements and engagement for this study. Details of the analyses and results are available in Chapter 6.

3.8 Stage 6: Communication

The final stage is the communication where all the results were reported. The analysed data with all the findings gathered in the study went through report writing and publication. The study has documented notable findings in report, journals, and

proceedings that explain in detail about the topic of study. This last phase is important to disseminate the information and the research topic to the public.

3.9 Chapter Summary

This chapter has been able to present the study methodology whereby detail explanations on the stages and activities used to conduct the study have been discussed. The study utilised DSR as a research methodology. The stages that were involved in this study include problem identification, proposed solution, design, development, evaluation and communication. In summary, by using the design science research methodology, each phase and activities have their own outcomes that contribute towards the completion of this research.

CHAPTER FOUR
CONCEPTUAL MODEL OF MOBILE AUGMENTED REALITY FOR ENGAGING HEARING-IMPAIRED MUSEUM VISITORS

4.1 Introduction

Going through an overview of the previous chapters, in Chapter 1, the research objectives of this study have been listed as well as the research questions. Then, Chapter 2 describes the literature review covering the four areas of this study which include Mobile Augmented Reality (MAR), Museum, Hearing-Impaired (HI) and Engagement. Chapter 3 explains the methodological approaches, processes, and techniques used to achieve the objectives leading up to Chapter 4. This chapter mainly discusses about the proposed conceptual model of MAR for engaging the HI museum visitors. It explains the development and validation phase of the conceptual model, which include focus group and expert review of the proposed elements for the conceptual model. These phases are presented in the following subsections.

4.2 Focus Group

The purpose of focus group in this study is to select the most appropriate engagement elements from twenty (20) elements that have been determined through literature review. The focus group involved eleven (11) participants, including five (5) HI, three (3) HI teachers, two (2) counselors and one (1) museum staff. The focus group ages are between 16 and 51 and of both genders. The level of education for the teachers and counsellor are degree holders and they possess over five (5) years of working experience. The students are secondary and primary education. The participants visited the museum before the focus group session so that they were able to have an

overview of their needs and expectations. In this study, all the participants could read and write. Table 4.1 shows the demographic profile of the focus group.

Table 4.1

Demographic Profile of the Focus Group

Participant Code (P)	Age	Gender	Level of Education	Field of work	Experience (year)
P1	19	Male	Secondary school	Student	-
P2	18	Male	Secondary school	Student	-
P3	17	Male	Primary school	Student	-
P4	16	Female	Primary school	Student	-
P5	21	Male	Secondary school	Student	-
P6	30	Male	Primary school	Museum Staff	5
P7	33	Female	Degree	Counselor	8
P8	35	Male	Degree	Counselor	12
P9	37	Female	Degree	Teacher	10
P10	45	Female	Degree	Teacher	17
P11	51	Male	Degree	Teacher	23

Figure 4.1 shows the participants involved in the focus group session. The session began with a brief presentation by the researcher with the help of a HI teacher. Explanation pertaining to the twenty (20) elements was done by providing detail descriptions of each element to all the participants. Then the HI students discussed among themselves and asked some questions to the researcher. The researcher answered the questions in a simplified manner in order to communicate the idea clearly. Finally, the participants were asked to fill out the form that has been prepared for this purpose within the criteria mentioned in the Appendix B. Table 4.2 shows the results of the focus group.

Figure 4.1. Focus group session

Table 4.2

Focus Group Results

No.	Elements	Yes	No
1	Aesthetics	11	0
2	Novelty	2	9
3	Usability	10	1
4	Feedback	2	9
5	Motivation	11	0
6	Focused Attention	10	1
7	Perceived Control	10	1
8	Curiosity	10	1
9	Enjoyment	11	0
10	Social skill	1	10
11	Self-efficacy	10	1
12	Felt Involvement	2	9
13	Endurability	3	8
14	Interest	10	1
15	Immersion	0	11
16	Challenge	1	10
17	Satisfaction	11	0
18	Concentration	0	11
19	Trust	2	9
20	Interaction	10	1

In general, the results show a high degree of satisfaction within the participants and the comments and suggestions from them were useful in identifying the elements through their experiences, needs, and expectations.

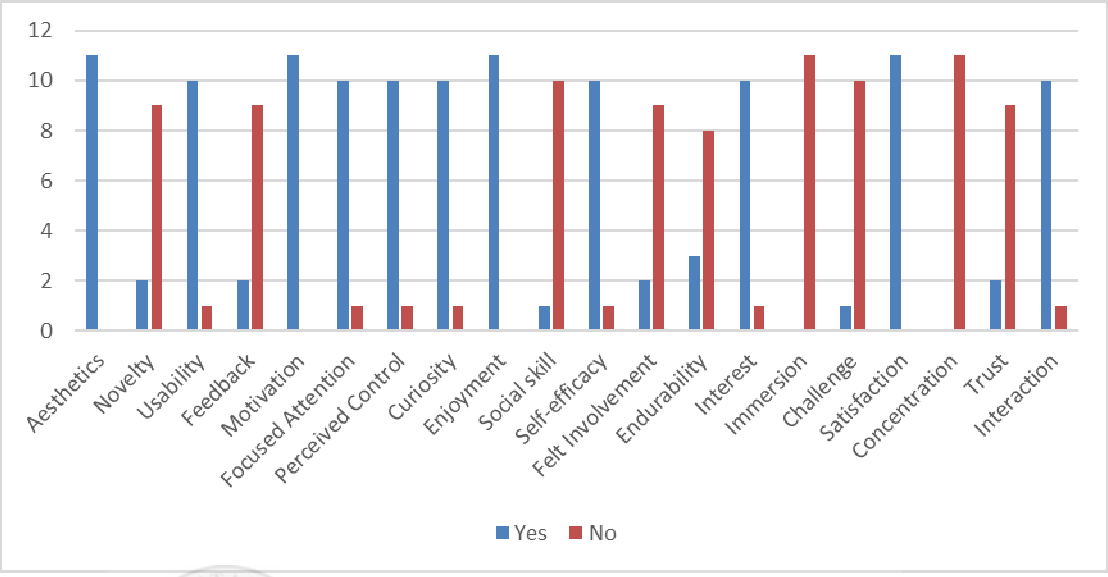


Figure 4.2. Results of elements for Focus Group

Table 4.2 and Figure 4.2 show the elements that have been selected by the participants having frequencies of ten (10) or eleven (11) "yes" responses. The elements are Aesthetics, Usability, Motivation, Focused Attention, Perceived Control, Curiosity, Enjoyment, Self-efficacy, Interest, Satisfaction, and Interaction. In addition, the participants also provided some comments and suggestions that could be summarized as follows:

1- It is recommended that the time to answer the questionnaire is shortened. When asked participants suggested the total number of items must not exceed twenty (20). The HI people find it difficult to complete long questionnaires (Tomitsch & Grechenig, 2007).

2- The participants requested the use of clearer phrases and easier vocabulary in the future for their colleagues. They have language problems and ways to

communicate with natural people (Barker et al., 2009; Mishra, Nagarkar, & Nagarkar, 2018).

These eleven (11) elements were proposed for the initial model of this study.

4.3 Initial Conceptual Model

Based on Oxman and Guyatt (1988) suggestions, a critical and comprehensive literature review was carried out by searching multiple bibliographic databases on engagement of MAR elements; searching reference list of previous eligible reviews on engagement of MAR elements; contacting scholars within MAR; searching conference proceedings, key journals and seminar articles related to engagement of MAR; HI, HCI and museum management. The outcome of these activities produced a number of elements which have been previously discussed in Chapter 2 and presented in Table 2.6. However, these elements are further scrutinized by checking their usage, definition and suitability to the HI museum visitors. Therefore, these elements were presented to the Focus Group. The results produced eleven (11) elements which are presented in Table 4.3. Based on the recommendations by the Focus Group, these elements were presented to academic expert review to validate. Figure 4.3 shows the initial conceptual model for this study.

Table 4.3

Selected Elements and their Operational Definition

No	Elements	Definitions	References
1	Aesthetics	Visual beauty or the study of natural and appealing mobile environments.	Wiebe et al. (2014); O'Brien and Toms (2010)
2	Interaction	Aware of being in control towards the application whereby interactivity, information and feedback are given-up-on an action.	Othman et al. (2011); Huang (2003).
3	Curiosity	This is when the human mind yearns for knowledge by investigates an environment, object, or situation in search of the knowledge.	Reychav et al. (2017); Webster & Ho, (1997); O'Brien and Toms (2010)
4	Usability	This is the measurement of consistency of information and ease of use application functionality as perceived by the users'	Othman et al. (2011); Hussain et al. (2015); Lund (2001)
5	Motivation	An act which encourages action or target activity to be performed by a user.	Chapman (1997); Fogg (2009).
6	Satisfaction	This is act of being content and fond with an application.	Alqahtani & Mohammad, (2015); Chin, Diehl, & Norman, (1988); Abdinnour-Helm, Chaparro and Farmer (2005).
7	Self-Efficacy	One's belief in the ability to succeed in specific situations or accomplish a task.	Beaudin (1998); Mahat, Ayub, and Luan, (2012).
8	Perceived Control	The act of dominating, commanding and regulating others, an activity, or a system.	O'Brien & Toms (2008); Boberg et al. (2015).
9	Enjoyment	The user experiencing fun, enjoy and entertainment with the usage of applications.	MäNtymäKi and Salo (2011); Nysveen et al. (2005); Pendit et al. (2014b)
10	Focused Attention	The ability to involved and absorbed on a specific task by losing track of time without being distracted	Wiebe et al. (2014); O'Brien and Toms (2010)
11	Interest	This when an object or system attract attention, provoke thought, intrigue, and fascinate a user.	Schraw, Bruning, and Svoboda (1995)

The eleven (11) elements were further evaluated in order to select the most suitable items for each measurement. For instance, the element of Aesthetics was previously measured based on items by O'Brien and Toms (2010) and it is described as the visual beauty or the study of natural and pleasing of a computer-based application. Likewise, the element of Interaction was based on items by Othman et al. (2011) and is

described as the measurement of the control, interactivity, information and feedback that are given-up-on an action. Similarly, the required items for all the other elements were also selected. The identified items for each element were adapted in order to cater to the needs of the HI and its context in museum visits. This is imperative for consistency and to ensure that the items directly measure the elements which have been identified.

Figure 4.3. The Initial Conceptual Model

A normal approach for element validation that suits the HI museum visitors is the academic expert review. Thus, the expert review phase 1 was conducted to validate the selected eleven (11) elements listed in Table 4.3.

4.4 Academic Expert Review

This subsection presents the findings from the expert review that was conducted to validate the conceptual model elements. The profiles and demographics of these experts are introduced in the subsequent section and their recommendation with respect to the conceptual model elements is also highlighted.

The academic expert review involved eleven (11) experts from the fields of Augmented Reality (AR), Mobile Augmented Reality (MAR), Multimedia systems Human Computer Interaction (HCI), Hearing Impaired (HI) and/or Museum from various countries namely: Malaysia, Romania, Australia and the United States of America (USA). The form used for the expert review containing all eleven (11) elements and their corresponding items is presented in Appendix D. The experts are all PhD holders in their domains (AR, MAR, HCI, HI, Multimedia and/or Museum) and they possess over five (5) years of working experience and of both genders (male and female). Table 4.4 below shows the profiles of the experts. The experts are assigned codes E1 to E11 to distinguish them when presenting their recommendations in the subsequent sections.

Table 4.4

Summary of Expert Details

Expert code	Country	Field of Expertise	Education	Experience (year)	Involvement stage(s)
E1	Malaysia	Museum, HCI	PhD	18	Review phase 1
E2	Malaysia	Museum, HCI	PhD	20	Review phase1
E3	USA	MAR, HI	PhD	11	Review phase1
E4	Romania	Museum, MAR	PhD	6	Review phase 1
E5	Malaysia	MAR, AR	PhD	16	Review phase 1, Review phase 2

Table 4.4 Continued

Expert code	Country	Field of Expertise	Education	Experience (year)	Involvement stage(s)
E6	Malaysia	HI, HCI, Multimedia	PhD	14	Review phase 1
E7	Australia	HCI	PhD	17	Review phase 1
E8	Malaysia	HCI, Multimedia	PhD	>5	Review phase 1, Review phase 2
E9	Malaysia	Multimedia, HCI	PhD	15	Review phase 2
E10	Malaysia	Multimedia	PhD	15	Review phase 2
E11	Malaysia	Museum	PhD	>5	Review phase 2

The first eight (8) experts were involved in Review phase 1, and two of them were involved again in the second review (Review phase 2) with the other three (3) experts. The recommendations and comments from the experts per review are further discussed.

The academic expert review form was distributed using two approaches since the experts were chosen from different continents. The first approach is via email (see Appendix C) and the other approach is hand-delivered. The forms were all collected back using the same platform in which they were given. All the experts provide their responses and some of them provide recommendations in written format for both Review phase 1 and Review phase 2. A sample of the expert review forms sent out for both Review phase 1 and 2 are documented in Appendix D and E respectively.

The measurement adapted for the elements and items followed a three-point scale: Definitely not relevant (D), Maybe not relevant (M) and Relevant (R) as cited from Sarif, Ibrahim, and Shiratuddin (2016); Pendit et al. (2014b); Burger (2009); Mason, McInnis, and Dalal (2012); Aziz, Mutalib, and Sarif (2014). The average congruent percentage value defined for the choice of elements by the experts in this research is 100%. This implies that the criterion to accept an element is based on all experts

agreed on the relevancy of the element. Details of the expert comments and recommendations with respect to each element are further discussed.

i. Aesthetics

The element of aesthetics is visual beauty or the study of natural and appealing mobile environments. This implies that the beauty which is introduced into the MAR must be apparent so that mobile users can be attracted with the application and representation of the message that the MAR application is conveying. During the first round of expert review, all the experts (E1 to E8) responded with relevant to the aesthetics element of the MAR application for HI museum visitors. This implies that the average congruency percentage value is 100%. This satisfies the criterion for selecting the element. Thus, the next step was to determine the content validity of the items. The aesthetics element adapted three items labelled.

With respect to the criteria for accepting an element and its items, the element Aesthetics is selected with certain modifications to its three items in preparation for Review phase 2. Table 4.6 gives the results of responses from Review phase 2 and Table 4.7 gives the results of the modifications after responses from Review phase 2.

ii. Interaction

Interaction is a form of awareness of being in control towards the application whereby interactivity, information and feedback are given upon an action. This implies that is a social relation and connection between a user and an application.

In Review phase 1, all the experts (E1 to E8) responded relevant on the Interaction element. This implies that the average congruency percentage value

was 100%. This satisfies the criterion for selecting an element from the response of the experts. Thus, the next step was to determine the content validity of the items. Interaction has adapted three items labelled as item 1-3.

With respect to the criteria for accepting an element and its items, the element Interaction is selected with certain modifications to its three items in preparation for Review phase 2. Table 4.6 gives the results of responses from Review phase 2 and Table 4.7 gives the results of the modifications after responses from Review phase 2.

iii. Curiosity

Curiosity is when the human mind yearns for knowledge by investigating an environment, object, or situation in search of the knowledge. From Review phase 1, not all the experts agreed that the element Curiosity is relevant as Expert E7 gave the response of 'maybe not relevant'. Expert E7 gave the opinion that since the element is required to measure engagement, Curiosity as an element may not produce relevant results to the research focus. Since the criterion to select an element requires all the experts to agree that the element is relevant and having an average congruent percentage value of 100%. Therefore, since only seven out of eight experts agreed, the element has an average congruent percentage value of 87.5% and did not satisfy the condition and hence was not chosen.

iv. Usability

The Usability element depicts consistent information and ease of use application functionality as perceived by the users. As mentioned by Sauro (2015); Othman et al. (2011), ease of use of a system is one of the measuring tools for evaluating

MAR applications and the element promotes users' engagement with an application.

From Review phase 1, the Usability element obtained an average congruency percentage value of 100% as all experts (E1 to E8) recommended the element as relevant. Therefore, the element satisfies the criterion for selection and the content validity of its items of measurement was investigated.

With respect to the criteria for accepting an element and its items, the element Usability is selected with certain modifications to its three items in preparation for Review phase 2. Table 4.6 gives the results of responses from Review phase 2 and Table 4.7 gives the results of the modifications after responses from Review phase 2.

v. Motivation

Motivation is defined as an act which encourages action or target activity to be performed by a user. This implies that Motivation is the ability for users to be willing to accomplish a task. It means is the drive towards excitement with the application in order to achieve a target.

From Review phase 1, the Motivation element obtained an average congruency percentage value of 100% as all experts (E1 to E8) recommended the element as relevant. Therefore, the element satisfies the criterion for selection and the content validity of its items of measurement was investigated.

With respect to the criteria for accepting an element and its three items, the element Motivation is selected with certain modifications to its items in preparation for Review phase 2. Table 4.6 gives the results of responses from Review phase 2 and Table 4.7 gives the results of the modifications after responses from Review phase 2.

vi. Satisfaction

Satisfaction is the act of being content and fond with an application. The element of satisfaction refers to pleasing moments with an application which leads to users fulfilling their expectations on the usage.

During the first version of the expert review, all experts (E1 to E8) responded relevant to the Satisfaction element. This implies that the average congruency percentage value is 100%. This satisfies the criterion for selecting an element from the response of the experts. Thus, the next step was to determine the content validity of the items.

With respect to the criteria for accepting an element and its items, the element Satisfaction is selected with certain modifications to its three items in preparation for Review phase 2. Table 4.6 gives the results of responses from Review phase 2 and Table 4.7 gives the results of the modifications after responses from Review phase 2.

vii. Self-Efficacy

Self-efficacy defines confidence in users' belief in their ability to succeed in specific situations or accomplish a task. For Review phase 1, not all the experts agreed that Self-Efficacy is relevant as Experts E1, E2, E4, E6 and E7 had their reservations about the element and thus responded with 'maybe not relevant'. The reservations of the element by the experts included the relation of this element to the target audience that is HI users, thus its contribution to this study was questionable. Since the criterion to select an element is by obtaining an average congruent value of 100%, this implies that self-efficacy did not satisfy the condition. This is because the percentage from the three experts who

recommended relevant for the element was only 37.5%. Thus, self-efficacy was not chosen.

viii. Perceived Control

Perceived control addresses the act of dominating, commanding and regulating others, an activity, or a system. From Review phase 1, not all the experts agreed that the element Perceived Control was relevant as Expert E7 gave the response of 'maybe not relevant'. Expert E7 gave the opinion that since the element and its corresponding items were required to measure engagement of the application, Perceived Control as an element may not produce relevant results to the research focus. The criterion to select an element requires that all experts agreed that the element is relevant and having an average congruent percentage value of 100%. Therefore, since seven out of eight experts agreed, the Perceived Control element has an average congruent percentage value of 87.5% and did not satisfy the condition and hence was not chosen.

ix. Enjoyment

Enjoyment refers to the user experiencing fun, enjoy and entertainment with the usage of the application. The element of enjoyment implies users' feeling of being benefiting to the conveying message of the interactive application.

From Review phase 1, the Enjoyment element obtained an average congruency percentage value of 100% as all experts (E1 to E8) recommended the element as relevant.

With respect to the criteria for accept an element and its four items, the element Enjoyment is selected with certain modifications to its items in preparation for Review phase 2. Table 4.6 gives the results of responses from Review phase 2

and Table 4.7 gives the results of the modifications after responses from Review phase 2.

x. Focused attention

Focused attention is the ability to be involved and absorbed on a specific task and losing track of time without being distracted. For Review phase 1, not all the experts agreed that the Focused Attention was relevant as Experts E5 and E8 had their reservations about the element and thus responded 'definitely not relevant' and 'maybe not relevant' respectively. The reservations of the element by the experts included the fact that why it must be Focused Attention' as attention should suffice. Since the criterion in selecting an element is to obtain an average congruent value of 100% implying that all the experts agree that the element is relevant, the Focused Attention did not satisfy the condition. This is because the obtained percentage for six experts recommending relevant for the element was only 75%. Thus, Focused Attention was not chosen.

xi. Interest

Interest, as defined in respect of this study is when the application attracts attention, provokes thought, intrigues and fascinates a user. For Review phase 1, not all the experts agreed that Interest was relevant as Expert E6 gave the response of 'maybe not relevant'. The reservation concerning this element by the expert was the conflict between the term interest being referred to such as long-term or short-term. For this reason, there could be conflicting results from this element to the research focus. As the usual trend for the previous elements is to select an element where all experts agree that the element is relevant and thus having an average congruent percentage value of 100%. Therefore, since

seven out of eight experts agreed, the element had an average congruent percentage value of 87.5% and did not satisfy the condition and hence was not chosen.

It was found that the instrument contained some elements that were not so relevant and certain proposed items of the elements required refinements. In terms of the proposed elements, it can be seen that only six elements are generally accepted by the experts which are Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment. Thus, only elements that are largely accepted by the experts will be considered and selected for the conceptual model development. Likewise, only the selected elements items will be taken to consideration in respect of the frequency of the corresponding items. The element threshold value was set at eight (8), that is, elements where all experts agree are relevant were selected. This implies that all the six selected elements (Aesthetics, Usability, Interaction, Motivation, Satisfaction, and Enjoyment) items are all picked and will be used for the conceptual model.

The following describes the responses of expert review phase 1 and 2 for further clarification about the selection of elements.

4.4.1 Expert Review Phase 1

All responses from the experts as discussed previously with respect to the choice of elements were then recorded. The findings from the results of the expert review phase 1 are documented in Table 4.5.

Table 4.5

Relevance of Elements for MARHIME Conceptual Model

Element	Relevant(R)	Maybe not Relevant(M)	Definitely not Relevant(D)
Aesthetics	8	0	0
Curiosity	7	1	0
Usability	8	0	0
Interaction	8	0	0
Motivation	8	0	0
Satisfaction	8	0	0
Self-Efficacy	3	5	0
Perceived Control	7	1	0
Enjoyment	8	0	0
Focused Attention	6	1	1
Interest	7	1	0

The details from Table 4.5 are displayed as a graph as shown in Figure 4.4. The legend shows the different scales, where the *x* and *y* axis represent the elements and the frequency of relevance from the experts respectively.

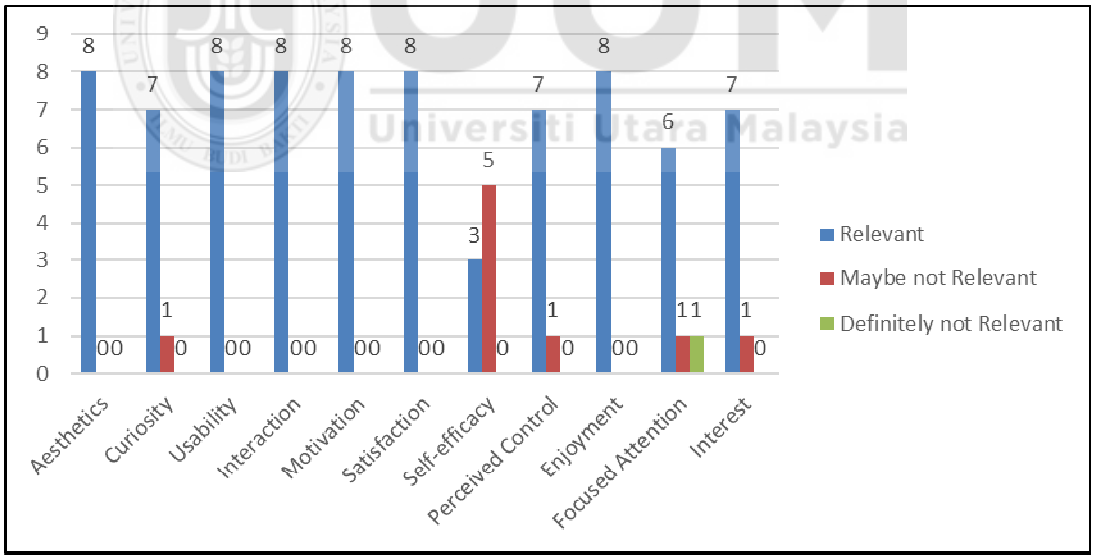


Figure 4.4. Relevancy of elements for the conceptual model

As aforementioned, the condition to select an element suitable for this study is based on the choice of all the experts review phase 1 agreeing that the element is relevant. This implies that having a frequency of 8 in Figure 4.3. Therefore, the elements

satisfying this condition and thus selected are: Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment. These selected elements from the expert review were utilized to construct the conceptual model for this study which as discussed in detail in section 4.5.

However, the proposed items for the remaining relevant elements required certain refinement. This is observed in Appendix F with the proposed items for aesthetics, interaction, satisfaction and enjoyment. Meanwhile, the number of proposed items for usability and motivation was reduced and also refined. Therefore, refinements were made based on the expert review phase 2.

4.4.2 Expert Review Phase 2

After the refinements were implemented, the instrument was resent for the expert review phase 2 using five experts. However, these five experts also requested that the conceptual model be sent alongside the edited elements. Therefore, the next section will first present the conceptual model sent to the five experts and afterwards, the response from the experts with regards to the elements will be presented. Table 4.6 displays responses from Expert Review phase 2.

Table 4.6

Responses from Experts in Review Phase 2

Element	Items	Relevant(R)	Maybe not Relevant(M)	Definitely not Relevant(D)
Aesthetics	*AES 1*	5	0	0
	AES 2	5	0	0
	AES 3	5	0	0
Usability	*USA 1*	5	0	0
	USA 2	4	1	0
	USA 3	5	0	0
Interaction	*INT 1*	5	0	0
	INT 2	5	0	0
	INT 3	4	1	0
Motivation	*MOT 1*	4	1	0
	MOT 2	5	0	0
	MOT 3	5	0	0
Satisfaction	*SAT 1*	5	0	0
	SAT 2	4	1	0
	SAT 3	5	0	0
Enjoyment	*ENJ 1*	5	0	0
	ENJ 2	5	0	0
	ENJ 3	5	0	0
	ENJ 4	4	1	0

It is worth to note that dealing with HI people is very challenging (Mishra, Nagarkar, & Nagarkar, 2018; Abdul Mutalib et al., 2015; Chen, 2014) since they have some difficulties and internal problems such as anxiety, depression, have low confidence and they tend to be isolated from the normal hearing people (Batten et al., 2013; Lesar & Vitulic, 2013; Chuan et al., 2017). In addition, they have language problems and ways to communicate with natural people (Barker et al., 2009; Mishra, Nagarkar, & Nagarkar, 2018), thus paying little or no attention to issues (Bhuvaneswari & Immanuel, 2013). For these reasons, HI people find it difficult to complete long questionnaires (Tomitsch & Grechenig, 2007). (Chuan et al., 2017) mentioned that HI are up to four times slower than normal people at completing reading. Therefore, to get the information and answers from them, the questionnaires should have short text and sentences which are clear and easy to understand in order to obtain true and realistic results (Abdul Mutalib et al., 2015; Zainuddin, Zaman, & Ahmad, 2009;

Chen, 2014). These reasons affirm the pattern of items highlighted in Table 4.7 as considered suitable for this group of HI participants. A sample of the questionnaire in English can be accessed in Appendix G while its translation to Arabic as suitable for the HI visitors to the Baghdad museum in Iraq, is presented in Appendix H. From Table 4.7, the six elements for MAR for engaging HI museum visitors have 19 items, whereby Aesthetics has three items, Usability has three items, Interaction has three items, Motivation has three items, Satisfaction has three and Enjoyment has four items.

Table 4.7

Items of Elements for Conceptual Model MARHIME

	Aesthetics
AES 1	The application is attractive.
AES 2	The application is appealing to my visual senses.
AES 3	The application screen layout is suitable.
	Usability
USA 1	The application was easy to use
USA 2	The application provides me the required guidance to perform my task
USA 3	The application provides consistent information.
	Interaction
INT 1	The application provided control through my actions.
INT 2	The application provided responses that I need.
INT 3	The application provided feedback smoothly.
	Motivation
MOT 1	The application increased my excitement with the museum exhibition
MOT 2	I feel more motivated to do an activity with the application
MOT 3	Touring the museum was more encouraging with the use of the application
	Satisfaction
SAT 1	Generally, I am satisfied with the application.
SAT 2	I became fond with the application
SAT 3	I will recommend the application to others.
	Enjoyment
ENJ 1	I enjoyed using the application
ENJ 2	The application provided me an entertaining experience
ENJ 3	It was fun using the application
ENJ 4	I did not feel the time has passed while using the application

Thus, the 19-item scale is acceptable. Therefore, the content validity of both the items and the entire scale has been validated.

The instrument used in this research was a set of questionnaires which consists of demographic profile, proposed elements, elements description and proposed items for measuring the elements as shown in Table 4.7. The process was continued by determining the scale of the instrument.

$$Interval = \frac{Range\ of\ scale}{Scale} = \frac{4}{5} = 0.8 \quad (4.1)$$

The scales that were used in this research are as follows.

i. 1-1.8: Strongly disagree

ii. 1.81-2.60: Disagree

iii. 2.61-3.40: Neutral

iv. 3.41-4.20: Agree

v. 4.21-5.00: Strongly Agree

A five-scale measurement with an interval of 0.8 ranging from strongly disagree to strongly agree was used. The interval was obtained by dividing the range of scale by the scale as given in equation 4.1 (Zikmund, Babin, Carr, & Griffin, 2010; Pendit et al., 2014b). Next section will first present the validated conceptual model. The instrument together with the scales is documented in Appendix G.

4.5 Validated Conceptual Model

Based on expert reviews findings it is suggested that the conceptual model has two (2) layers; one layer for six (6) elements and another layer is more detailed of Technology and more information Architecture.

4.5.1 First Layer of MARHIME Conceptual Model

The first layer conceptual model depicts the six selected elements from the expert review phase 2 as discussed in the previous section. The elements are Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment in relation with the elements of Engagement. The combination of these six elements of Engagement representing the first layer of the conceptual model of mobile augmented reality for engaging the HI museum visitors and it is illustrated in Figure 4.5.

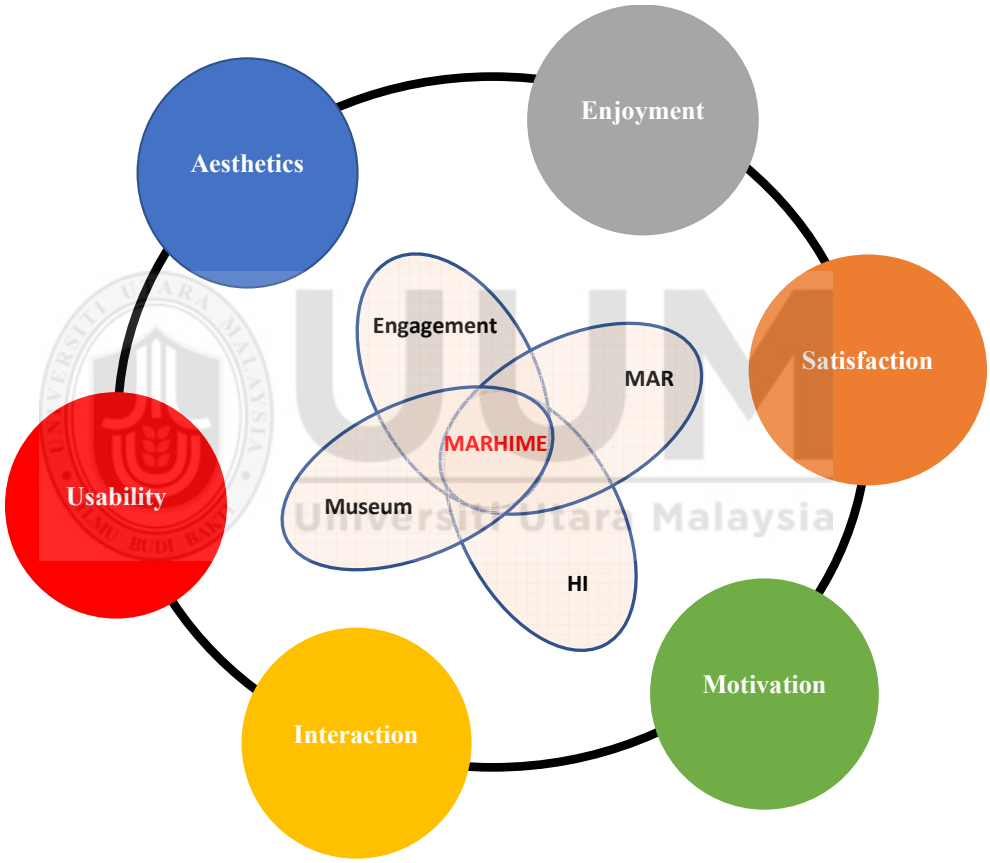


Figure 4.5. First Layer of the MARHIME Conceptual Model

As shown in Figure 4.5, the four main components are Museum, MAR, HI, and Engagement altogether produced the first layer of the MARHIME conceptual model. On top of that, six elements have been incorporated into the MARHIME conceptual

model that includes: Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment.

The MARHIME conceptual model covers areas of Engagement, MAR, Museum and HI. The six selected elements are for engagement between the HI visitors and the application. Meanwhile, the six selected elements initiate the engagement between the HI visitors and the application. This conceptual model was verified by the experts involved in Review phase 2 for all the elements and their respective items. The aim of conducting the expert review is to validate the conceptual model. In Review phase 2, besides reviewing the elements, recommendations pertaining to the model were provided. The response from the experts was that they accepted the conceptual model as suitable.

4.5.2 Structure of the MARHIME Conceptual Model

The final version of the MARHIME conceptual model is illustrated in Figure 4.6 which consists of two levels. In the first level 'Technology' is divided into two components. The first main component is 'Hardware' that is needed for developing the MAR which consists of 'Mobile & Tablet'. While the second main component is the Software which consists of 'Vuforia/Unity 3D/C++', 'Android SDK/Java SDK', 'Target Database', 'Target Tracking for AR marker' and 'Multimedia Objects'. The multimedia objects in this model consist of four elements; '3D mode', 'Text', 'Video' and 'Images'. The following are the components of the 'Technology':

- 'Vuforia/Unity 3D/C++' – all the tools used to develop the MARHIME conceptual model in addition to other software to create the video by Window Movie Maker and to create and edit the 3D model by using 3DS MAX.

- 'Android SDK/Java SDK' – these are the software development tools to build the MARHIME prototype for Android phones and tablets.
- 'Target Database' – it is used to store the images that were uploaded as target markers, the database created by using the Vuforia online database.
- 'Target Tracking for AR Marker' – The tracking method involves registering what is being captured by the mobile camera and linking it with a specified 3D computer generated image. Marker-based tracking is easy to implement with the use of artificial features tracking and are quite suitable for indoor AR prototype such as the MARHIME which is for indoor museum environment. The MARHIME prototype will display and superimpose the respective computer-generated object (image, text, video, or 3D model) onto the mobile device screen once a marker has been recognised.
- 'Multimedia Objects' – many types of multimedia objects ('3D mode', 'Text', 'Video' and 'Images') are used to display the content of application such as background, AR markers and multimedia information for the artefacts of the museum.

The second level consists of six engagement elements and their features have been incorporated into the MARHIME conceptual model namely; Aesthetics, Usability, Interaction, Motivation, Satisfaction, and Enjoyment. The following subsections discuss each element in the MARHIME conceptual model as illustrated in Figure 4.6. The discussion reflects the relationship between the elements and their features as expressed by the conceptual model of Mobile Augmented Reality for Engaging the Hearing-Impaired Museum Visitors.

i. Aesthetics in MARHIME

Aesthetics is defined as visual beauty or the study of natural and appealing mobile environments. It is shown through the interface of the MARHIME application so that the HI visitors can appreciate the expression and representation of the message that the application is conveying. This element revolves around the attractiveness of the application, its visual appeal and screen layout which would compel users to continue to engage with the application. This finding is in line with Carlson (1993) explanation on the linkage between aesthetics and engagement whereas the result outcomes from O'Brien and Toms (2010); Wiebe et al. (2014) support the fact that the element of aesthetics increases engagement in application's interaction. Based on the expert review, it shows that aesthetics may affect the HI engagement of MAR. Therefore, the aesthetics element consists of three main features that include; 'Attraction', 'Screen Layout' and 'Visual Sense' as implemented in O'Brien and Toms (2010); Wiebe et al. (2014). The first feature is 'Attraction' could be 'Image background', 'Splash screen' and 'Colours of icons'. The second feature is 'Screen layout' could be ' Splash screen in full size' and 'Suitable video in a full-screen layout'. Last feature is 'Visual Sense' could be 'Appealing text', 'Appealing colours' and 'Appealing images '.

ii. Usability in MARHIME

Usability depicts consistency of information; ease of use and providing required guidance to complete assigned tasks. Ease of use of a system is one of the measuring tools for evaluating the MARHIME application and the element promotes user engagement with an application. This element entails application consistent information provided which represents the ease of use of the

application. Likewise, usability element promotes positive HI experience during HI interaction with the application. This outcome supports arguments from Hector and Payel (2014); Pribeanu (2014); O'Brien and Toms (2010); Huang and Liao (2015); Nilsson and Johansson (2007) studies that usability enhances continuity usage of the application and promotes engagement. Therefore, the Usability element consists of two main features namely; ‘Ease of Use’ and ‘Consistent Information’ implemented in Othman et al. (2011); Al-Aidaroos (2017). The first feature is ‘Ease of Use’ could be 'Easy to use video', ' Easy to use scan camera', ' Easy to use AR markers', 'Easy to use scrollbars', 'Easy to rotate 3D model' and 'Help screen as guidance to perform the task'. The second feature is ‘Consistent information’ could be 'The amount of information', 'The duration of video' and 'The size and style of multimedia object’.

iii. Interaction in MARHIME

The element of interaction reflects the awareness of being in control towards the application whereby interactivity, information and feedback are provided upon an action. Interactive platform and application communication nature will promote the HI engagement. The control must be effectively used between the HI and the application. The application then must provide responses to the HI upon actions and the feedback must be smooth. This is critical to engagement because it will determine if the user is willing to continue to use the application. This is found to be in line with outcomes from Wu, Y., Wu, Y., and Yu, S. (2015); Sutcliffe (2009); Othman et al. (2011) which pointed out that interaction enhances engagement. The Interaction element which consist of two main features namely; ‘Control’ and ‘Feedback’ was implemented in Othman et al. (2011); Permadi and Rafi (2016). The first feature is ‘Control’ could be ' On moving images', 'During

video playback', 'Interaction with AR markers', 'Rotating the 3D model' and 'During game'. The second feature is ‘Feedback’ could be ' Smooth 3D rotation', 'Responses upon camera scanning' and 'Responses on scrollbar movement'.

iv. Motivation in MARHIME

Motivation is defined as an act which encourages action or target activity to be performed by the HI. This implies that Motivation is the ability for the HI to be willing to accomplish a task. The HI may engage with applications that they perceive to increase their excitement and motivate them towards completing their tasks. This element depicts that the application should be able to encourage the HI participation in related museum activities. These arguments support the findings from Gopalan et al. (2016); Przybylski, Rigby, and Ryan (2010); Di Serio et al. (2013) studies where it was pinpointed that MAR may contribute to motivation during the user-application interaction. The Motivation element consists of two main features namely; ‘Excitement’ and ‘Sharing’ was implemented in Chapman (1997); Gopalan et al. (2016). The first feature is ‘Excitement’ could be 'Moveable image during display' and 'Wide range of activities'. Second feature is ‘Sharing’ could be 'The like to social media' and 'Social encouragement to further touring the museum'.

v. Satisfaction in MARHIME

Satisfaction is defined as an act of being content and fond with an application. The user would generally feel satisfied and become fond with an application which leads to the HI fulfilling their expectations on the usage. This element pinpoints that every HI usually has predefined target or aim for exploring an application whereas if this target or aim is not met then they will disengage with

the application. On the other hand, if the target or aim is met then they will become more engaged with the application and will recommend the application to other HI. This finding corroborates the argument by Kim et al. (2013); Alqahtani and Mohammad (2015) whereby satisfaction is found to be related to engagement. The Satisfaction element consists of two main features namely; ‘Recommendation’ and ‘Fond’ which has been implemented in Alqahtani & Mohammad, (2015); Permadi and Rafi (2016). The first feature is ‘Recommendation’ could be 'Satisfied on AR marker', 'Satisfied with video', 'Satisfied with text information' and 'Share to others using social media'. The second feature is ‘Fond’ could be 'Like to use AR'.

vi. Enjoyment in MARHIME

Enjoyment implies fun, enjoy and entertainment with the usage of applications. This concept involves the HI experiencing enjoyment, fun, and entertainment while using the application in touring the museum with fulfilment based on their interaction with the MARHIME application. The element of enjoyment is linked with the element of engagement in such a way that when the HI are experiencing enjoyment as the result of their interaction with the application, then the HI engagement with the application will be increased. This outcome supports fthe indings from Karimi and Lim (2010); Xie, Antle, and Motamedi (2008) where it can be seen that when the HI experience enjoyment due to their interaction with an application, then it will increase the HI engagement with the application. Enjoyment consists of two main features namely; ‘Manipulating’ and ‘Entertainment’ as implemented in Pendit et al. (2014b). The first feature is ‘Manipulating’ could be 'Playing game', 'Enjoy reading text', 'Enjoy looking at images', 'Enjoy watching video' and 'Scanning the AR marker'. Second feature is

‘Entertainment’ could be 'Long time using the application'. The instrument together with the scales is documented in Appendix G.

4.6 Chapter Summary

This chapter describes the development of the conceptual model of MAR for engaging the HI museum visitors. Chapter 2 has presented a critical and comprehensive literature review that was carried out by searching multiple bibliographic databases on engagement of MAR elements. Then twenty (20) elements were presented to the focus group of which eleven (11) elements were selected. The eleven (11) elements were then put through the expert review phase 1 for validation purpose. The outcome from the expert review phase 1 resulted with six elements which were used to develop the first layer of the MARHIME conceptual model and then the final MARHIME conceptual model. The penultimate section shows the final version of the conceptual model after the expert review phase 2. The next chapter will discuss the design of the MARHIME prototype. In addition, the validation of the prototype will also be mentioned.

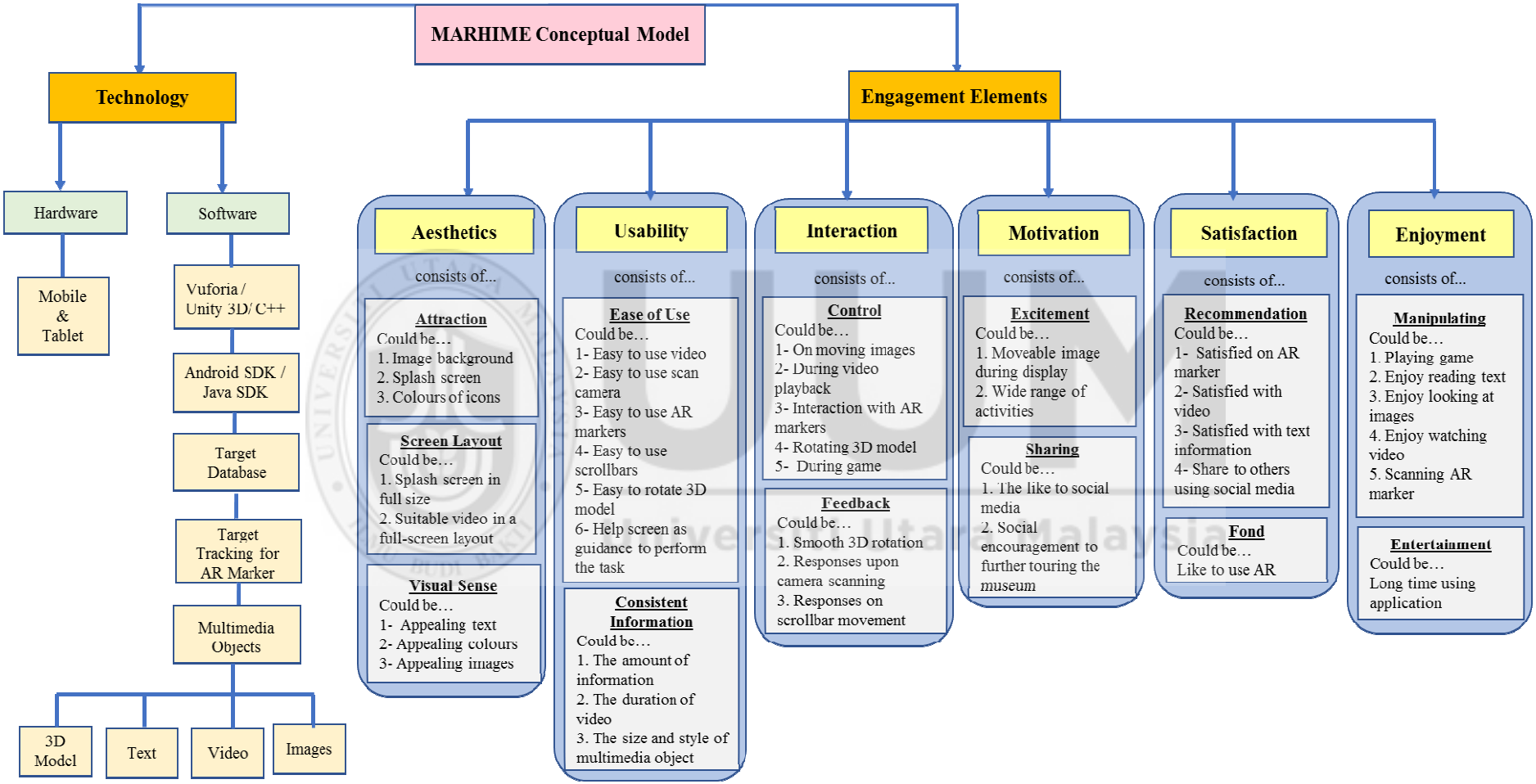


Figure 4.6. A Conceptual Model of Mobile Augmented Reality for Engaging the HI Museum Visitors

CHAPTER FIVE
PROTOTYPE DEVELOPMENT AND EVALUATION OF MAR FOR ENGAGING HI MUSEUM VISITORS

5.1 Introduction

This chapter highlights the design, development and evaluation of the MARHIME prototype based on the conceptual model discussed in Chapter 4. The main objective of the MARHIME prototype is to engage Hearing-Impaired (HI) museum visitors. In the subsequent sections of this chapter, the requirements and architecture that were adapted for the development of the MARHIME prototype are highlighted. The subsequent sections of this chapter shed more light on the phases encountered for the design, development and evaluation of the MARHIME prototype.

5.2 Requirements of MARHIME

To develop an accurate and useful mobile prototype, a significant step is to identify the requirements. The general requirements for any prototype such as the MARHIME include both the functional and technical specifications. Therefore, the following subsections will highlight those requirements and in addition a discussion on the relations of the functions with the selected elements of the MARHIME conceptual model.

5.2.1 Components Related to the Elements of MARHIME

The components that allow the user to view the input and program response actions in terms of the prototype capabilities are shown in Table 5.1. These components are listed with respect to each interface that has been developed for the prototype. This

study develops the MARHIME prototype highlighting three artefacts from the Iraq museum including game and connection to social media in order to increase the HI visitors' engagement with the prototype. Thus, the prototype suitably justifies its usage of granting the HI visitors with palatable visit to the museum.

Table 5.1

Components Related to the Elements of MARHIME

No	MARHIME Component	Aesthetics	Usability	Interaction	Motivation	Satisfaction	Enjoyment	References
1	Image	√	√	√	√	√	√	Pendit (2015); Al-Aidaroos (2017); Gopalan et al. (2016); Permadi and Rafi (2016); Chapman (1997)
2	Text	√	√		√		√	Pendit (2015); Al-Aidaroos (2017); Gopalan et al. (2016); Chapman (1997)
3	Video	√	√	√	√	√	√	Pendit (2015); Al-Aidaroos (2017); Gopalan et al. (2016); Permadi and Rafi (2016); Chapman (1997)
4	Colours	√						Al-Aidaroos, A. S. A. (2017); Chapman (1997)
5	Help screen		√					Al-Aidaroos (2017)
6	Scan camera		√	√	√	√	√	Pendit (2015); Gopalan et al. (2016); Permadi and Rafi (2016)
7	Image target (AR object)		√	√	√	√	√	Pendit (2015); Gopalan et al. (2016); Permadi and Rafi (2016)
8	Video target (AR object)		√	√	√	√	√	Pendit (2015); Gopalan et al. (2016); Permadi and Rafi (2016)
9	Text target (AR object)		√	√	√	√	√	Pendit (2015); Gopalan et al. (2016); Permadi and Rafi (2016)
10	3D target (AR object)		√		√	√	√	Pendit (2015); Gopalan et al. (2016); Permadi and Rafi (2016)
11	Scroll horizontal and vertical bar		√		√			Al-Aidaroos, A. S. A. (2017)
12	Rotate 360 degree		√		√		√	Pendit (2015); Gopalan et al. (2016)
13	Random movement						√	Pendit (2015).
14	Touch screen		√		√		√	Pendit (2015); Gopalan et al. (2016)
15	Facebook link					√	√	Pendit (2015)

Table 5.1 Continued

No	MARHIME Component	Aesthetics	Usability	Interaction	Motivation	Satisfaction	Enjoyment	References
17	Twitter link						√	Pendit (2015)
18	Game		√	√	√	√	√	Pendit (2015); Permadi and Rafi (2016)
19	Video Time		√					(Shelena, 2017).

Having presented the discussion for the components related to the elements of MARHIME, the next section considers the technical requirements needed to be in place to ensure great experience by the users of the prototype.

5.2.2 Technical Requirements

Technical requirements are a set of specifications that must be met to allow a hardware product to be fully operational. There are certain compatible technical requirements that must be satisfied to ensure efficiency and effectiveness, thus, these specifications to be discussed are chosen for optimal performance of the MARHIME prototype.

The usage of the MARHIME prototype requires the displaying of augmented 3D computer generated object. For this reason, this research uses a smartphone. The MARHIME prototype works on a mobile device with a minimum Android version 2.3 for the operating system (OS) and the Android platform includes a set of managed prototype programming interfaces (API). In addition, for the MARHIME to operate in a smooth, hitch free manner, it is necessary to run with a Central Processing Unit (CPU) with at least 1.4 GHz, 2GB of RAM and display screen resolution of 1024 x 600 pixels. The MARHIME prototype requires an android device with a Graphic User Interface (GUI). The GUI is useful for better engaging HI visitors in the museum

through the adaptation of many types of multimedia objects such as image, text, video and 3D model. These multimedia objects give visitors and all-round knowledge and information pertaining to the artefacts in the museum. For this research, the android device used is a Samsung Note 5 with specifications; Android 5.1.1 OS, 32GB storage, 1.5 GHz octa-core processor, 1440 x 2560 pixels resolution and 16-megapixel rear camera.

The presence of the rear camera is very important in mobile device for tracking of AR markers. These markers are usually square shaped predefined images printed on a piece of paper and placed on the scene to identify the place where digital information is to be presented. The tracking method involves registering what is being captured by the camera and linking it with a specified 3D computer generated image. Marker based tracking are easy to implement with the use of artificial features tracking and are quite suitable for indoor AR prototype such as the MARHIME which is for indoor museum environment. More details on the usage of AR markers will be addressed when discussing the MARHIME prototype development.

5.3 MARHIME Architecture

To validate the conceptual model developed in the previous chapter, a prototype for MARHIME has been developed. In developing this prototype, a mobile simulator architecture was first designed using an assembly process for the MAR environment. AR technology has great relevance for prototype in different fields, thus assembly process is suitable for designing the MAR architecture as the assembly task in itself requires making a sequence of operations and procedures. A two-dimensional (2D) sketch is normally used in the assembly process to guide users in the phases involved in the assembly steps. This sketch contains a list of labelled portions and phases and

how they are executed or accomplished. Therefore, the concept of using 2D sketches in assembly is adopted in this study to design the MAR architecture. This architecture consists of the phases executed in developing the MARHIME prototype which include the required development tools, AR markers and scenes to complete the assembly procedure as shown in Figure 5.1.

This Figure illustrates the architecture of MARHIME prototype showing that the prototype design passes through different stages with the use of several tools. The utilization of the MARHIME prototype requires interaction of the device's camera with the AR markers as depicted in the development tools section. The MARHIME architecture requires a new database created from Vuforia AR toolkit online database (Qualcomm, 2014) to set the target markers for each of the museum artefacts. A single target-based image is selected with customised dimensions and uploaded, to add a target to the database. This allows the activation of the authoring part in the Unity 3D software (Unity, 2014) which will be discussed later in this chapter. Overall, to materialize this MARHIME architecture requires the use of four software; Windows Movie Maker, 3DS Max, Vuforia Software Development Kit (SDK) and Unity 3D. The next section discusses the role played by each of this software in the prototype development.

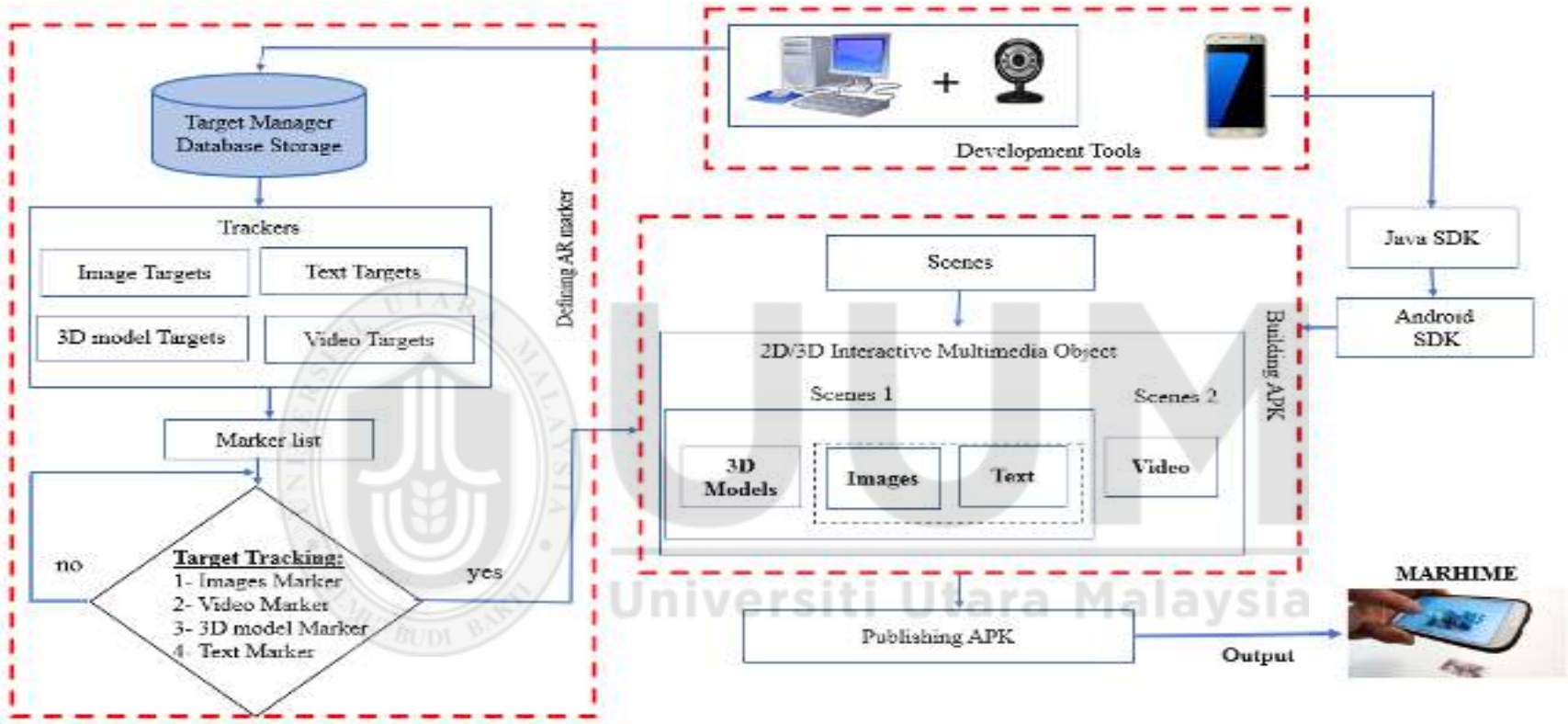


Figure 5.1. Architecture of MARHIME Prototype Development

5.4 Prototype Development

The MARHIME prototype was designed specifically for engaging HI museum visitors and the development of the prototype involved two main stages. The first stage handles the creation of content while the second stage deal with the integration of the prototype on the mobile device. The roles of the previously mentioned software for the MARHIME prototype development include: Windows Movie Maker for compiling videos of the artefacts, 3DS Max for the creations and modifications of the 3D models, Vuforia SDK as Android development SDK and Unity 3D for the development and deployment of MARHIME onto the android device. On utilizing the software, the prototype can be installed on any Android smartphone.

5.4.1 Contents of the MARHIME Prototype

Considering the first stage that involves the creation of content, this phase started with the gathering of relevant information to be included in the prototype. The contents of MARHIME entails images, videos, text and 3D models (in suitable smartphone requirement format) gathered for the three artefacts from the Iraq museum. The reason for requiring images, videos, text and 3D models of each artefact is because the target audience are the HI, therefore, it is important to insert appropriate formats in order to interact with their visual sense. The content of MARHIME also covers the features and history of the selected artefacts.

The use of the MARHIME prototype in the museum requires the use of AR markers. These markers must be implemented with the installed prototype for proper functioning. The MARHIME prototype will display and superimpose the respective computer-generated object (image, text, video, or 3D model) onto the mobile device screen once a marker has been recognised. Therefore, the Vuforia software marker

manager was used in creating the marker. A device database was created using the Vuforia online database and a new target has been identified and given a name as shown in Figure 5.2. For MARHIME prototype, the targets include image, text, video and 3D model. The target dimensions or size were set and then the target image file was uploaded to the Vuforia database. With Vuforia, the marker can be saved in either a JPEG or PNG image file format. For the MARHIME prototype, the markers were saved in JPEG as shown in Figure 5.3. The Unity 3D software was used to integrate the contents of the MARHIME prototype in three phases that include; 3D modelling, video text and finally using the augmented reality SDK.

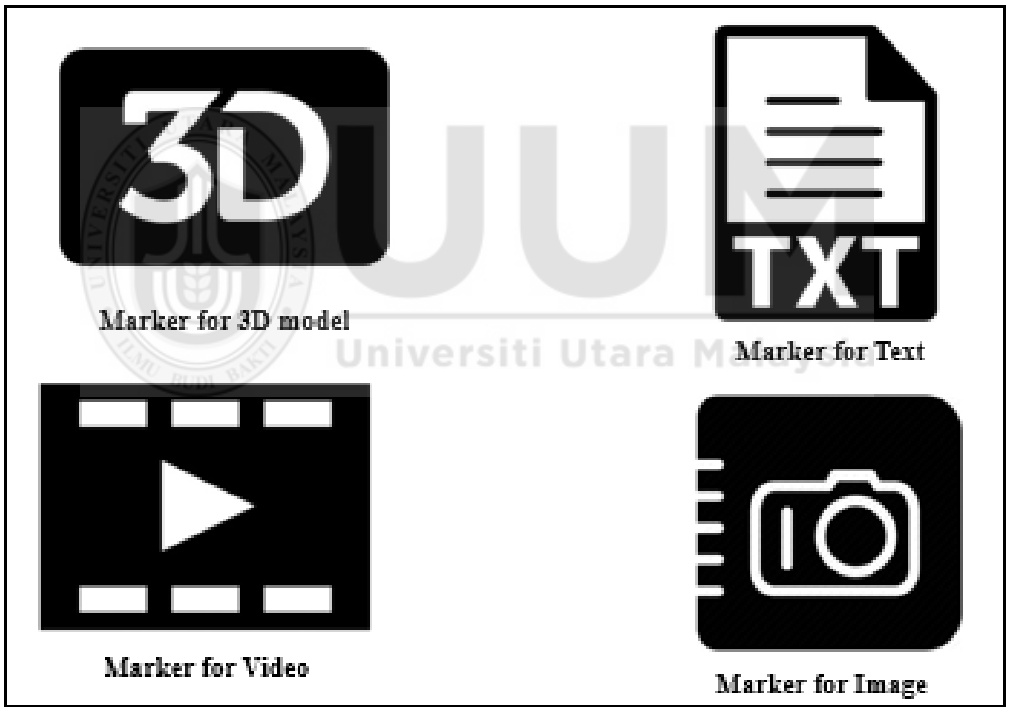


Figure 5.2. Image-based markers for the MARHIME prototype

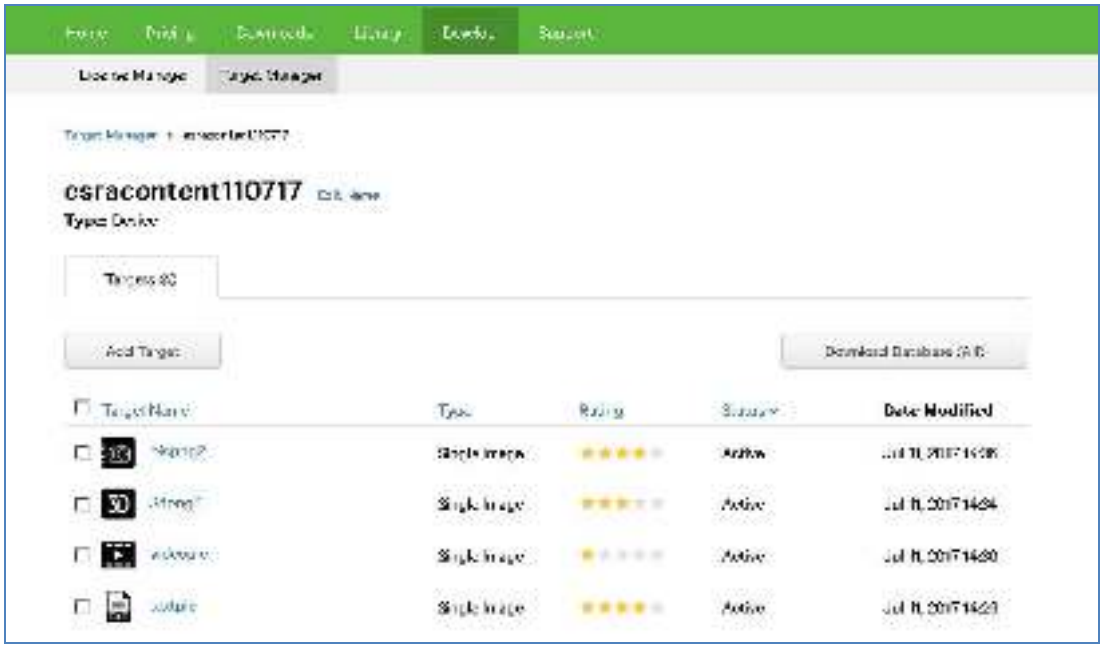


Figure 5.3. Vuforia database for MARHIME prototype

5.4.2 Integration of MARHIME on Mobile Device

In order to achieve the augmented reality environment, Vuforia was used. Several features were determined for MARHIME as highlighted in the previous subsection and set in Vuforia. These features comprise of image targets, text targets, 3D model targets, video targets and the SDK project file for the Android development. The marker project file was downloaded from the Vuforia database after the images were uploaded as target markers. A Unity Editor file was selected to match the authoring development of the Unity 3D software. Then the augmented reality unity project was set up with Vuforia SDK, saved and downloaded for further development in the Unity 3D software. This implied that, the development of MARHIME requires the merging of Vuforia and Unity 3D software. The prototype also used C++ language during the development phase. The overall development of MARHIME including compilation, visual development, interaction, content presentation and deployment to mobile device, employed the use of Unity 3D.

The main interface of the MARHIME prototype includes 4 main icons consisting of three artefacts and a game, in addition to the icons for navigation to social media. These icons are stored in the Unity workspace. For the MARHIME prototype, a raw image was inserted and saved in the Unity workspace to function as the background of the prototype. This prototype requires a scene exchange; as such an object named Manager was created and the script for the corresponding icons was attached to the object. In order to scan, a script written in C++ was created. Therefore, when a marker is scanned, the virtual content that is attached to the marker appears on the mobile screen. The details of the output on the mobile screen will be discussed in detail in subsequent sections. Figures 5.4-5.7 presents some screenshots of the interfaces for Unity 3D, Windows Movie Maker, 3DS Max and a sample of C++ codes respectively.

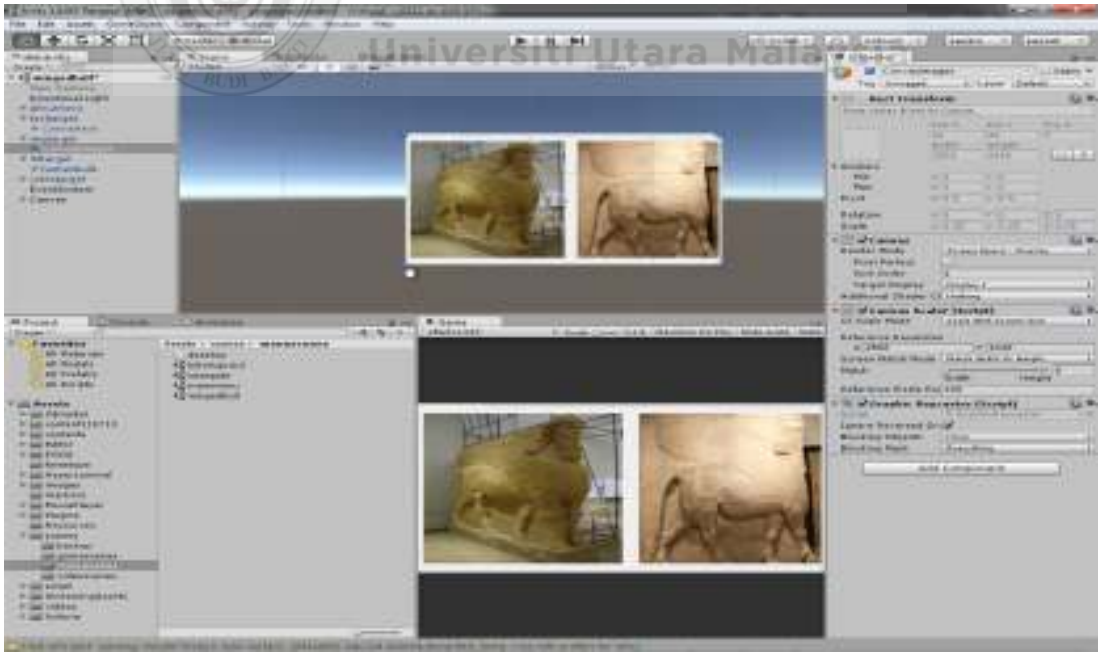


Figure 5.4. Unity 3D Interface

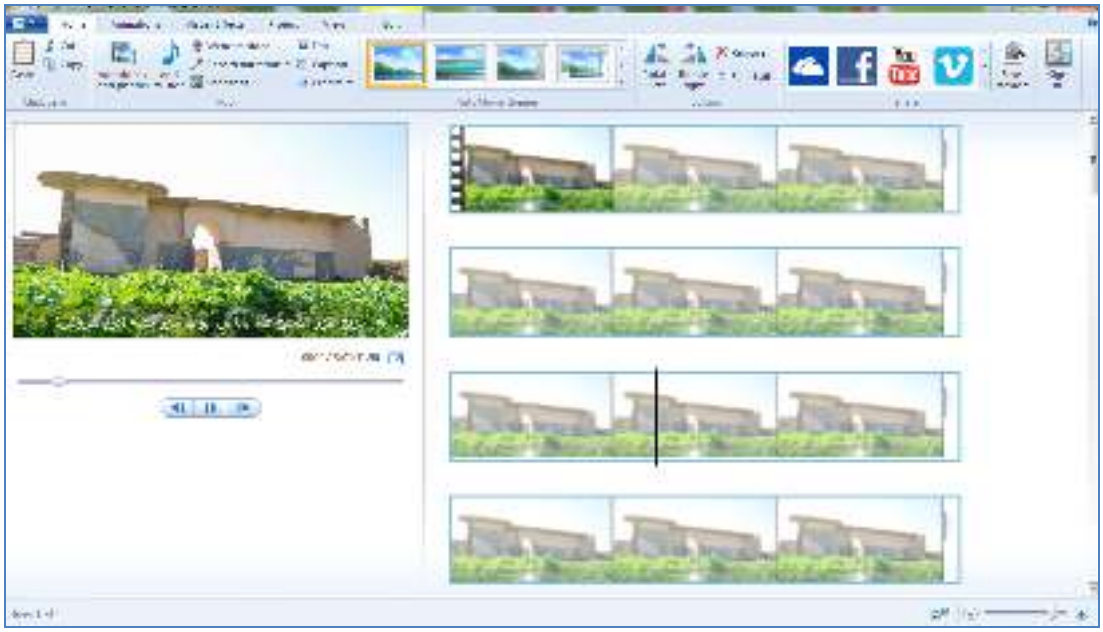


Figure 5.5. Windows Movie Maker

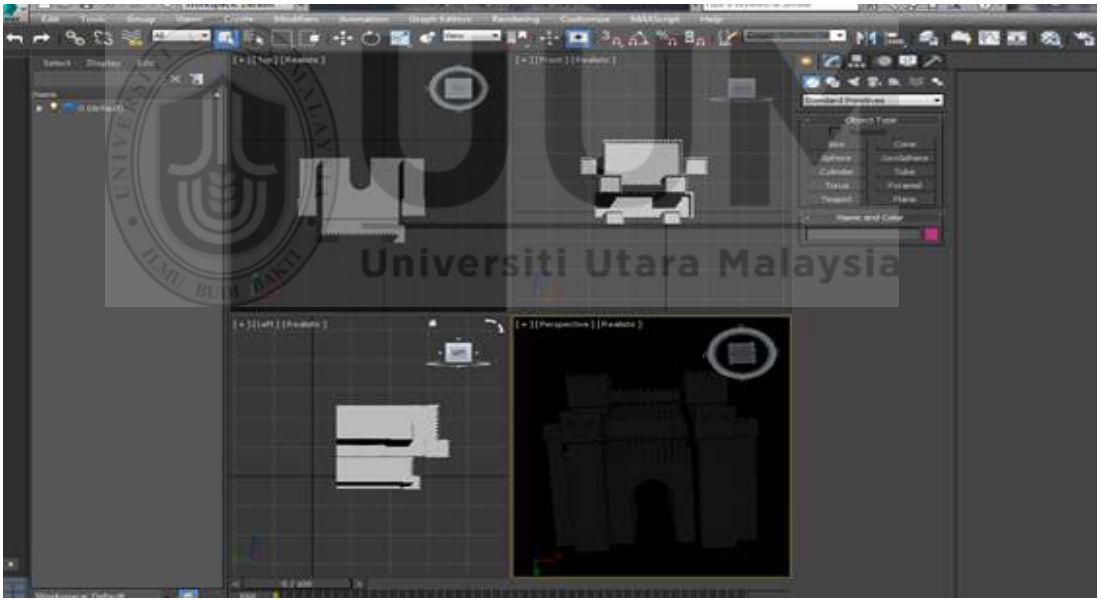


Figure 5.6. 3DS Max

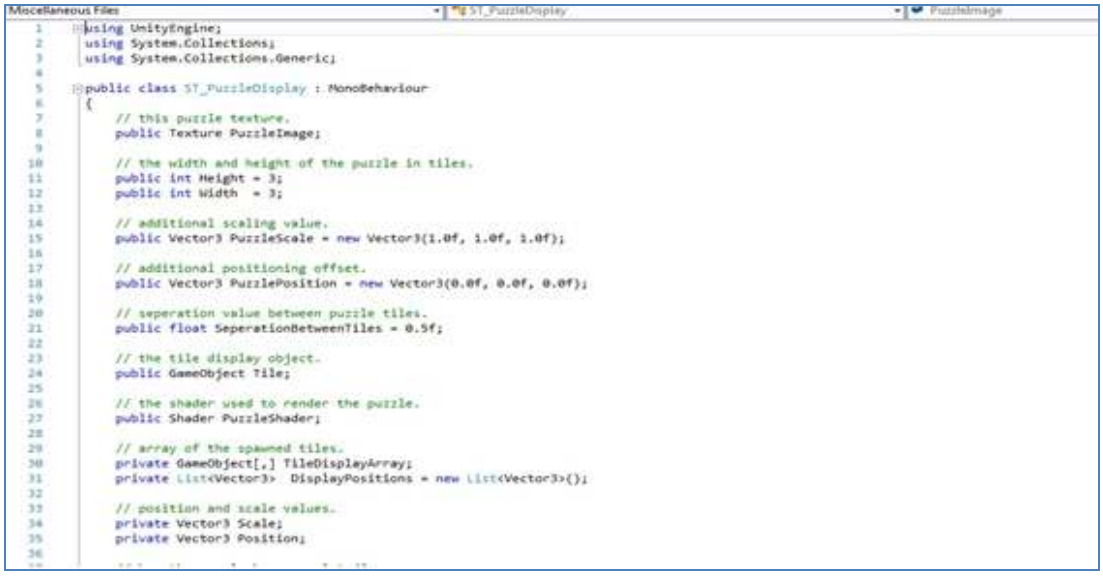


Figure 5.7. Sample C++ Codes

5.5 MARHIME Prototype Version 1

The resultant MARHIME prototype from the phases discussed in the previous section can be installed on any Android smartphone. This prototype has taken into consideration all the functional and technical requirements and is therefore ready for use. The interfaces of the MARHIME prototype will be displayed in the following sections. These interfaces are grouped into two; the home page and the interaction function interface.

5.5.1 Home Page

The prototype starts with a splash screen which precedes the home page. This splash screen consists of images of the Iraq museum displayed in a slideshow for few seconds. At the end of the slideshow, the Main Menu pops up and the user can further interact with the prototype. Figure 5.8 shows the interfaces from the splash screen to the Main Menu.

Figure 5.8. Splash Screen and Main Menu

5.5.2 Interaction Function Interface

The Main Menu has several icons as seen on the right in Figure 5.8. The top two icons on the right and left execute the help and exit buttons respectively. Meanwhile, the four icons in the middle execute the three artefacts (Ishtar gate, Winged Bull and Harmal Hill respectively) while the last icon executes the game. The Facebook, YouTube and Twitter icons below are the social media icons.

In order to execute the icons for the artefacts of the museum to display 3D model, image, text and video information about these artefacts, two main components are required. These components are the AR markers (3D model, Image, Text, Video) and the MARHIME prototype on the mobile device. The steps when these icons are displayed are discussed as follows.

1. **Ishtar Gate**

   The Ishtar gate was the eighth gate to the inner city of Babylon, the ancient Mesopotamian city in what is today Iraq. When the user clicks its icon on the

Main Menu, it automatically opens the mobile device camera. As soon as the camera is launched, the user can now scan the desired marker by placing the marker in front of the camera to display the corresponding information.

When the user places the camera over the 3D AR marker from Figure 5.2, the 3D model of the Ishtar gate is displayed on the device screen as seen in Figure 5.9. The user can touch the screen to rotate the object in 360 degrees and also zoom in and out of the object by moving the camera closer or farther from the marker.

Figure 5.9. 3D Interface and display for the Ishtar Gate

When the image marker from Figure 5.2 is superimposed, MARHIME displays images of the Ishtar gate as seen in the museum. The user can navigate through these images using the scrollbar as shown in Figure 5.10.

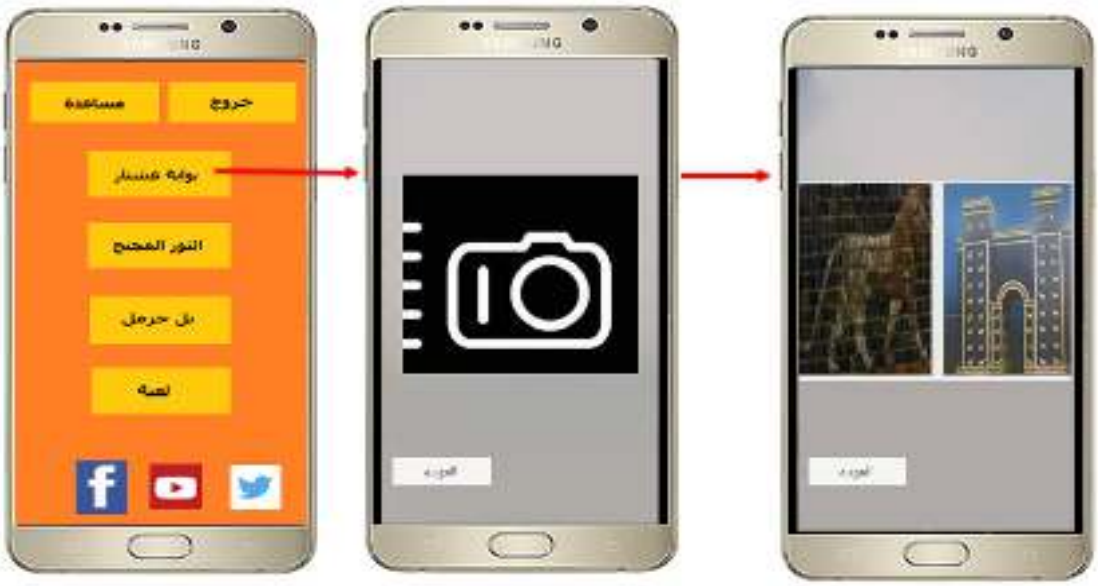


Figure 5.10. Image Interface of Ishtar Gate

Likewise, when the user places the text marker from Figure 5.2 in front of the mobile device camera, the prototype shows information about the Ishtar gate as a text document. The user can scroll up and down to read more about this artefact as seen in Figure 5.11.

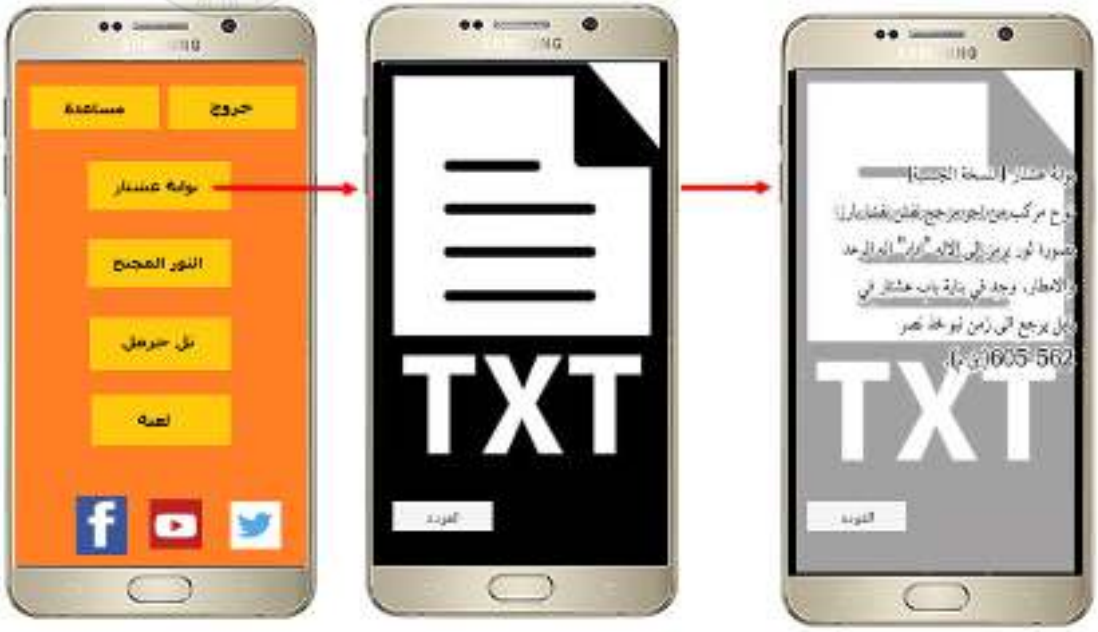


Figure 5.11. Text Interface of Ishtar Gate

The last marker from Figure 5.2 is the video AR marker. Superimposing this marker with the mobile device camera initiates a short, subtitled video about the Ishtar gate. The video displays different video clips of the Ishtar gate while giving some historical details about the artefact. Figure 5.12 shows the execution of these steps.

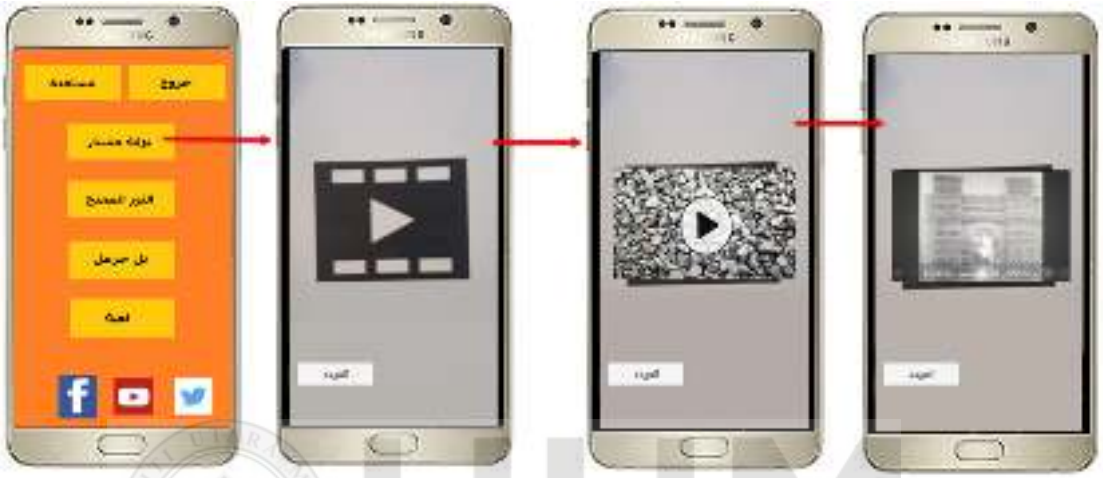


Figure 5.12. Video Interface of Ishtar Gate

2. Winged Bull

It has been recorded in history that the winged bull stood at one of the many gates along Nineveh's city walls, as a protective spirit and a symbol of the power of the Assyrian king. A click on the icon of the winged bull on the main menu screen also launches the camera of the mobile device just as the case of the previous artefact. The user can now scan the 3D model, text, image or video markers by placing the required marker in front of the camera to display the corresponding information.

For the winged bull interface, when the user places the camera over the 3D AR marker, the 3D model of the winged bull is displayed on the device screen as seen in Figure 5.13. This model can be rotated or resized by the user as preferred.

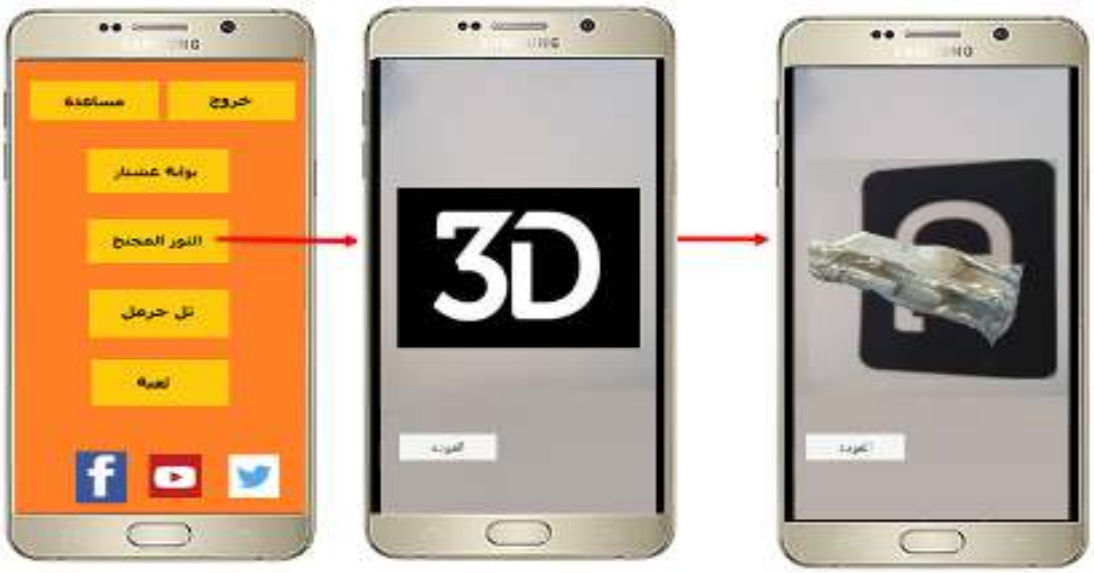


Figure 5.13. 3D Interface of Winged Bull

The second marker is the image marker from Figure 5.2. After clicking the icon for the winged bull and superimposing this image marker, MARHIME prototype displays the images of the Winged Bull as seen in the museum. The user can navigate through these images using the scrollbar as displayed in Figure 5.14.

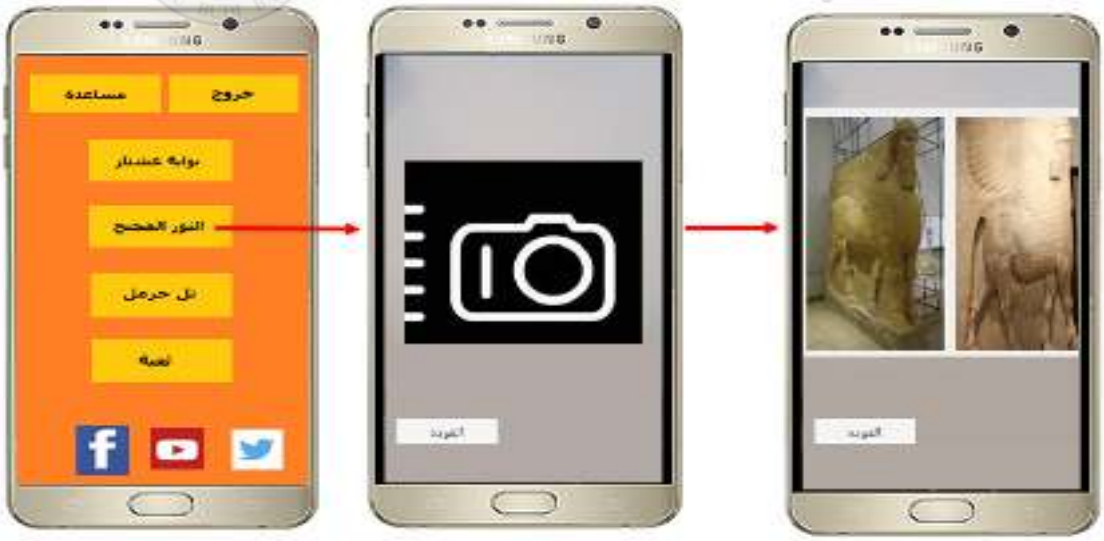


Figure 5.14. Image Interface of Winged Bull

Likewise, when the user places the text marker from Figure 5.2 in front of the mobile device camera after clicking the winged bull icon, the prototype shows information about the Winged Bull as a text document. Scrolling up and down allows the user to read more about this artefact as seen in Figure 5.15.

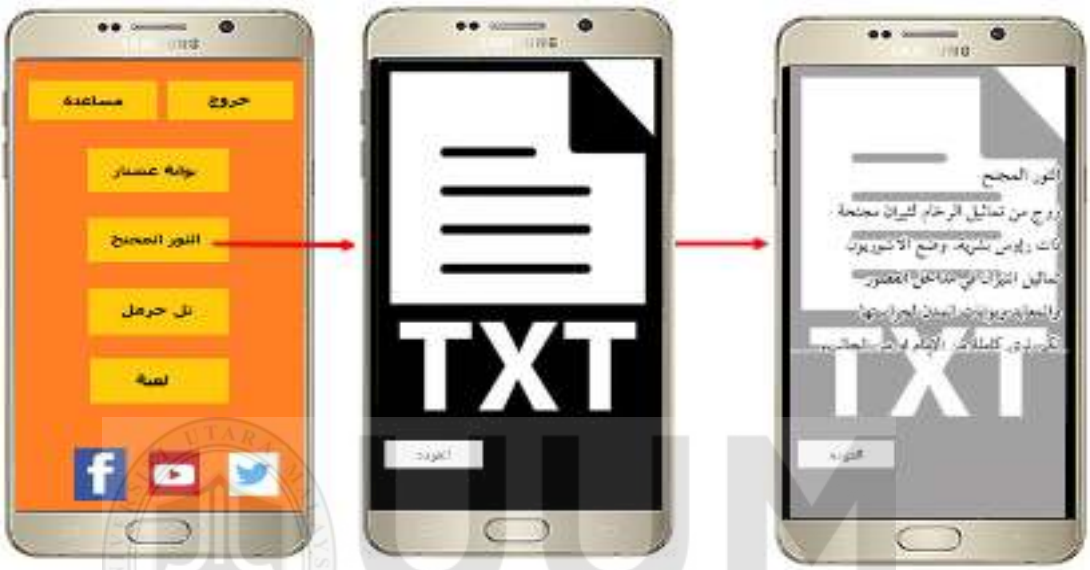


Figure 5.15. Text Interface of Winged Bull

Finally, for the video marker from Figure 5.2, a scan of the marker with the mobile device camera displays a short, subtitled video about the Winged Bull. The history and other relevant information are highlighted in this video using a video clip slideshow with text interpreting each scene. The flow of the steps is seen in Figure 5.16.

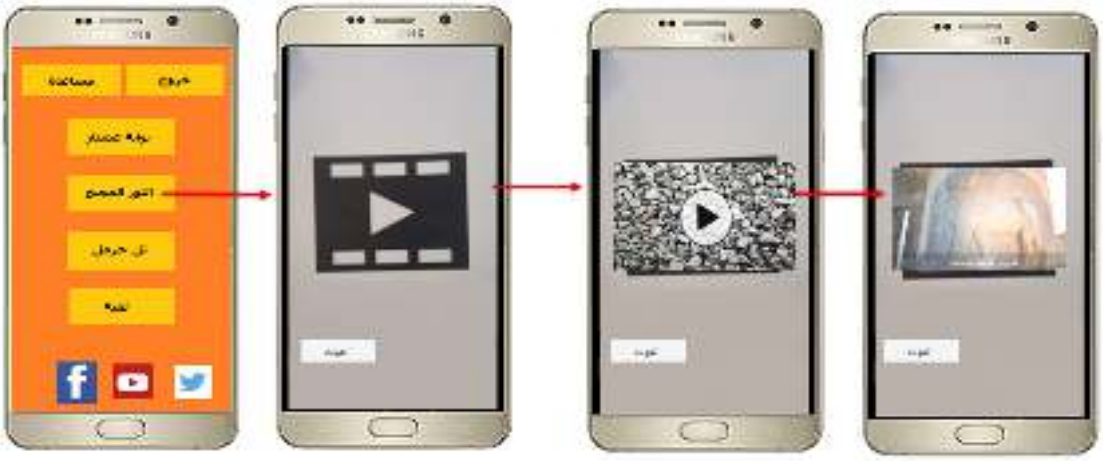


Figure 5.16. Video Interface of Winged Bull

3. Harmal Hill

This terracotta guardian lion is documented in history from the temple of Harmal. When the user clicks its icon on the Main Menu, it automatically opens the mobile device camera. As soon as the camera is launched, the user can now scan the desired marker by placing the marker in front of the camera to display the corresponding information.

When the user places the camera over the 3D AR marker from Figure 5.2, the 3D model of the Harmal Hill is displayed on the device screen as seen in Figure 5.17. The user can touch the screen the rotate the object in 360 degrees and also resize the object by moving the camera closer or farther from the marker.

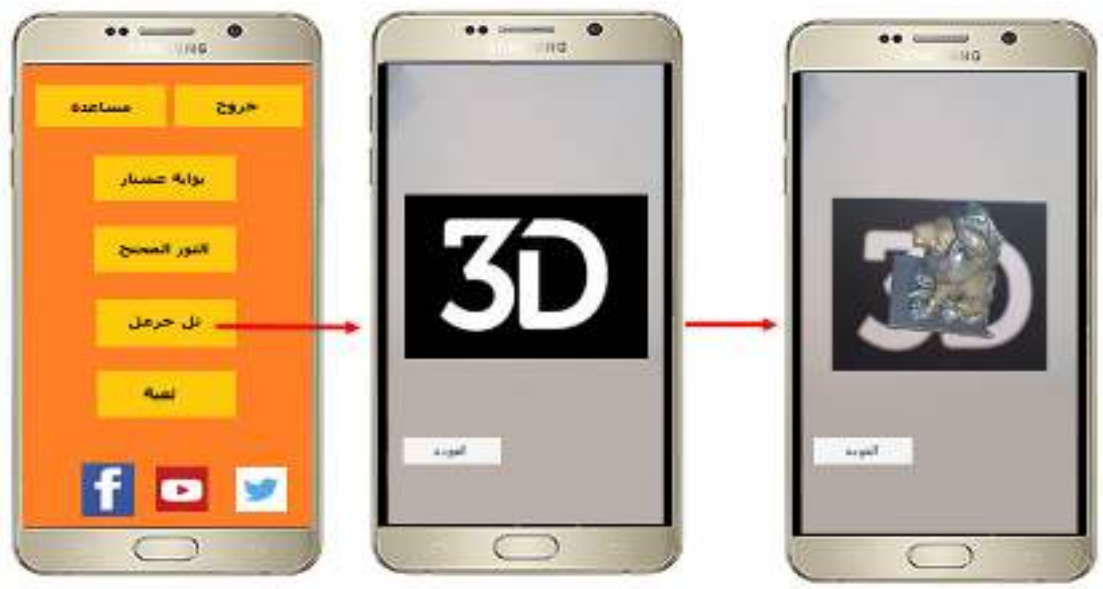


Figure 5.17. 3D Interface of Harmal Hill

When the image marker from Figure 5.2 is superimposed, MARHIME displays the images of the Harmal Hill as seen in the museum. The user can navigate through these images using the scrollbar. Figure 5.18 displays the interface.

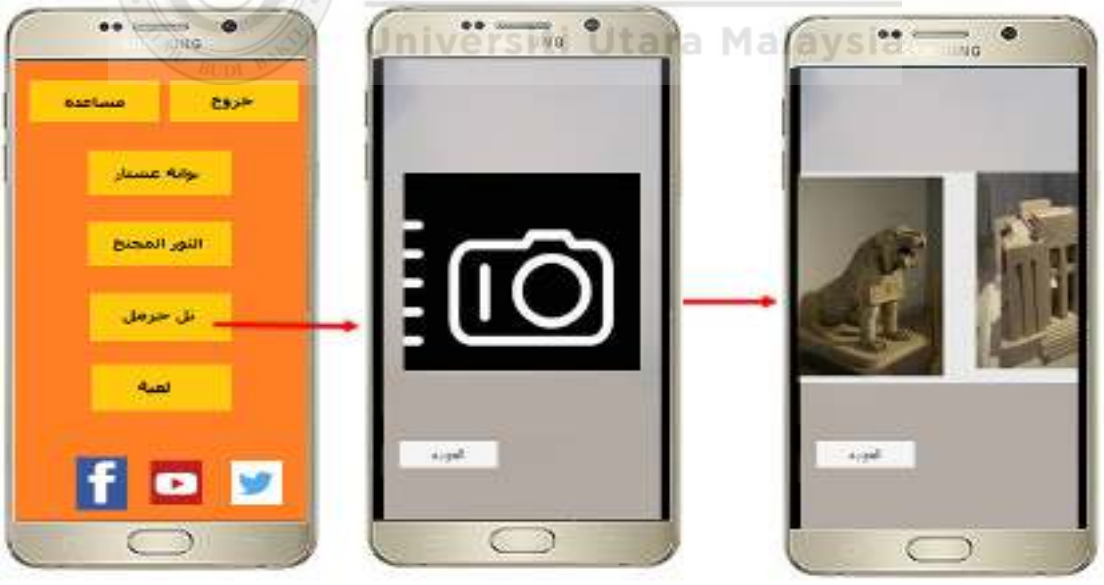


Figure 5.18. Image Interface of Harmal Hill

Likewise, when the user places the text marker from Figure 5.2 in front of the mobile device camera, the prototype shows information about the Harmal Hill as a

text document. The user can scroll up and down to read more about this artefact as seen in Figure 5.19.

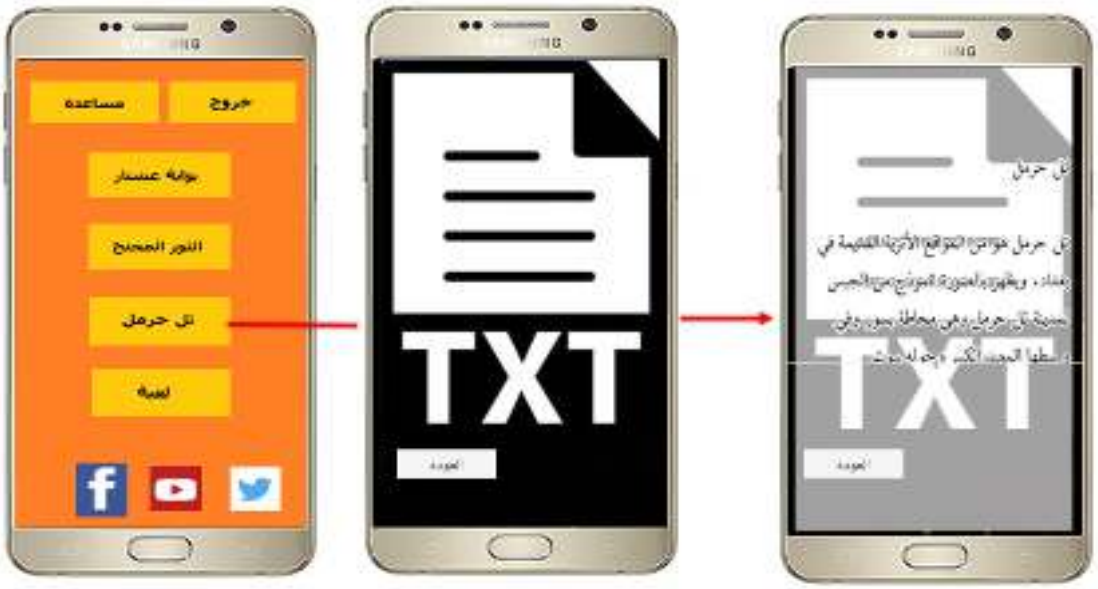


Figure 5.19. Text Interface of Harmal Hill

The last marker from Figure 5.2 is the video AR marker. Superimposing this marker with the mobile device camera initiates a short, subtitled video about the Harmal Hill. The video displays different video clips of the Harmal Hill while giving some historical details about the artefact. Figure 5.20 shows the execution of these steps.

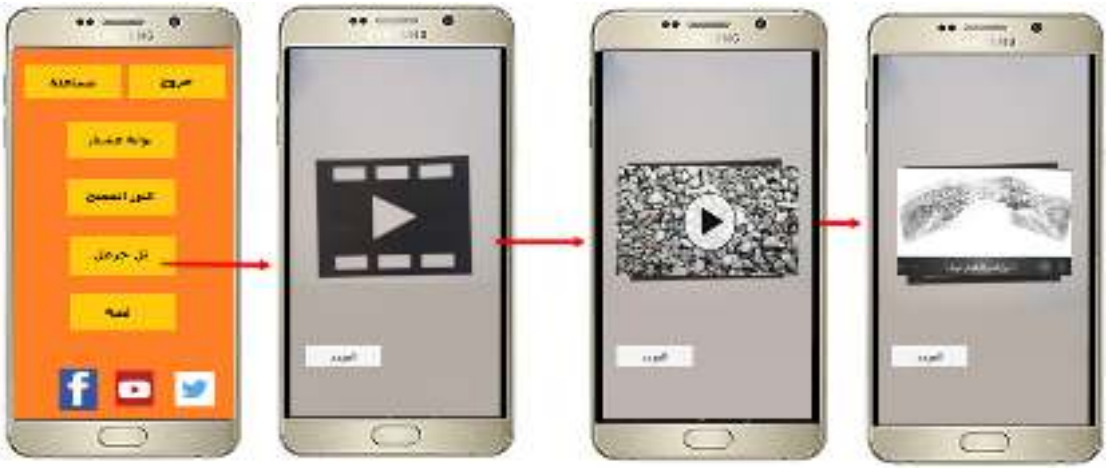


Figure 5.20. Video Interface of Harmal Hill

4. Game

Discussions have been provided about three of the four major icons on the main menu of MARHIME which include the artefacts of the museum as seen in Figure 5.8. The fourth icon incorporates a game into the MARHIME prototype. The advantage of this game includes enhancing the learning motivation of the HI visitor while also keeping the visitor engaged to learning process at the museum. The game incorporated a simple puzzle on a 3 x 3 tiles to trigger engagement among the user when playing this game. Figure 5.21 gives the steps in initiating and playing the game.

Figure 5.21. Game Interface for MARHIME prototype

5. Social Media

It is generally known that there is a high rave when it comes to social media. A lot of mobile users, either young or old, occasionally visit social media sites on their devices. This observed passion by users triggered the initiating of social media icons when using the MARHIME prototype. The three major social media platforms namely; YouTube, Facebook and Twitter are incorporated to the main menu screen of the MAR prototype (see Figure 5.8). A click by the user on either

of these buttons redirects the user to the corresponding social media platform. This is displayed in Figure 5.22.

Figure 5.22. Social Media Interface for MARHIME Prototype

6. Help

The last icon to be considered for the interaction interface is the help icon. It is important to always provide a platform where users can get information about a prototype and its usage. The MARHIME prototype is a MAR prototype for engaging HI museum visitors and information on how to use the prototype needs to be provided. For this reason, a help icon is incorporated in the main menu

screen as shown in Figure 5.8. Clicking on this icon button launches the help screen interface as shown in Figure 5.23.

Figure 5.23. Help Screen Interface for MARHIME

The interpretation of the text on the help screen is “Point your camera at the marker to view the content”. This guides the user on what to do when using the MARHIME prototype.

This section has presented the first version of the MARHIME prototype as developed using Vuforia and Unity 3D as discussed previously. The interfaces have been displayed and the mode of use has been highlighted. To affirm the suitability of this version for HI users, its interfaces and contents were evaluated by certain individuals such as teachers for the HI and museum staff from the Iraq museum.

5.5.3 MARHIME Prototype Evaluation

The aim of Section 5.5 is to evaluate the first version of MARHIME prototype. It is important to request feedback about the prototype to know if it is suitable to achieve its objective, which is to engage HI visitors to the museum. Four groups of individuals were involved in this session. The first group were teachers for HI at a school for HI in Malaysia, the second group were also teachers for HI at a school for HI in Iraq while the third group were staff from Iraq museum in Baghdad. The final group was academic experts in AR and museum.

For the first group (teachers of HI in Malaysia), feedback was requested in terms of the interface and text of the MARHIME prototype. Figure 5.24 shows one of the images for the HI teachers in Penang with the students checking the prototype interface design.

Figure 5.24. HI Teacher and Students in Penang using MARHIME prototype

The response from the teachers as documented in Appendix I states that MARHIME prototype is beneficial and useful for the HI or the deaf community. The images for the artefacts are of different angles with captions are very helpful and the 3D features were interesting. The prototype is easy to understand even though it was in Arabic language, very simple and friendly to use. However, the teachers suggested that having the video in full screen mode would be more suitable, and a bit of colour should be added as the HI or deaf community are people who are attracted with visual things.

The second group of evaluators was teachers for the HI in Iraq. It was important to consult this group of individuals since the language of the prototype is in Arabic. In order to ascertain the suitability of the prototype, teachers who understand Arabic were consulted. The teachers also agreed that the MARHIME prototype is a novel development which is very advantageous in engaging HI people. The teachers further commented that the ideas and interface is suitable for HI. Figure 5.25 shows some of the teachers who provided their report on the suitability of the MARHIME prototype in engaging HI people when visiting the museums. In addition, the response from the HI teachers in Iraq as documented in Appendix J.

Figure 5.25. Some of the HI Teachers in Iraq who evaluated the MARHIME prototype

The third group of individuals was the Iraq museum employees and their responses are documented in Appendix J. These employees interacted with the MARHIME prototype and responded that the prototype helps the HI museum visitors to understand, enjoy and consolidate with the artefact by knowing and learning from about the historical background. The integration of 3D models, information, videos, and images has generalized everything that benefits the visitor. The information given by the prototype is very valuable to the visitors and helps them understand these artefacts. In addition, the presence of a game in the prototype removes monotony and helps overcome the boredom. Thus, it is considered that this kind of prototype will have a positive effect for its usage in museums as it has contributed in terms of

science and knowledge to HI people who receive less attention. Figure 5.26 shows one of the museum staff giving her report after interaction with the MARHIME prototype.

Figure 5.26. Museum Staff giving report after using the MARHIME prototype

Finally, MARHIME prototype was evaluated by AR, multimedia systems and museum experts. Their reports can be accessed in Appendix L. The three (3) experts are PhD holders in their domains. The evaluation of the interface used Heuristic and Subheuristics method which is adopted using the questionnaire cited by Ibrahim and Ahmad (2014). These Heuristics are: Interface (IN), Multimedia (MM), and Interactivity (IV). All responses for experts were positive without further comments as shown in Table 5.2.

Table 5.2

Expert Responses for MARHIME Interface

Heuristic	Code	Items	Yes	No
Interface (IN)	IN1	The instruction given is clear and easy to understand.	3	0
	IN2	The interface design is attractive.	3	0
	IN3	The MARHIME application is easy to use.	3	0
	IN4	The colour scheme used is appropriate.	3	0
	IN5	Attractive display of the screen design.	3	0
	IN6	Appropriate interface.	3	0
	IN7	The readability of text suits the target.	3	0
Multimedia (Image, Video, Text, and 3D model) (MM)	MM1	Each multimedia elements used serves a clear purpose.	3	0
	MM2	Usage of multimedia elements is suitable with the content.	3	0
	MM3	The presentation of multimedia elements is well managed.	3	0
	MM4	The use of multimedia elements supports meaningfully the information provided.	3	0
	MM5	The quality of multimedia elements used is good.	3	0
	MM6	The use of multimedia elements enhances the content presentation.	3	0
Interactivity (IV)	IV1	The interactivity is easy to understand.	3	0
	IV2	The interactivity is not misleading.	3	0
	IV3	The help functions provided may be useful.	3	0

This implies that MARHIME prototype is considerably good prototype to be further tested upon HI visitors at the museum.

5.6 MARHIME Prototype Version 2

Following the responses from the evaluation session by the teachers of the HI, museum staff and functionality and interface experts, it was necessary to implement some changes in the first version of the MARHIME prototype. One important modification that was made is to change the orientation of the display of the prototype from portrait to landscape view. Figure 5.27 shows the wireframe for the second version of the MARHIME prototype.

Figure 5.27. Wireframe of the MARHIME prototype

This figure highlights the process flow from the splash screen to the main menu which allows the user to further interact with the prototype. From the new landscape view, it is observed that the help, exit and social media icons have been modified so as not to distract the user from the more important icons (artefacts and game). In addition, the colour choices have been improved for a better visual experience by the HI users. Finally, the suggestion of having a direct link for the social media icons to information regarding the artefacts and HI has been incorporated as evident in the screenshot images from YouTube, Facebook and Twitter.

Figure 5.28 shows the interfaces for the 3D model, image, text and video outputs for each of the artefacts now in the modified landscape mode.

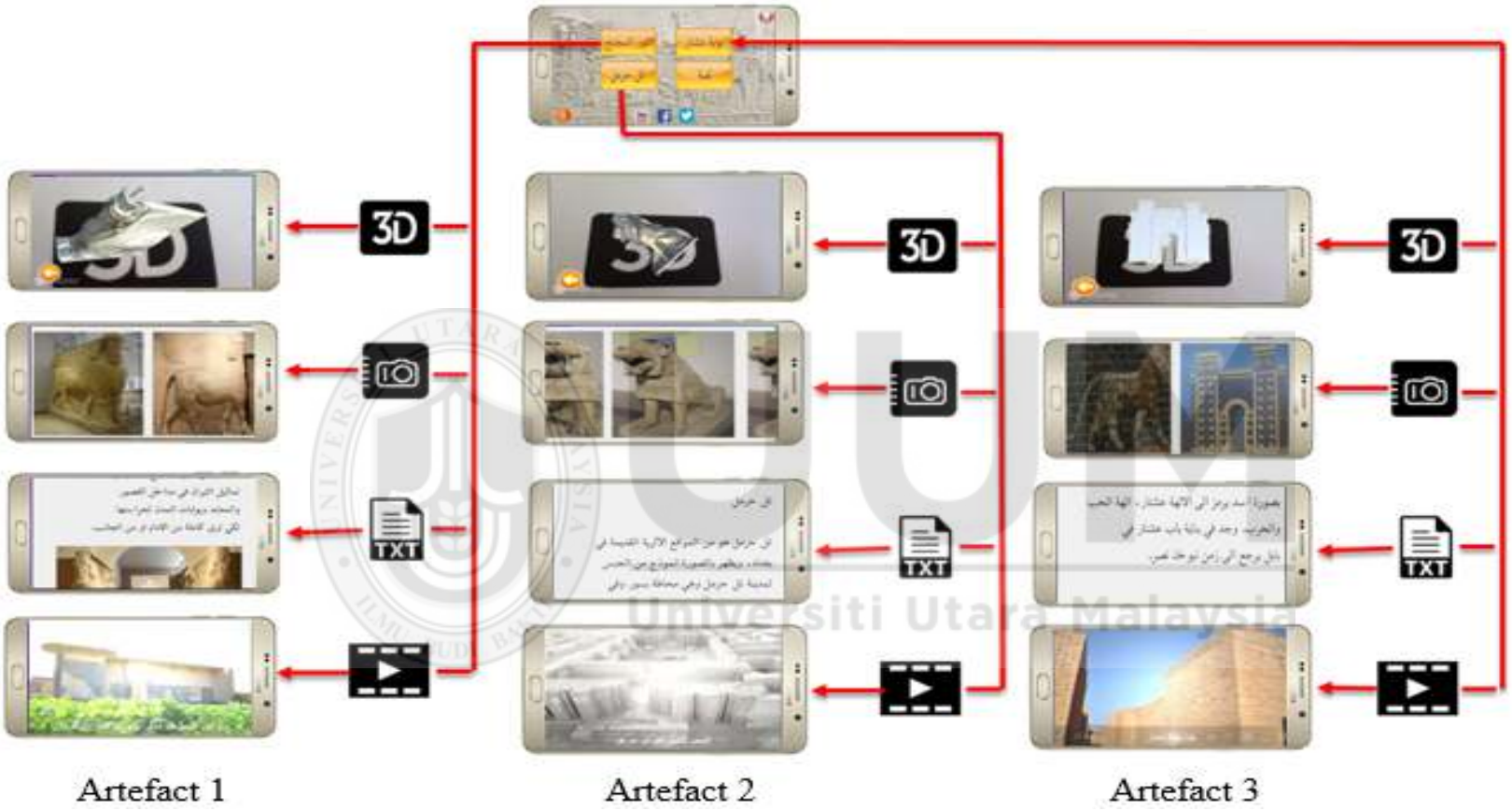


Figure 5.28. Wireframe of the Artefacts in the MARHIME prototype

Figures 5.27 and 5.28 represent the total package for the MARHIME prototype. The interfaces and different steps to view the 3D model, image, text and video outputs for each artefact have also been highlighted. However, it is important to show the relationships between the elements of the conceptual model (Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment) and the developed prototype. Thus, the next section discusses the elements that were embedded in the MARHIME prototype.

5.7 Embedding Elements in the MARHIME Prototype

In the implementation phase, all the elements that have been planned for designing the MARHIME are implemented in the prototype. The prototype comprises of virtual contents in the form of texts, images, 3D animations and videos which are coded into AR markers so that the HI users can view the virtual contents when held in front of the camera. Note that the elements of the conceptual model were infused in the development of the prototype. The following subsections provide some insights about the MARHIME conceptual model elements.

5.7.1 Aesthetics

Aesthetics as defined by O'Brien and Toms (2010) describes the visual beauty of computer-based environments or the study of natural and pleasing computer-based environments. Aesthetics element focuses on the look and feel. Aesthetics is important to HI because quality illustrations and presentation which are colourful and realistic in style conforms to their developmental, cognitive, cultural and emotional needs (Yaman, Dönmez, Avci, & Yurdakul, 2016). HI are attracted to nice looking interfaces, coloured buttons, style, and feel to visual senses with AR objects. This is

evident in the developed MARHIME prototype such as when viewing the splash screen and attractive colour for buttons as seen in the main menu design and general attractive screen design for each interface as shown in Figure 5.29.

Figure 5.29. Splash screen for MARHIME prototype

5.7.2 Usability

Usability is refers to the consistent information and ease of use based on the functionality of an prototype as perceived by the user (Hussain et al., 2015). The element of usability in MAR prototype is important to HI because technology presents an enormous potential to help HI by providing their needs to perform tasks easily and efficiently (Nathan, Hussain, Hashim, & Omar, 2017; Chuan et al., 2017). Thus, usability of the MARHIME prototype is significant as this element is concerned with specific features to use. In MARHIME prototype, the HI can easily use videos, camera, select the options in the main menu and move from screen to another (Figure 5.28). One notable usability trait that has been observed in the MARHIME prototype is the help screen for HI visitor to understand the navigation of the interface. The expression as seen in Figure 5.30 guides the user by stating “Point the camera toward the marker to view the content” as translated from Arabic language.

Figure 5.30. Selected Help Menu for MARHIME prototype

5.7.3 Interaction

A form of awareness to control the prototype where interactivity, information and feedback are given on action. This implies that social relation and connection between the user and the prototype is referred to as interaction (Dix, 2009). Interaction as part of a computing process, considers how users understand and interpret multimedia signals at the perceptual, cognitive, and affective levels, and how they interact naturally by embedding the cultural and social contexts as well as personal factors such as emotion, attitude, and attention. Interaction is important to the HI because any prototype without enhanced interactivity would be ineffective to them as users (Ryu, Han, Yoon, & Ryu, 2016). The MARHIME prototype properly infuses the interaction as evident whenever the HI user was viewing the 3D superimposition of the artefacts. It was observed that the HI could move his/her finger on the 3D model to understand more information about the artefact and resize the 3D model to view a clearer display. Likewise, the virtual objects move and rotate whenever there was movement or rotation of the marker by the HI user as shown in Figure 5.31.

Figure 5.31. Interaction with the 3D model artefact of the MARHIME prototype

5.7.4 Motivation

Gopalan et al. (2016) defined motivation as the drive towards involvement in order to achieve a target. Motivation as an element on MARHIME is the act which encourages action or target activity to be performed by the HI. Motivation determines the participation, hard work and continuous learning of an individual (Chen, 2012). When considering MAR prototype for HI, motivation is an issue of concern since they are mostly passive users, thus it is expected that the prototype can arouse or sustain interests of HI visitors to the museum and whether it can enhance their learning and engagement (Chen, 2014). In view of this, the MARHIME prototype was designed in an interactive and self-regulated environment. This is evident in the infusion of social media in the prototype to increase the excitement of the HI visitor with the museum exhibition and also allowing the user to share with other HI groups on these social media platforms. An instance is shown in Figure 5.32.

Figure 5.32. Social Media Menus for MARHIME prototype

5.7.5 Satisfaction

Satisfaction addresses the act of being content and fond of a prototype (Alqahtani & Mohammad, 2015). Members of the HI community have a higher thirst for satisfaction when adopting MAR prototype. This is because their shortcoming in hearing spikes their satisfaction desire level due to the fact that they are limited to use other senses such as sight to attain an engaging MAR experience (Chen, 2014). The MARHIME prototype aims at satisfying the HI visitor by being implemented on an AR technology. Therefore, the user does not experience hitches, lags or unexpected shutdown when operating the mobile with the markers. In addition, the implementation of image, text, 3D model, and video in the prototype for observing the artefacts provides an all-round experience for the HI users as they totally engaged and thoroughly enlightened. A sample of the image, text, 3D model and video of one of the artefacts is shown in Figure 5.33.

Figure 5.33. A sample of the image, text, 3D model and video from the MARHIME prototype

5.7.6 Enjoyment

Enjoyment as defined by MäNtymäKi and Salo (2011) is the experience of fun, enjoy and entertainment. Enjoyment is very crucial in the development of the MARHIME prototype since HI visitors are most times unreceptive (Chen, 2014) and therefore it is important in integrating something fun to engage them during their museum visit. For this reason, the game scene (puzzle) was incorporated into the MARHIME prototype. Puzzle is known in engaging users as the aim is always to get it solved. Therefore, the view of a scrambled puzzle game (see Figure 5.34) within a museum visit spikes a level of enjoying the total package of MARHIME prototype as a whole.

Figure 5.34. Puzzle game for MARHIME prototype

It is evident from the discussions above that the six elements of the MARHIME conceptual model which have been validated by the expert have been infused into the MARHIME prototype. This further establishes the suitability of the MAR prototype for engaging HI visitors to the museum. The next phase involved a pilot study in identifying the limitations of the research instrument and the MARHIME prototype.

5.8 Chapter Summary

This chapter explains the validation of the MARHIME conceptual model in chapter 4 through prototyping. The development of the prototype begins with an emphasis on the functional and technical requirements necessary to be in place for smooth running of the prototype. These requirements were the guide for developing the first version of the prototype using Vuforia and Unity 3D software. After this initial prototype has been completely developed, it has to undergo an evaluation process by several groups of individuals related to the field of HI, HCI and Museum. Their recommendations informed the modifications to the second version of the prototype. Therefore, the next stage is embarked upon, which is the prototype evaluation. The next chapter presents discussion on the user evaluation of the MARHIME prototype in engaging HI visitors to the museum.

CHAPTER SIX
USER EVALUATION

6.1 Introduction

The previous chapter has discussed the steps involved in designing and developing the MARHIME prototype. This chapter goes further to evaluate the MARHIME prototype for Hearing-Impaired (HI) on museum visitors' engagement. This evaluation was initiated by first conducting a pilot study to investigate any shortcomings or limitations. Prior to the HI museum visitors' evaluation, the pilot study was conducted to obtain satisfactory results from the participants' responses. The collected data were analysed to determine how effective the MARHIME prototype in achieving its aim of engaging the HI visitors. Statistical analysis was conducted using SPSS version 24 and the results and findings were documented. Subsequent sections in the chapter give more insights into what the entire evaluation process entailed.

6.2 Data Coding

Data coding is the first step in data preparation for analysis (Sekaran and Bougie, 2016). All elements and items in the questionnaire were coded for ease of presentation as shown in Table 6.1.

Table 6.1

Data coding for Elements

Element	Code	Item	Code
AESTHETICS	AES	The MARHIME prototype was attractive.	AES.1
		The MARHIME prototype was appealing to my visual senses.	AES.2
		The MARHIME prototype screen layout was suitable.	AES.3
USABILITY	USA	The MARHIME prototype was easy to use.	USA.1
		The MARHIME prototype provides me the required guidance to perform my task.	USA.2
		The MARHIME prototype provides consistent information.	USA.3
INTERACTION	INT	The MARHIME prototype provided control through my actions.	INT.1
		The MARHIME prototype provided responses that I need.	INT.2
		The MARHIME prototype provided feedback smoothly.	INT.3
MOTIVATION	MOT	The MARHIME prototype increased my excitement with the museum exhibition.	MOT.1
		I feel more motivated to do an activity with the MARHIME prototype.	MOT.2
		Touring the museum was more encouraging with the use of the MARHIME prototype.	MOT.3
SATISFACTION	SAT	Generally, I am satisfied with the MARHIME prototype.	SAT.1
		I became fond with the MARHIME prototype.	SAT.2
		I will recommend the MARHIME prototype to others.	SAT.3
ENJOYMENT	ENJ	I enjoyed using the MARHIME prototype.	ENJ.1
		The MARHIME prototype provided me an entertaining experience.	ENJ.2
		It was fun using the MARHIME prototype.	ENJ.3
		I did not feel the time has passed while using the MARHIME prototype.	ENJ.4

6.3 Pilot Study

The pilot study which is also known as pre-test (Colton & Covert, 2007) is a small study of the main study which aims to provide useful information to improve the scale

of the study and determine the level of reliability of the scale (Bordens & Abbott, 2011). The pilot study helps to save time in real evaluation and to benefit from the participants' responses by improving some of the items of the scale, because there may be a weakness in formulating some of them due to not using appropriate words that lead to misunderstanding (Bordens & Abbott, 2011; Saunders, Lewis, & Thornhill, 2009).

In ensuring the reliability of the elements in the pilot study, many authors such as Carmines and Zeller (1979); Peter (1979); Tabachnick and Fidell (2013) recommended testing the Cronbach's alpha for the pilot survey. This tool has been used to assess whether the items measure the same thing that was set for it (DeVellis, 2016). Hair et al. (2010) mentioned that the level of reliability ranges from 0 to 1 and the minimum acceptance is between 0.60 and 0.70. Besides, item analysis method was conducted by means of Corrected Item-Total Correlation test to show the most related items with the construct, where any items less than 0.30 in value will be deleted (Nunnally, 1978).

According to Sheatsley (1983), the number of sample size ranging from 12 to 25 is sufficient to provide the necessary information on weaknesses in the pilot study. Therefore, 16 HI visitors involved in this pilot study with the highest level of education to ensure the accuracy of their responses. Consequently, some unclear words were modified in order to increase the understanding of the real evaluation. Table 6.2 shows that all the items correlate higher than 0.30 for the Corrected Item-Total Correlation, which ranged from 0.438 to 0.916. Also, it is clear that the items have a very high reliability which is ranged between 0.952 and 0.961 as a result of Cronbach's Alpha if Item Deleted. Besides, all constructs have achieved acceptable

reliability because the values of Cronbach's Alpha ranging from 0.750 to 0.942, which is higher than 0.70.

Table 6.2.

Pilot Study Measurement Reliability

Elements	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Aesthetics	AES.1	.771	.956	.757
	AES.2	.814	.954	
	AES.3	.695	.956	
Usability	USA.1	.783	.954	.884
	USA.2	.677	.956	
	USA.3	.778	.954	
Interaction	INT.1	.775	.955	.875
	INT.2	.438	.958	
	INT.3	.916	.955	
Motivation	MOT.1	.869	.955	.750
	MOT.2	.553	.957	
	MOT.3	.752	.955	
Satisfaction	SAT.1	.902	.952	.942
	SAT.2	.900	.952	
	SAT.3	.829	.953	
Enjoyment	ENJ.1	.642	.961	.802
	ENJ.2	.853	.953	
	ENJ.3	.738	.955	
	ENJ.4	.750	.955	

6.4 Evaluation Session

From the satisfactory results obtained from the pilot study, the evaluation session can now be delved into. The evaluation was conducted to investigate the engagement ability of the MARHIME prototype. The venue was at the Iraq Museum in Baghdad

where HI visitors were granted access to interact with the mobile application as seen in Figures 6.1 and 6.2.

Figure 6.1. Group of HI Students during the Evaluation Session at the Iraq Museum, Baghdad

Figure 6.2. HI visitors during the Evaluation Session at the Iraq Museum, Baghdad

The evaluation conducted was measured by the questionnaire documented in Appendix G and H. After conducting the evaluation, a data analysis was carried out and the findings are explained in detail in the following subsections.

6.4.1 Participants' Background

All participants in the current study are Iraqis. The characteristic of the participants will be clarified and interpreted based on Table 6.3 and the figures for each characteristic.

Figure 6.3. Gender characteristic

Table 6.3 and Figure 6.3 show that more than half of the participants (65.8%) were male. Table 6.3 still illustrates the age groups as seen in Figure 6.4. The age group 21 - 29 years (37.0%) was the highest among the participants, followed by the age group less than 20 years (27.4%), followed by the age group 30 - 39 years (23.3%), then the age group 40 - 49 years (9.6%), and finally, the age group Over 50 years (2.7%).

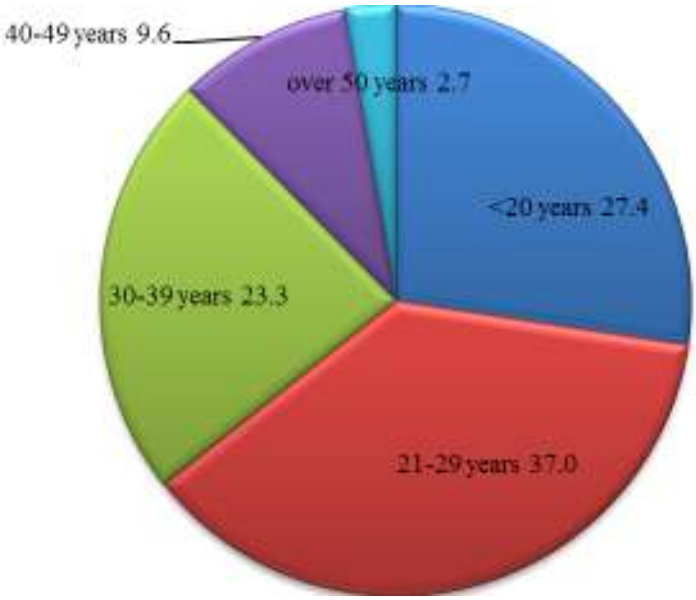


Figure 6.4. Age groups

Figure 6.5 and Table 6.3 show the educational levels. 36 (49.3%) of the participants were secondary school certificate holders, followed by preliminary school certificate holders (28.8%), bachelor's degrees holders (15.1%) and none of the above (5.5%). They were only 1.4% having postgraduate degrees.

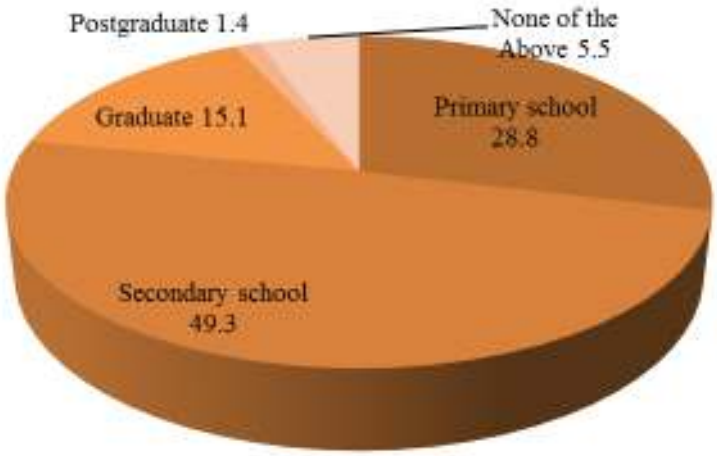


Figure 6.5. Educational levels

Finally, Table 6.3 and Figure 6.6 present details concerning experience in mobile applications. Most of the participants (87.7%) had more than one year of experience in mobile applications. A few of them (12.3%) have a year or less experience in mobile applications. The experience in mobile applications helps in terms of their interaction and acceptance of mobile application in this current study.

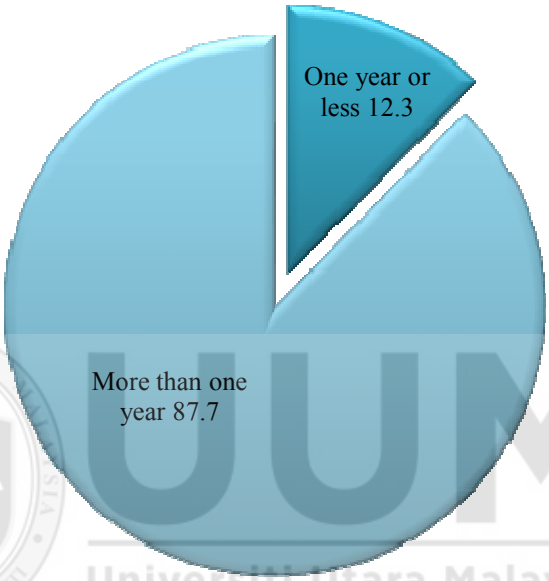


Figure 6.6. Experience in mobile applications

Table 6.3

Profile of participants' background

No.	Participants' Background	Category	Frequency	Percentage (%)
1	**Gender**	Male	48	65.8
		Female	25	34.2
	Total		**73**	**100.0**
2	**Age**	<20 years	20	27.4
		21-29 years	27	37.0

Table 6.3 Continued

No.	Participants' Background	Category	Frequency	Percentage (%)
		30-39 years	17	23.3
		40-49 years	7	9.6
		Over 50 years	2	2.7
	Total		**73**	**100.0**
3	**Educational Level**	Primary school	21	28.8
		Secondary school	36	49.3
		Graduate	11	15.1
		Postgraduate	1	1.4
		None of the Above	4	5.5
	Total		**73**	**100.0**
4	**Your Experience on Mobile Applications**	One year or less	9	12.3
		More than one year	64	87.7
	Total		**73**	**100.0**

6.4.2 Validity

Validity refers to the accuracy of a measure or the extent to which a score truthfully represents a concept (Zikmund, Babin, Carr, & Griffin, 2013). In other words, validity means using an instrument in a study that actually measures what to measure accurately (Sekaran & Bougie, 2016). In this study, two types of validity will be conducted: content validity and construct validity.

6.4.2.1 Content validity

Content validity refer to the degree to which the content of the items represents the appropriate universe of all relevant items under study (Cooper & Schindler, 2014). It can be verified by three types of experts; experts in the content area, experts in

instrument construction (they have experience in statistics and instruments) (Davis, 1992), and professional experts (Cooper & Schindler, 2014). Waltz, Strickland and Lenz (2010) stated that the number of academic experts should be at least two (2) experts. According to Lynn (1986), the minimum number for content validity is five (5) academic experts. In the current study, eleven (11) academic experts were involved in the content validity whereby, eight (8) experts from Malaysia, one (1) from the United States of America, one (1) from Australia and one from Romania. Meanwhile, for the instrument construction, according to Waltz et al. (2010), there should be at least one expert. That was done in this study, where an expert from the School of Quantitative Sciences, Universiti Utara Malaysia was appointed. This was done in addition to the statistical results of the pilot study and the main study (see Appendix M). On the other hand, the professional experts are HI, and their feedbacks were included by changing a few words in the items of the instrument (see Section 6.3).

6.4.2.2 Construct Validity

Besides content validity, the other type is the construct validity. According to Hair, Black, Babin, and Anderson (2014), construct validity is the extent to which a set of measured items actually reflects the theoretical latent construct those items are designed to measure. In the same vein, the construct validity means measuring the extent to which the measure fits theoretical expectations (De Vaus, 2002). Construct validity can be verified through factor analysis (Fabrigar & Wegener, 2012; Thompson, 2004). Therefore, the construct validity has been expressed as "factorial validity" (Nunnally, 1994). In this study, the Exploratory Factor Analysis (EFA) was used because the measurements were adapted from previous studies. For the EFA,

SPSS version 24 was used through the principal component analysis (PCA), which is one of the most common methods for this purpose (Field, 2009).

In achieving the construct validity using the PCA method, a set of requirements and assumptions should be achieved. Assumptions include the adequacy of the sample size for conducting the factor analysis, which is measured by using Kaiser-Meyer-Olkin (KMO), where it should be greater than 0.50 (Field, 2009; Kaiser, 1974), and testing that enough correlations exist among the factors by using Bartlett's test of sphericity, which should be of a statistically significant (sig. < .05) (Field, 2009; Hair et al., 2014).

As already mentioned, there are some requirements to be met and one of these requirements is communalities. Tabachnick and Fidell (2013) pointed out that the communality for a variable is the variance accounted for by the factors, it is the squared multiple correlation of the variable as predicted from the factors. Communality is the sum of squared loadings (SSL) for a variable across factors. Also, according to Field (2009), variable that has no specific variance (or random variance) would have a communality of 1, a variable that shares none of its variance with any other variable would have a communality of 0. Besides, the communality value with small samples of less than 100 can be acceptable when communality more than 0.60 (Field, 2009).

Second requirement is the eigenvalue. The eigenvalue is a measure of the importance of the factor (Field, 2009). The factors that have the eigenvalue of above 1 are significant, and the factors that have eigenvalue value of less than 1 are not significant (Hair et al., 2014). The last requirement is the factor loading. Factor loading indicates the extent to which each variable is related to the factor (Tabachnick & Fidell, 2013), and the higher the loading level the greater the representation of the variable to the

factor (Hair et al., 2014). Since the sample size in the current study is 73, Hair et al. (2014) noted that when the sample size is 70 the factor loading should be 0.65 or more. Using the SPSS version 24, the exploratory factor analysis of the six elements of engagement was carried out as shown in Table 6.4 (see Appendix N for more details).

Table 6.4 shows the results of the exploratory factor analysis for the six elements of engagement, which include 19 items. The results showed that all the items accurately measure the six elements of engagement, therefore achieved the construct validity. The Kaiser-Meyer-Olkin value is 0.779, which means that the sample size was suitable for the factor analysis. The Bartlett's Test of Sphericity has a significant value of 0.000 which means that the correlations exist among the constructs are adequate and statistically significant. Besides, communalities for all the items ranged between 0.619 and 0.864, which were higher than 0.60. All the six elements were significant since all of them had eigenvalues of greater than 1, and these elements were 75.307 % of the total variance from the items. Finally, all of the items represented the elements that they measure whereby the factor loadings for all the items ranged between 0.667 and 0.848 and all of them were more than 0.65.

Table 6.4

Results of exploratory factor analysis for elements of engagement (N=73)

Element	Item	Factor Loading						Communalities
		1	2	3	4	5	6	
AES	AES.3	.833						.729
	AES.1	.774						.793
	AES.2	.774						.759
ENJ	ENJ.3		.831					.762
	ENJ.2		.762					.812
	ENJ.4		.759					.809
	ENJ.1		.678					.714
MOT	MOT.2			.829				.864
	MOT.3			.720				.619
	MOT.1			.667				.683
SAT	SAT.3				.787			.814
	SAT.2				.748			.767
	SAT.1				.729			.797
USA	USA.3					.848		.754
	USA.2					.827		.680
	USA.1					.704		.732
INT	INT.3						.753	.730
	INT.1						.670	.775
	INT.2						.667	.715
Eigenvalues		6.598	2.139	1.790	1.495	1.273	1.013	
% of Variance		34.729	11.256	9.421	7.867	6.702	5.332	
Total variance Explained								75.307
Kaiser-Meyer-Olkin								.779
Bartlett's Test of Sphericity Sig.								.000

6.4.3 Correlation & Multicollinearity Test

Correlation is a statistical technique to explore the relationships between the elements and engagement for this study. Through a matrix of Pearson correlation which determines the strength, direction and significance of the relationship between the variables (Field, 2009; Hair et al., 2014; Pallant, 2010; Sekaran & Bougie, 2016). Cohen (1988) suggested the following guidelines to determine the strength and direction of the relationships between the elements or variables as shown in Table 6.5. The multicollinearity of the elements can be determined from the matrix of Pearson correlation (Field, 2009; Verma, 2013). Indeed, the problem of multicollinearity occurs when two interrelated elements having a value of greater than 0.70 (De Vaus, 2002), or 0.90 (Pallant, 2010).

Table 6.6 illustrates the Pearson correlation matrix which shows the relationships between the six elements (usability, motivation, aesthetics, satisfaction, interaction and fun) and engagement. The relationships ranged from 0.537 - 0.785 which is considered strong and these indicate that all of these elements represent engagements. Besides that, there was no problem of multicollinearity between all the six elements since all the correlations between them ranged from 0.174 - 0.540, which did not exceed 0.70 or 0.90 as suggested by De Vaus (2002) and Pallant (2010).

Table 6.5

Categories of correlation strength

Correlation	Strength
±.10 - ±.29	Small
±.30 - ±.49	Medium
±.50 - ±1.0	Large

Source: Cohen (1988, pp. 79-81)

Table 6.6

Matrix of Pearson correlation

	AES	USA	INT	MOT	SAT	ENJ	Engagement
AES	1						
USA	.342**	1					
INT	.477**	.363**	1				
MOT	.508**	.203	.540**	1			
SAT	.327**	.278*	.452**	.517**	1		
ENJ	.270*	.174	.316**	.394**	.404**	1	
Engagement	.693**	.537**	.785**	.765**	.716**	.637**	1

**. Correlation is significant at the 0.01 level.
*. Correlation is significant at the 0.05 level.

6.4.4 Descriptive Statistics

Through descriptive statistics, we can obtain the maximum, minimum, mean and standard deviation, for the data, which help us to know many of the trends and characteristics of the sample answers (Sekaran & Bougie, 2016). In addition, it describes the results by summarising the responses in specific patterns (De Vaus, 2002). According to Verma, (2013), the purpose of the descriptive statistics is to describe the interest of the sample or their point of view about something specific. SPSS version 24 was used to determine the descriptive statistics as shown in Table 6.9.

6.4.4.1 Usability

Table 6.7 shows the results of the descriptive statistics that include the values of the means for three items (4.15, 4.56, 4.40) respectively.

Table 6.7

Descriptive Analysis for Usability

Items	Min	Max	Mean	Std. Deviation	Ranked
USA.2	3.00	5.00	4.56	.62	1
USA.3	3.00	5.00	4.40	.64	2
USA.1	3.00	5.00	4.15	.81	3
Usability	**3.33**	**5.00**	**4.37**	**.57**	

The highest level of agreement by the users was towards the second item (The MARHIME prototype provides me the required guidance to perform my task). While the lowest level of agreement by the users was towards the first item (The MARHIME prototype was easy to use). These results show that the users were having positive opinions with regard to all of the items, meaning that the users agreed on the usability of the prototype. In addition, the standard deviations for all the items were small and ranged from 0.62-0.81, and this indicates the accuracy of the users' answers to the questionnaire. Moreover, the level of agreement by the users around the usability element was 4.37 and the standard deviation was 0.57, which strengthened their agreement on the items.

6.4.4.2 Motivation

Table 6.8 shows the results of descriptive statistics that include the values of the means for three items (4.52, 4.32, 4.22), respectively.

Table 6.8

Descriptive Analysis for Motivation

Items	Min	Max	Mean	Std. Deviation	Ranked
MOT.1	2.00	5.00	4.52	.71	1
MOT.2	2.00	5.00	4.32	.81	2
MOT.3	2.00	5.00	4.22	.79	3
Motivation	**2.33**	**5.00**	**4.35**	**.66**	

The highest level of agreement by the users was towards the first item (The MARHIME prototype increased my excitement with the museum exhibition). While the lowest level of agreement by the users was towards the third item (Touring the museum was more encouraging with the use of the MARHIME prototype). These results show that the users were having positive opinions with regard to all of the items, meaning that the users agreed on the motivation of the prototype. In addition, the standard deviations for all the items were small and ranged from 0.71 to 0.81, and this indicates the accuracy of the users' answers to the questionnaire. Moreover, the level of agreement by the users around the motivation element was 4.35 and the standard deviation was 0.66, which strengthened their agreement on the items.

6.4.4.3 Aesthetics

Table 6.9 illustrates the results of the descriptive statistics that include the values of the means for three items (4.42, 4.18, 4.33) respectively.

Table 6.9

Descriptive Analysis for Aesthetics

Items	Min	Max	Mean	Std. Deviation	Ranked
AES.1	3.00	5.00	4.42	.69	1
AES.3	3.00	5.00	4.33	.73	2
AES.2	2.00	5.00	4.18	.79	3
Aesthetics	**2.67**	**5.00**	**4.31**	**.64**	

The highest level of agreement by the users was towards the first item (The MARHIME prototype was attractive). While the lowest level of agreement by the users was towards the second item (The MARHIME prototype screen layout was suitable). These results show that the users were having positive opinions with regard to all of the items, meaning that the users agreed on the aesthetics of the prototype. In addition, the standard deviations for all the items were small and ranged from 0.69-0.79, and this indicates the accuracy of the users' answers to the questionnaire. Moreover, the level of agreement by the users around the aesthetics element was 4.31 and the standard deviation was 0.64, which strengthened their agreement on the items.

6.4.4.4 Satisfaction

Table 6.10 show the results of descriptive statistics that included the values of the means for three items (4.27, 4.25, 4.25), respectively.

Table 6.10

Descriptive Analysis for Satisfaction

Items	Min	Max	Mean	Std. Deviation	Ranked
SAT.1	2.00	5.00	4.27	.80	1
SAT.2	2.00	5.00	4.25	.74	2
SAT.3	2.00	5.00	4.25	.81	3
Satisfaction	**2.00**	**5.00**	**4.26**	**.66**	

The highest level of agreement by the users was towards the first item (Generally, I am satisfied with the MARHIME prototype). While the lowest level of agreement by the users was towards the second item (I became fond with the MARHIME prototype), and the third item (I will recommend the MARHIME prototype to others). These results show that the users were having positive opinions with regard to all of the items, meaning that the users agreed on the satisfaction in using the prototype. In addition to that, the standard deviations for all the items were small and ranged from 0.74-0.81, and this indicates the accuracy of the users' answers to the questionnaire. Moreover, the level of agreement by the users around the satisfaction element was 4.26 and the standard deviation was 0.66, which strengthened their agreement on the items.

6.4.4.5 Interaction

Table 6.11 exhibits the results of the descriptive statistics that included the values of the means for three items (4.27, 4.15, 4.10), respectively.

Table 6.11

Descriptive Analysis for Interaction

Items	Min	Max	Mean	Std. Deviation	Ranked
INT.1	2.00	5.00	4.27	.95	1
INT.2	1.00	5.00	4.15	1.15	2
INT.3	2.00	5.00	4.10	.99	3
Interaction	**1.67**	**5.00**	**4.17**	**.86**	

The highest level of agreement by the users was towards the first item (The MARHIME prototype provided control through my actions). While the lowest level of agreement by the users was towards the third item (The MARHIME prototype provided feedback smoothly). These results show that the users were having positive

opinions with regard to all of the items, meaning that the users agreed on the interaction of the prototype. In addition, the standard deviations for all the items were small and ranged from 0.95-1.15, and this confirms the accuracy of the users' answers to the questionnaire. Moreover, the level of agreement by the users around the interaction element was 4.17 and the standard deviation was 0.86, which strengthened their agreement on the items.

6.4.4.6 Enjoyment

Table 6.12 clarifies the results of the descriptive statistics that include the values of the means for four items (4.23, 4.00, 3.96, 3.95), respectively.

Table 6.12

Descriptive Analysis for Enjoyment

Items	Min	Max	Mean	Std. Deviation	Ranked
ENJ.1	2.00	5.00	4.23	.99	1
ENJ.2	2.00	5.00	4.00	1.01	2
ENJ.3	2.00	5.00	3.96	.96	3
ENJ.4	2.00	5.00	3.95	.93	4
Enjoyment	**2.00**	**5.00**	**4.03**	**.77**	

The highest level of agreement by the users was towards the first item (I enjoyed using the MARHIME prototype). While the lowest level of agreement by the users was towards the fourth item (I did not feel the time has passed while using the MARHIME prototype). These results show that the users were having positive opinions with regard to all of the items, meaning that the users agreed on the enjoyment in using the prototype. In addition, the standard deviations for all the items were small and ranged from 0.93-1.01, and this confirms the accuracy of the users' answers to the questionnaire. Moreover, the level of agreement by the users around

the enjoyment element was 4.03 and the standard deviation was 0.77, which strengthened their agreement on the items.

Table 6.13 shows the results of the descriptive statistics that included the values of the means of the six elements that include; usability, motivation, aesthetics, satisfaction, interaction and enjoyment (4.37, 4.35, 4.31, 4.26, 4.17, 4.03), respectively. The highest level of agreement by the users was towards usability, while the lowest level of agreement by the users was towards enjoyment. These results show that the users were having positive opinions with regard to all of the items, meaning that the users agreed on all the elements of the prototype. In addition, the standard deviations for all the elements were small and ranged from 0.57-0.86, and this confirms the accuracy of the users' answers to the questionnaire.

Table 6.13

Descriptive Analysis for Elements of Engagement

Element	Min	Max	Mean	Std. Deviation	Ranked
USABILITY	3.33	5.00	4.37	.57	1
MOTIVATION	2.33	5.00	4.35	.66	2
AESTHETICS	2.67	5.00	4.31	.64	3
SATISFACTION	2.00	5.00	4.26	.66	4
INTERACTION	1.67	5.00	4.17	.86	5
ENJOYMENT	2.00	5.00	4.03	.77	6

Graph is the most frequently used methods in descriptive statistics because it provides clearer and easier idea of understanding information (Bryman & Bell, 2015; De Vaus, 2002). Figure 6.7 shows the graphs for the means and the standard deviations of all the elements in the current study.

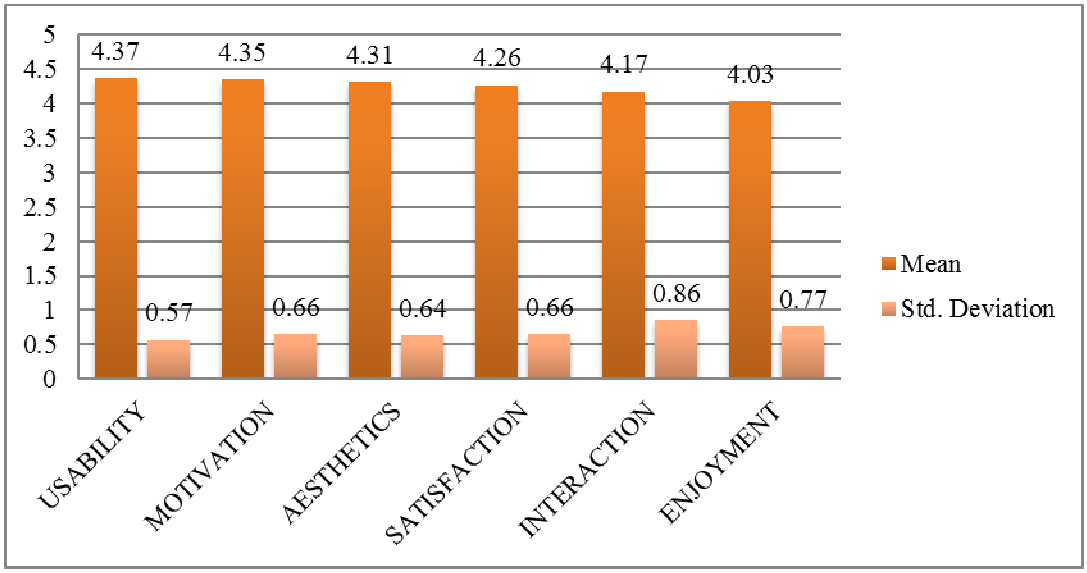


Figure 6.7. Descriptive Analysis for Elements of Engagement

6.5 Discussion of Concurrence between Previous Studies Findings and Current Study Findings

As mentioned earlier, there are six elements (Usability, Motivation, Aesthetics, Satisfaction, Interaction and Enjoyment) for measuring the engagement of HI visitors to the museum. Based on the descriptive statistics, the mean for Usability was 4.37 which indicated that the users strongly agreed on this element. This finding is consistent with the studies by O'Brien and Toms (2010); O'Brien & Cairns, (2015); Permadi and Rafi (2016); Othman et al. (2011); Nilsson and Johansson (2007), which indicate that the users are interested in using the application when the application is easy to use in terms of selecting options, provides consistent information and providing required guidance to complete assigned tasks. For HI, this study also supports findings by Chuan et al. (2017) which found that HI is interested to use an application with good usability.

The mean for Motivation was 4.35 which indicated that the users strongly agreed on this element. This finding is consistent with the studies by Gopalan et al. (2016); Chang et al. (2015); Di Serio et al. (2013); Alqahtani and Mohammad (2015) which

indicate that the users are interested in using the application when the application is able to increase the user's excitement, feeling more motivated and encouraging with the use of the application. However, it is difficult to find any support or contradict findings related to HI.

The mean for Aesthetics was 4.31 which indicated that the users strongly agreed on this element. This finding is consistent with the studies by O'Brien & Toms, (2010); O'Brien & Cairns, (2015); Wiebe et al. (2014) which indicate that the users are interested in using the application when the application emphasizes on attractive, visual senses and the screen layout is suitable. However, it is difficult to find any support or contradict findings related to HI.

The mean for Satisfaction was 4.26 which indicated that the users strongly agreed on this element. This finding is consistent with the studies by Alqahtani and Mohammad (2015); Permadi and Rafi (2016); Kim et al. (2013) which show that when users are satisfied with the application, they become fond with the application and they will recommend it to others. For HI, this study also supports findings by (Chen 2014) which found that HI is interested to use an application with good Satisfaction.

The mean for Interaction was 4.17 which indicated that the users agreed to this element. This finding is consistent with the studies by Othman et al. (2011); Wu, Y., Wu, Y., and Yu, S. (2015) which show that the users are interested in using the application when the application provides good feedback to the user, provided control on their actions and also the application provides responses on their needs. For HI, this study also supports findings by (Adamo-Villani, Carpenter, and Arns, 2006) which found that HI is interested to use an application with good Interaction. Although this finding contradicts with Permadi and Rafi (2016), which fails in establishing the relationship between interaction and engagement. Finally, the mean

for Enjoyment was 4.03 which indicated that the users agreed to this element. This finding is consistent with the studies by Gopalan et al. (2016); Pendit et al. (2014b, 2016); Karimi and Lim (2010); Xie, Antle, and Motamedi (2008); Lin, Fernandez, and Gregor (2012) which show that the user feels fun, enjoy, entertaining, and does not feel the passage of time with using the MAR application. However, it is difficult to find any support or contradict findings related to HI.

Therefore, it can be concluded from this study that the HI users strongly agreed on Usability, Motivation, Aesthetics and Satisfaction elements and agreed on Interaction and Enjoyment elements. The Usability element was ranked the highest with mean of 4.37 while Enjoyment was the lowest with mean of 4.03.

6.6 Notable Findings on Observation of HI Museum Experience

During the evaluation, there were several observations that were recorded on HI visitors in the museum during their use of the MARHIME application. These observations were generally classified into seven categories as shown in Table 6.14.

Table 6.14

Observation of HI Museum Experience

Categories	Observation Description
Expectations	The HI visitors were comfortable with the use of the MARHIME application because it is designed in a way that meets their ambitions and expectations, which increased their motivation and passion for engaging with it.
Emotions	The HI visitors felt comfortable, enjoyed and happy especially when using the game and social networking sites.
Ease to use	The HI visitors successfully completed the task without any difficulties.
No guide	The HI visitors get the information without the help either from a person, guide or teacher to transfer the information to them and this increased their self-reliance
Behaviours	The HI visitors successfully completed the task of using the MARHIME application. They have made slight mistakes but recovered quickly and successfully.

Table 6.14 Continued

Categories	Observation Description
Knowledge and options	The HI visitors had many options to gain new knowledge with the MARHIME application, in addition to strengthening their previous knowledge. This was obvious during the discussion that took place among the participants regarding the information.
Communications	The MARHIME application gave the HI the opportunity to discuss among them through the use of social networking sites and invite each other to use the application.
Interaction	HI interaction with the application by reading information about the application and using the provided multimedia.

From the table above, most of the observations were positive, they satisfied and enjoyed the MARHIME application.

6.7 Chapter Summary

The main aim of conducting the evaluation in this chapter is to ascertain that the developed MARHIME prototype from Chapter 5 based on the conceptual model in Chapter 4, achieves its aim in engaging the HI visitors at the museum. In justifying this aim, statistical analysis was conducted with an initial analysis from the pilot study upto the main evaluation. The results obtained from the analysis, has statistically confirmed that the MARHIME prototype is capable of engaging the HI when visiting the museum. The findings show that the main objective of this study has been successfully achieved.

CHAPTER SEVEN
CONCLUSION

7.1 Introduction

This chapter briefly outlines all the important phases and steps that were undertaken to achieve the main aim of this study. This chapter identifies the appropriate responses to answer the research questions, hence showing how the research objectives were actualized. The chapter further discusses the contributions of this research to various fields, limitation of the study and future works.

7.2. Research Discussion

The aim of this research is to develop a conceptual model for engaging HI visitors in the museum. To achieve this aim, the study has identified suitable elements of MAR for HI museum visitors' engagement, to be implemented in the development of the conceptual model. Therefore, the study was directed towards answering these three research questions.

i. What are the elements of MAR for engaging the HI museum visitors?

ii. How to develop the conceptual model of MAR for engaging the HI museum visitors based on the identified elements?

iii. How to validate the conceptual model of MAR for engaging the HI museum visitors through expert review and prototyping?

With respect to the research questions highlighted, this study likewise has three objectives to be achieved as mentioned below.

i. To identify the elements of MAR for engaging the HI museum visitors.

ii. To develop a conceptual model of MAR for engaging the HI museum visitors based on the identified elements.

iii. To validate the conceptual model of MAR for engaging the HI museum visitors through expert review and prototyping.

The achievement of these objectives which serves as answers to the research questions are provided in the following sections.

7.2.1. Research Objective One

To identify the elements of MAR for engaging the HI museum visitors.

In order to achieve this objective, it is necessary to delve into literature sources, theses and research using different platforms especially the online academic databases, to find out more about the elements of engagement. This investigation of literature gave rise to twenty (20) elements of engagement as documented in section 2.4.4. From these elements, eleven (11) elements were extracted the most preferred elements of engagements based on the focus group session (refer to section 4.2). These eleven (11) elements were then presented to eight (8) experts in the field of Museum, HI, MAR, AR, HCI and Multimedia who recommend those elements which are suitable in order to achieve the aim of the research. The review from the experts resulted in the selection of six elements for engaging HI museum visitors. Details of the procedure of selection can be accessed in Section 4.3 of Chapter 4. This meets the first research objective and the selected elements are: Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment. The following is the list of the selected elements and their proposed definitions.

i. Aesthetics refers to visual beauty or the study of natural and appealing mobile environments.

ii. Usability refers to consistency of information and ease of use based on the application functionality as perceived by the users.

iii. Interaction refers to aware of being in control towards the application whereby interactivity, information and feedback are given upon an action.

iv. Motivation refers to an act which encourages action or target activity to be performed by a user.

v. Satisfaction refers to act of being content and fond with an application.

vi. Enjoyment refers to the user experiencing fun, enjoy, and entertainment with the usage of the application.

7.2.2. Research Objective Two

To develop a conceptual model of MAR for engaging the HI museum visitors based on the identified elements.

The achievement of this objective is dependent on the review of the literature conducted in Chapter 2 of this research. The conceptual model for this study was built based on the review of research related to the fields of Museum, HI, MAR, and Engagement. Thus, the conceptual model for this study in the first layer consists of these four components (Museum, MAR, HI and Engagement) incorporating the six elements (Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment) obtained from the focus group and the expert review. Section 4.5 of Chapter 4 discusses these elements in relation with the concept of engagement in developing the conceptual model. In addition, the structure of MARHIME conceptual model

developed to consists of two levels. In the first level, Technology and the second level for engagement elements that consist of six elements and their features that have been incorporated into the MARHIME conceptual model that include: Aesthetics, Usability, Interaction, Motivation, Satisfaction, and Enjoyment. The development of the conceptual model based on these elements is discussed in chapter 4. Each of these elements is measured by certain number of items: Aesthetics (3 items), Usability (3 items), Interaction (3 items) Motivation (3 items), Satisfaction (3 items) and Enjoyment (4 items). These elements together with their corresponding items are implemented in the research instrument administered in this research.

7.2.3 Research Objective Three

To validate the conceptual model of MAR for engaging the HI museum visitors through expert review and prototyping.

In achieving this objective requires adapting the research instrument as a measurement for the elements of the conceptual model. The conceptual model was validated to suit the needs of the HI museum visitors by means of the academic expert review. Next, the validity of the conceptual model was measured by means of prototyping. A pilot study was conducted to pre-test the instrument before implementing it on the HI users which are the target users of this study. Statistical analysis was then conducted to determine the contribution of each element of the conceptual model towards engagement of the HI museum visitors.

The initial version of the prototype was developed based on the conceptual model. Subsequently, the research instrument was developed by adapting items to measure each element of the conceptual model. This instrument was presented to a panel of experts as discussed in Section 5.5 of Chapter 5. Meanwhile, the initial version of the

prototype was evaluated by the experts for recommendations of improvement. Based on their feedbacks and recommendations, modifications were implemented on the initial version to obtain a second and final version of the prototype.

This final version of the prototype was also investigated for any limitations by putting it through a pilot study. The pilot study was conducted to get responses from the participants, improving the items of the scale and determining its level of reliability. From the statistical analysis conducted Chapter 6, the results of the pilot study were acceptable on the basis that all the elements were acceptable according to the measurements.

In Chapter 6, details of how the HI museum visitors interacted with the prototype at the Iraq museum were documented. After the interaction, the users were requested to fill out the questionnaires. The responses from the questionnaires were collated and analysed statistically. The results showed that the elements selected for the conceptual model, which were further incorporated into the prototype, were acceptable among the HI users. Therefore, the third which is also the last objective is achieved.

Six elements are found to affect HI engagement in using MAR during museum visit. These are Usability, Motivation, Aesthetics, Satisfaction, Interaction, and Enjoyment. Usability has the highest mean due to the users' strong agreement to this element as observed in its computed mean of 4.37. This result is consistent with O'Brien and Toms (2010); O'Brien and Cairns (2015); Permadi and Rafi (2016); Othman et al. (2011), Chuan et al. (2017); Nilsson and Johansson (2007), which indicate that the users are interested in using the application when the application is easy to use in terms of selecting options, provides consistent information and providing required guidance to complete assigned tasks. While Motivation has in the second highest mean due to the users' strong agreement to this element as observed in its computed

mean of 4.35. This result is consistent with Gopalan et al. (2016); Chang et al. (2015); Di Serio et al. (2013); Alqahtani and Mohammad (2015) which indicate that the users are interested in using the application when the application is able to increase the user's excitement, feeling more motivated and encouraging with the use of the application.

The third highest mean is Aesthetics as it is strongly agreed by participant based on the mean of 4.31 to be able to engage the HI visitors. This is consistent with the study of O'Brien and Toms (2010); O'Brien and Cairns (2015); Wiebe et al. (2014) which indicate that the users are interested in using the application when the application emphasizes on attractive, visual senses and the screen layout is suitable. The fourth highest mean is Satisfaction based on the mean of 4.26. This is consistent with the study of Alqahtani and Mohammad (2015); Chen (2014); Permadi and Rafi (2016); Kim et al. (2013) which show that when users are satisfied with the application, they become fond with the application and they will recommend it to others.

The fifth highest mean is Interaction as agreed by the participants to affect their engagement based on the mean of 4.17 which consistent with the study of Othman et al. (2011); Wu, Y., Wu, Y., and Yu, S. (2015); Adamo-Villani, Carpenter, and Arns, (2006) which show that the users are interested in using the application when the application provides good feedback to the user, provided control on their actions and also the application provides responses on their needs. While, this finding is contradicted with Permadi and Rafi (2016), which still have minor problems with engagement. While the last affecting engagement is Enjoyment based on the mean of 4.03 which consistent with a number of studies such as Gopalan et al. (2016); Pendit et al. (2014b, 2016); Karimi and Lim (2010); Xie, Antle, and Motamedi (2008); Lin,

Fernandez, and Gregor, (2012) which show that when the user feelings fun, enjoy, entertaining, and does not feel the passage of time with using the application.

It is also found that these elements have strong relationship with engagement and do not interrelate.

7.3 Contributions of the study

The findings of this study which aimed to developing a conceptual model for engaging the HI museum visitors has contributed to various fields of knowledge. It has contributed in terms of theoretical contribution perspective, application contribution perspective, social contribution, education and technology for HI, and also for the HI museum visitors. The following discussions highlight how these studies have positively affected these sectors.

7.3.1 Theoretical Contribution Perspective

The major theoretical contribution of this study is the conceptual model of MAR for the HI museum visitors' engagement. This major theoretical contribution is achieved in two different ways. Firstly, the study theoretically identifies the elements of the MAR which contributes to the HI museum visitors' engagement. Based on the first theoretical contribution, the second contribution obtained is the conceptual model of MAR for the HI museum visitors' engagement. The conceptual model is unique since its elements emphasise on engagement with MAR for the HI. Secondly, the study contributes to theories such as the engagement theory (Kearsley & Shneiderman, 1998) which can be used as the underpinning and guide by designers in order to develop applications that are engaging, particularly for the HI people. In addition, the instrument to measure the engagement of HI museum visitors was also developed.

The instrument was proven to be reliable through reliability test and can be implemented by future researchers (refer to Appendix G).

This study also offers guidelines for developing MAR for HI people. This guideline would assist computing professionals and researchers to understand the needs and requirement of one of the underserved communities.

7.3.2 Application Contribution Perspective

Apart from the theoretical contribution perspective, the second contribution dimension is the application contribution perspective. This is achieved by using the proposed model to develop an engagement with MAR application which explicitly emphasises on engage the HI visitors within the museum. This application was developed using Vuforia and Unity 3D based on the C++ programming language. Besides that, Windows Movie Maker and 3DS Max were used to edit and compile the videos and also editing of 3D models respectively. The application was designed with features to further compliment the elements given in the design of engaging technology by Brandztæog, Følstad, and Heim (2005).

7.3.3 Social Contribution

The progress of communities has been measured by their particular interest in special needs. This has led the United Nations World Tourism Organization (UNWTO) in 2005 to acknowledge the need for tourism for all which was tagged as “accessible tourism for all”. Therefore, the contribution of this research to this special need especially for HI can be summed up as follows:

i. HI visitors can learn about a country's culture and history and establish its importance by visiting the museum and having an engaging experience. This

increases their cultural awareness of tourism by linking them to their past and thus generating a sense of belonging to the society in its present and past.

ii. HI visitors can communicate with HI communities and other individuals through social networking sites using one of the features provided in the MARHIME prototype. This reduces isolation and increases knowledge by sharing of educational and cultural information between members of the HI communities.

iii. MARHIME prototype eradicates inferiority complex among the HI. They can experience the same level of engagement as normal people. This increases their social confidence value and thus erasing all thoughts of inferiority. The overall self-esteem is encouraged to initiate relationships with normal hearing individuals.

iv. The MARHIME prototype grants the HI a sense of self dependence. This is because they can make use of the prototype without having to rely on others. It enhances their interaction in getting more information and this motivates them to visit the museum again in the future.

v. The museum can then be seen as a disabled-friendly place for the HI to learn about national culture and history.

7.3.4 Education and Technology

The field of technology and education has also contributed to providing historical information directly by using augmented reality technology in the museum. The MARHIME prototype supports video, text, image and 3D objects, and the use of these multimedia elements can increase the users' interest in learning. Hence, knowledge can be conveyed through the use of technology and increased enthusiasm to further

explore the historical artefacts (Carillo, Rodriguez-Ischaria, & Arnold, 2007). This leads to the HI visitors' engagement, improved memory, rapid learning as well as lifelong learning (Damala et al., 2008) that affect the growth of knowledge and awareness and simultaneously increase their knowledge of modern technology.

7.3.5 Museum Visitors

The government and museum management can use the prototype to provide service to HI visitors. It is effective to explore the artefacts in the museum in an attractive manner as proven from all analysis conducted in this research. Thus, being an interesting tool helps in keeping the HI visitors engaged in the museum. These conclusions are drawn from the evaluation results which are described in detail in Chapter 6. The use of the prototype creates more interest in HI individuals to visit the museum. This will increase the government's income by encouraging tourism which has increased the government resources as a source of national income.

7.4 Limitation of the study

This study has been conducted with certain limitations because it deals with a group of minority community that is the HI in a country namely Iraq. These limitations are summarized as follows:

i. The conceptual model of MARHIME was developed for indoor image-based AR environment such as the museum which has been considered in this study. The indoor navigation works using scans within the museum environment.
ii. The study covers numerous multimedia elements in delivering information through MAR. It is found however the amount of data storage is quite

enormous for mobile phone users. This may hinder users to install the MAR app. Thus, another study may extend the capability of storage optimization.

iii. The most important problem faced by the researcher is that the number of participants in the evaluation was not many. This is because the level of education for the HI in Iraq is low and the study was conducted for HI individuals who can only read and write. Therefore, the researcher sought for cases of people that have an average level of education or individuals that are educated before encountering hearing loss as a result of accidents and injuries. On the other hand, as a result of the security situation in Iraq, the HI turnout to schools for HI is low. All these reasons affected the sample size.

iv. The researcher encountered difficulty in dealing with HI people because they are sensitive and shy in dealing with normal people and also feel bored when talking to them for a long time.

v. The task of bringing the HI to visit the museum was quite difficult. This is because of the culture and also conservative attitude towards the researcher as a woman.

vi. The operating system (OS) that was used for the MARHIME prototype was based on Android. Therefore, the MARHIME prototype only runs on Android mobile devices, which does not reflect the effectiveness and feasibility of other operating systems.

7.5 Future Work

Considering the limitations mentioned in the previous section, it is clear that the room for improvement exists. Therefore, list of future directions for this study is as follows:

i. The extension of the conceptual model may include advanced features using location-based MAR for outdoor cultural heritage sites.

ii. This study warrants the inclusion of cloud storage to be integrated in the MARHIME model.

iii. This study may further expand to include sensor capabilities built in smartphones for extensive use by HI visitors.

iv. This study was applied in Iraq and the language used was Arabic and the participants were HI Iraqis. Thus, it is suggested that new elements be investigated for any other variables, for example the interaction of the HI in other languages, for example English or Malay.

v. Future studies may include larger sample size in order to generalize the findings.

vi. Future work may focus on comparing the use of the MARHIME prototype according to the culture of the country. In this study, it was difficult to recruit females as participants; hence the findings are more inclined to male participants. On the other hand, culture of the country may affect the nature of the study and warrants further research.

7.6 Chapter Summary

This study has identified the elements of MAR for the HI museum visitors' engagement, and the MARHIME conceptual model was then developed based on the identified elements. This study has identified six elements of MAR for engaging HI museum visitors. The validity of these six elements was proven through validation steps and prototyping. All elements were validated through the expert reviews and HI responses gathered through the use of the MARHIME prototype in the museum aimed

at measuring the engagement experience. This study demonstrates the importance and benefits of MARHIME prototype in engaging HI museum visitors. Thus, when preparing applications such as this, emphasis should be placed in the development of the contents that reflect the relevant theoretical architecture in its design and development. The contents should be engaging and helpful enough in assisting the HI visitors in the museum. The results showed that all the HI visitors agreed that they had an engaging visit to the museum by using the prototype. Many visitors also prefer the application in the museum and wish to use it again in the future. All these results conclude that the prototype is suitable to be used for engaging HI visitors in the museum. Finally, the elements and conceptual model may be a guideline for developers to develop MAR for engaging HI at the museum.

In summary, the following is the notable findings of the study.

i. The validated conceptual Model of MARHIME is reliable.
ii. The validated elements of aesthetics, usability, interaction, motivation, satisfaction, and enjoyment, in the MARHIME prototype contribute to the engagement of HI museum visitors.
iii. The validated MARHIME prototype is provides engagement for the HI museum visitors.
iv. Conceptual model may serve as a guideline for future of MAR in order to engage the HI during the museum visit.

Overall, this study has developed and evaluated the conceptual model of MAR for engaging HI museum visitors.

REFERENCES

Abdinnour-Helm, S. F., Chaparro, B. S., & Farmer, S. M. (2005). Using the end-user computing satisfaction (EUCS) instrument to measure satisfaction with a web site. *Decision Sciences*, *36*(2), 341-364.

Abdul Mutalib, A., Salam, A., Nur, S., Mahmuddin, M., Ahmad, M., & Syed Yahya, S. N. (2015). A concept of assertive courseware for hearing impaired learners. *ARPN Journal of Engineering and Applied Sciences*.

Abhishekh, D., Reddy, B. R., Kumar, R. R., & Rajeswarappa, G. (2013). Interactive learning in education using Augmented Reality. *International Journal of Scientific & Engineering Research*, *4*(1).

Adamo-Villani, N., Carpenter, E., & Arns, L. (2006, July). An immersive virtual environment for learning sign language mathematics. In *ACM SIGGRAPH 2006 Educators program* (p. 20). ACM.

Adams, J., Khan, H. T., Raeside, R., & White, D. I. (2007). *Research methods for graduate business and social science students*: SAGE publications India

Ahmad, H., Zainuddin, N. M. M., Ali, R., Maarop, N., Yusoff, R. C. M., & Hassan, W. A. W. (2018). Augmented reality to memorize Al-Quran for hearing impaired students: a preliminary analysis. *Journal of Fundamental and Applied Sciences*, *10*(2S), 91-102.

Al-Aidaroos, A. S. A. (2017). *Conceptual model for usable multi-modal mobile assistance during Umrah* (Doctoral dissertation, Universiti Utara Malaysia).

Alén, E., Domínguez, T., & Losada, N. (2012). New opportunities for the tourism market: Senior tourism and accessible tourism. In *Visions for global tourism industry-Creating and sustaining competitive strategies*. InTech

Alexander, J. M., Kopun, J. G., & Stelmachowicz, P. G. (2013). Effects of frequency compression and frequency transposition on fricative and affricate perception in listeners with normal hearing and mild to moderate hearing loss. *Ear and hearing*, *35*(5), 519-532.

Ali, S., Koleva, B., Bedwell, B., & Benford, S. (2018, June). Deepening visitor engagement with museum exhibits through hand-crafted visual markers. In *Proceedings of the 2018 on Designing Interactive Systems Conference 2018* (pp. 523-534). ACM.

Alkhamisi, A. O., & Monowar, M. M. (2013). Rise of augmented reality: Current and future application areas. *International Journal of Internet and Distributed Systems*, *2013*.

Almanasreh, E., Moles, R., & Chen, T. F. (2018). Evaluation of methods used for estimating content validity. *Research in Social and Administrative Pharmacy.*

Alqahtani, M., & Mohammad, H. (2015). Mobile Applications' Impact on Student Performance and Satisfaction. *TOJET: The Turkish Online Journal of Educational Technology*, *14*(4).

Alturki, A. (2015). Information System Design Theory: A Lifecycle Perspective.

Alzua-Sorzabal, A., Linaza, M. T., & Abad, M. (2007). An experimental usability study for Augmented Reality technologies in the tourist sector. *Information and Communication Technologies in Tourism 2007*, 231-242

Analysis of Preservice Teacher Talk. *The Qualitative Report*, *20*(6), 830.

Andriotis, K. (2016). Beggars–tourists' interactions: An unobtrusive typological approach. *Tourism Management*, *52*, 64-73.

Angelopoulou A, Economou D, Bouki V, Psarrou A, Jin L, Pitchard C, & Kolyda F. (2011). Mobile Augmented Reality for Cultural Heritage. In 4th International ICST Conference Mobilware, p. 15-22.

Angkananon, K., Wald, M., & Gilbert, L. (2016). Evaluation of Technology Enhanced Accessible Interaction Framework and Method for Local Thai Museums. *วารสาร วิทยาการ จัดการ มหาวิทยาลัย ราชภัฏ สุราษฎร์ธานี*, *2*(2), 19-46.

Arehart, K. H., Souza, P., Baca, R., & Kates, J. M. (2013). Working memory, age and hearing loss: susceptibility to hearing aid distortion. *Ear and hearing*, *34*(3), 251.

Arrasvuori, J., (2006). *Augmented reality assisted shopping*. U.S. Patent Application 11/523,162.

Asbury, J (1995). Overview of focus group research. Qualitative Health Research, 5 (November), 414–420.

Assaker, G., Vinzi, V. E., & O'Connor, P. (2011). Examining the effect of novelty seeking, satisfaction, and destination image on tourists' return pattern: A two factor, non-linear latent growth model. *Tourism Management*, *32*(4), 890-901.

Azaiez, H., Booth, K. T., Bu, F., Huygen, P., Shibata, S. B., Shearer, A. E., & Smith, R. J. (2014). TBC1D24 Mutation Causes Autosomal-Dominant Nonsyndromic Hearing Loss. *Human mutation*, *35*(7), 819-823.

Aziz, N., Mutalib, A. A., & Sarif, S. M. (2014). Conceptual design model of assistive courseware for low vision (AC4LV) learners. In *International Conference on Advances in Educational Technology (ICAET'14)* (pp. 1-12).

Bainbridge, K. E., & Wallhagen, M. I. (2014). Hearing loss in an aging American population: extent, impact, and management. *Annual review of public health*, *35*, 139-152.

Baktash, A., Nair, V., Subramonian, H., & Ragavan, N. A. (2016). Conceptualising a framework to study behavioural intention of tourists of distinct cultures towards wearable Augmented Reality (AR) applications

Bala, R., Ding, H., Zhao, Y., Furst, M.R. and Kompalli, P.S., Xerox Corporation, 2015. *Methods and systems for realistic rendering of digital objects in augmented reality*. U.S. Patent 9,214,137.

Balch, G. I., & Mertens, D. M. (1999). Focus group design and group dynamics: Lessons from deaf and hard of hearing participants. *American Journal of Evaluation*, *20*(2), 265-277.

Balcisoy, S., & Thalmann, D. (1997, June). Interaction between real and virtual humans in augmented reality. In *ca* (p. 31). IEEE.

Banhawi, F., Ali, N. M., & Judi, H. M. (2012). User engagement attributes and levels in facebook. *Journal of Theoretical and Applied Information Technology*, *41*(1), 11-19.

Barello, S., Triberti, S., Graffigna, G., Libreri, C., Serino, S., Hibbard, J., & Riva, G. (2015). eHealth for Patient Engagement: a systematic review. *Frontiers in psychology*, *6*.

Barker, D. H., Quittner, A. L., Fink, N. E., Eisenberg, L. S., Tobey, E. A., Niparko, J. K., & CDaCI Investigative Team. (2009). Predicting behavior problems in deaf and hearing children: The influences of language, attention, and parent–child communication. *Development and psychopathology*, *21*(2), 373-392.

Barsom, E. Z., Graafland, M., & Schijven, M. P. (2016). Systematic review on the effectiveness of augmented reality applications in medical training. *Surgical endoscopy*, 1-10.

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The Lancet*, *383*(9925), 1325-1332

Batten, G., Oakes, P. M., & Alexander, T. (2013). Factors associated with social interactions between deaf children and their hearing peers: A systematic literature review. *Journal of Deaf Studies and Deaf Education*, *19*(3), 285-302.

Baudisch, P., Pohl, H., Reinicke, S., Wittmers, E., Lühne, P., Knaust, M., & Holz, C. (2014, April). Imaginary reality basketball: a ball game without a ball. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems* (pp. 575-578). ACM.

Beaudin, L. C. (1998). Computer self-efficacy and classroom practice: *what is the correlation?* (Doctoral dissertation, Lethbridge, Alta.: University of Lethbridge, Faculty of Education, 1998).

Bell, C. (2002). The Museum as 'Cultural Econology. Retrieved October 25, 2016 from

Bell, J. (2005). *Doing Your Research Project: A guide for first-time researchers* (4th ed.): McGraw-Hill Education (UK)

Benko, H., Ofek, E., Zheng, F., & Wilson, A. D. (2015, November). FoveAR: Combining an Optically See-Through Near-Eye Display with Projector-Based Spatial Augmented Reality. In *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology* (pp. 129-135). ACM.

Betsworth, L., Bowen, H., Robinson, S., & Jones, M. (2014). Performative technologies for heritage site regeneration. Personal and Ubiquitous Computing, 18(7), 1631-1650.

Bevans, S. E., Chen, B. S., & Crawford, J. V. (2013). Acquired Mixed Hearing Loss. In *Encyclopedia of Otolaryngology, Head and Neck Surgery* (pp. 15-29). Springer Berlin Heidelberg.

Bhuvaneswari, M., & Immanuel, S. (2013). PSYCHOLOGICAL ISSUES AMONG HEARING IMPAIRED ADOLESCENTS. *Education Sciences & Psychology*, *24*(2).

Biocca, F., Tang, A., Owen, C., & Xiao, F. (2006, April). Attention funnel: omnidirectional 3D cursor for mobile augmented reality platforms. In *Proceedings of the SIGCHI conference on Human Factors in computing systems* (pp. 1115-1122). ACM.

Bitgood, S. (2010). An attention-value model of museum visitors. *Center for Advancement of Informal Science Education: Washington, DC, USA*

Blanco, R., Morales, G. D. F., & Silvestri, F. (2015). Intonews: Online news retrieval using closed captions. *Information Processing & Management*, *51*(1), 148-162.

Boberg, M., Karapanos, E., Holopainen, J., & Lucero, A. (2015). PLEXQ: Towards a Playful Experiences Questionnaire. In *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play* (pp. 381-391). ACM.

Bolter, J. D., Engberg, M., & MacIntyre, B. (2013). Media studies, mobile augmented reality, and interaction design. *interactions*, *20*(1), 36-45

Bordens, K. S., & Abbott, B. B. (2011). *Research design and methods: A process approach* (8th ed.): McGraw-Hill.

Brandztæog, P. B., Følstad, A., & Heim, J. (2005). Enjoyment: lessons from karasek. In J. Karat & J. Vanderdonckt (Eds.), *Funology from usability to enjoyment* (pp. 55–66). Dordrhect, Netherlands: Kluwer Academic Publishers.

Bressler, D. M., & Bodzin, A. M. (2013). A mixed methods assessment of students' flow experiences during a mobile augmented reality science game. *Journal of Computer Assisted Learning*, *29*(6), 505-517.

Brooke, J. A. T. (2015). Preventing the summer slide: Using closed captioning and same-language subtitling on television as a literacy tool in the home to increase reading achievement. Seattle University.

Brown, C. J., Hughes, M. L., Luk, B., Abbas, P. J., Wolaver, A., & Gervais, J. (2000). The relationship between EAP and EABR thresholds and levels used to program the Nucleus 24 speech processor: data from adults. Ear and hearing, 21(2), 151-163.

Bryman, A., & Bell, E. (2015). *Business Research Methods* (4th ed.): Oxford University Press.

Buchmann, V., Violich, S., Billinghurst, M., & Cockburn, A. (2004). FingARtips: gesture based direct manipulation in Augmented Reality. In *Proceedings of the 2nd international conference on Computer graphics and interactive techniques in Australasia and South East Asia* (pp. 212-221). ACM.

Buhalis, D., & Darcy, S. (2010). Accessible tourism: Concepts and issues (Vol. 45).

Burger, K. (2009). *Country affect-scale development and validation* (Doctoral dissertation, uniwien).

Caimi, A. (2006). Audiovisual translation and language learning: The promotion of intralingual subtitles. *The Journal of Specialised Translation*, *6*, 85-98.

Caldera-Serrano, J., & León-Moreno, J. A. (2015). Implications of augmented reality in the management of television audiovisual information. *Journal of Information Science*, 0165551515608341.

Calhoun, G. L., Draper, M. H., Abernathy, M. F., Delgado, F., and Patzek, M. (2005) Synthetic Vision System for Improving Unmanned Aerial Vehicle Operator Situation Awareness, 2005 Proceedings of SPIE Enhanced and Synthetic Vision, Vol. 5802, pp. 219–230

Capretz, L. F., Ali, A., & Ouda, A. (2012). A conceptual framework for measuring the quality aspect of mobile learning. *Bulletin of the IEEE Technical Committee on Learning Technologies*, *14*(4), 31-34.

Carillo, E., Rodriguez Echavarria, K., & Arnold, D. (2007). Displaying intangible heritage using ICT. Roman everyday life on the frontier: Vindolanda.

Carlson, A. (1993). Aesthetics and engagement. *The British Journal of Aesthetics*, *33*(3), 220-228.

Carmigniani, J., & Furht, B. (2011). Augmented reality: an overview. In *Handbook of augmented reality* (pp. 3-46). Springer New York

Carmines, E.G., & Zeller, R.A. (1979). *Reliability and Validity Assessment*: SAGE Publications.

Carter, D. S. (2014). *Mobile Application Design to Encourage Civic Engagement* (Doctoral dissertation, Pennsylvania State University).

Cesário, V., Radeta, M., Matos, S., & Nisi, V. (2017, October). The Ocean Game: Assessing Children's Engagement and Learning in a Museum Setting Using a Treasure-Hunt Game. In *Extended Abstracts Publication of the Annual Symposium on Computer-Human Interaction in Play* (pp. 99-109). ACM.

Chaballout, B., Molloy, M., Vaughn, J., Brisson III, R., & Shaw, R. (2016). Feasibility of Augmented Reality in Clinical Simulations: Using Google Glass With Manikins. *JMIR Medical Education*, *2*(1), e2.

Chang, K. E., Chang, C. T., Hou, H. T., Sung, Y. T., Chao, H. L., & Lee, C. M. (2014). Development and behavioral pattern analysis of a mobile guide system

with augmented reality for painting appreciation instruction in an art museum. *Computers & Education*, *71*, 185-197.
Chang, Y. L., Hou, H. T., Pan, C. Y., Sung, Y. T., & Chang, K. E. (2015). Apply an Augmented Reality in a Mobile Guidance to Increase Sense of Place for Heritage Places. *Educational Technology & Society*, *18*(2), 166-178.
Chapman, P. M. (1997). *Models of engagement: Intrinsically motivated interaction with multimedia learning software* (Doctoral dissertation, University of Waterloo).
Chapman, P., Selvarajah, S., & Webster, J. (1999, January). Engagement in multimedia training systems. In *Systems Sciences, 1999. HICSS-32. Proceedings of the 32nd Annual Hawaii International Conference on* (pp. 9-pp). IEEE.
Chavan, S. R. (2014). Augmented reality vs. virtual reality: differences and similarities. *Int. J. Adv. Res. Comput. Eng. Technol*, *5*, 1-6.
Chen, C. M., & Chen, M. C. (2009). Mobile formative assessment tool based on data mining techniques for supporting web-based learning. *Computers & Education*, *52*(1), 256-273.
Chen, C. Y., Chang, B. R., & Huang, P. S. (2014). Multimedia augmented reality information system for museum guidance. *Personal and ubiquitous computing*, *18*(2), 315-322.
Chen, D. R., Chen, M. Y., Huang, T. C., & Hsu, W. P. (2013). Developing a mobile learning system in augmented reality context. *International Journal of Distributed Sensor Networks*, *2013*.
Chen, M., Kolko, B. E., Cuddihy, E., & Medina, E. (2005, June). Modeling and Measuring Engagement in Computer Games. In *DiGRA Conference*.
Chen, Y. T. (2012). A study of learning effects on e-learning with interactive thematic video. *Journal of Educational Computing Research*, *47*(3), 279-292.
Chen, Y. T. (2014). A study to explore the effects of self-regulated learning environment for hearing-impaired students. *Journal of computer assisted learning*, *30*(2), 97-109.
Cheng, J. C. P., Chen, K., & Chen, W. (2017). Comparison of Marker-based AR and Marker-less AR: A Case Study on Indoor Decoration System. In *Lean and Computing in Construction Congress (LC3): Proceedings of the Joint Conference on Computing in Construction (JC3)*.
Chikuta, O., Kabote, F., & Chikanya, N. (2017). Tour guides experiences with tourists with disabilities. *European Journal of Tourism, Hospitality and Recreation*.
Chin, J. P., Diehl, V. A., & Norman, K. L. (1988, May). Development of an instrument measuring user satisfaction of the human-computer interface. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 213-218). ACM.
Cho, M. E., Choi, H. H., & Kim, M. J. (2013). A Usability Study On Museum Installations Emphasizing Interaction Design for User Experience. *Korean Institute of Interior Design Journal*, *22*(5), 302-310.
Cho, S., Kwak, E., Kwak, S., & Lopez, J. (2015). Randomized Controlled Trial Evaluating Threshold Sound Conditioning in the treatment of Sensorineural Hearing Loss (S26. 006). *Neurology*, *84*(14 Supplement), S26-006.
Chou, T. L., & Chanlin, L. J. (2014). Location-Based Learning through Augmented Reality. *Journal of Educational Computing Research*, *51*(3), 355-368.
Chuan, N. K., Sivaji, A., Loo, F. A., Ahmad, W. F. W., & Nathan, S. S. (2017, November). Evaluating 'Gesture Interaction'requirements of mobile applications for deaf users: Discovering the needs of the hearing-impiared in using

touchscreen gestures. In *Open Systems (ICOS), 2017 IEEE Conference on* (pp. 90-95). IEEE.
Chung, N., Lee, H., Kim, J. Y., & Koo, C. (2017). The role of augmented reality for experience-influenced environments: the case of cultural heritage tourism in Korea. *Journal of Travel Research*, 0047287517708255.
Churchill Jr, G. A. (1979). A paradigm for developing better measures of marketing constructs. Journal of marketing research, 64-73.
Ciolfi, L., & Bannon, L. (2002, September). Designing Interactive Museum Exhibits: Enhancing visitor curiosity through augmented artefacts. In *Eleventh European Conference on Cognitive Ergonomics.*
Clark, J. G. (1981). Uses and abuses of hearing loss classification. *Asha*, *23*(7), 493-500.
Clason, D. (2014). Universal signs for hearing loss. Healthy Hearing.
Cohen, J. (1988). Statistical power analysis for the behavioral sciences. 2nd (2nd ed.): Hillsdale, NJ: erlbaum.
Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education* (6th ed.): Taylor & Francis.
Colpani, R., Homem, P., & Rodrigo, M. (2015). Preliminary study on systematic literature review of augmented and virtual reality applied to motor and cognitive disabilities. In *Information Systems and Technologies (CISTI), 2015 10th Iberian Conference on* (pp. 1-4). IEEE.
Colton, D., & Covert, R. W. (2007). *Designing and constructing instruments for social research and evaluation*: John Wiley & Sons.
Conley, Q. (2013). Exploring the impact of varying levels of augmented reality to teach probability and sampling with a mobile device. Arizona State University.
Cooper, Donald R, & Schindler, Pamela S. (2014). *Business research methods* (12th ed.): McGraw-hill education.
Côté, S., Trudel, P., Desbiens, M., Giguère, M., & Snyder, R. (2013). Live mobile panoramic high accuracy augmented reality for engineering and construction. *Proceedings of the Construction Applications of Virtual Reality (CONVR), London, England*.
Cranmer, E., Jung, T., tom Dieck, M. C., & Miller, A. (2016). Understanding the Acceptance of Augmented Reality at an Organisational Level: The Case of Geevor Tin Mine Museum. In *Information and Communication Technologies in Tourism 2016* (pp. 637-650). Springer International Publishing.
Creswell, J. (2012). Planning, Conducting, and Evaluating Quantitative and Qualitative Research. *America.*
Cronbach, Lee J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334. doi: http://10.1007/bf02310555
Cronbach, Lee J., & Meehl, Paul E. (1955). Construct validity in psychological tests. *Psychological bulletin, 52*(4), 281. doi: http://dx.doi.org/10.1037/h0040957
Curran, J. R., & Galster, J. A. (2013). The Master Hearing Aid. Trends in amplification, 17(2), 108-134.
Damala, A., Cubaud, P., Bationo, A., Houlier, P., & Marchal, I. (2008, September). Bridging the gap between the digital and the physical: design and evaluation of a mobile augmented reality guide for the museum visit. In *Proceedings of the 3rd international conference on Digital Interactive Media in Entertainment and Arts* (pp. 120-127). ACM.
Damala, A., Stojanovic, N., Schuchert, T., Moragues, J., Cabrera, A., & Gilleade, K. (2012, October). Adaptive augmented reality for cultural heritage: ARtSENSE

project. In *Euro-Mediterranean Conference* (pp. 746-755). Springer Berlin Heidelberg

Darcy, S., Dickson, T., & Edwards, D. (2010). Sydney World Masters Games: Volunteer Legacy Outcomes

Datcu, D., Lukosch, S., Lukosch, H., & Cidota, M. (2015). Using augmented reality for supporting information exchange in teams from the security domain. *Security Informatics*, *4*(1), 1.

Davis, L. L. (1992). Instrument review: Getting the most from a panel of experts. *Applied nursing research*, *5*(4), 194-197.

de Araújo, T. M. U., Ferreira, F. L. S., dos Santos Silva, D. A. N., Lemos, F. H., Neto, G. P., Omaia, D., ... & Tavares, T. A. (2013). Automatic generation of Brazilian sign language windows for digital TV systems. *Journal of the Brazilian Computer Society*, *19*(2), 107-125.

De Marsico, M., Galdi, C., Nappi, M., & Riccio, D. (2014). FIRME: face and iris recognition for mobile engagement. *Image and Vision Computing*, *32*(12), 1161-1172.

De Vaus, D. (2002). *Surveys in Social Research* (5th ed.): Taylor & Francis.

De Vreede, T., Nguyen, C., De Vreede, G. J., Boughzala, I., Oh, O., & Reiter-Palmon, R. (2013, October). A theoretical model of user engagement in crowdsourcing. In *International Conference on Collaboration and Technology* (pp. 94-109). Springer, Berlin, Heidelberg

Debevc, M., Kosec, P., & Holzinger, A. (2010). *E-learning accessibility for the deaf and hard of hearing-practical examples and experiences* (pp. 203-213). Springer Berlin Heidelberg.

Debevc, M., Milošević, D., & Kožuh, I. (2015). A comparison of comprehension processes in sign language interpreter videos with or without captions. *PloS one*, *10*(5), e0127577.

Dede, C. (2009). Immersive interfaces for engagement and learning. *science*, *323*(5910), 66-69.

Deng, L., Turner, D. E., Gehling, R., & Prince, B. (2010). User experience, satisfaction, and continual usage intention of IT. *European Journal of Information Systems*, *19*(1), 60-75.

Denny, P. (2013). The effect of virtual achievements on student engagement. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 763-772). ACM.

DeVellis, R. F. (2016). *Scale development: Theory and applications* (Vol. 26): Sage publications.

Di Serio, Á., Ibáñez, M. B., & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education*, *68*, 586-596.

Dispenza, F., De Stefano, A., Costantino, C., Marchese, D., & Riggio, F. (2013). Sudden sensorineural hearing loss: results of intratympanic steroids as salvage treatment. *American journal of otolaryngology*, *34*(4), 296-300.

Dix, A. (2009). Human-computer interaction. In *Encyclopedia of database systems* (pp. 1327-1331). Springer US.

Dixon, B. J., Daly, M. J., Chan, H., Vescan, A. D., Witterick, I. J., & Irish, J. C. (2013). Surgeons blinded by enhanced navigation: the effect of augmented reality on attention. *Surgical endoscopy*, *27*(2), 454-461.

Du, H., Venkatakrishnan, A., Youngblood, G. M., Ram, A., & Pirolli, P. (2016). A Group-Based Mobile Application to Increase Adherence in Exercise and

Nutrition Programs: A Factorial Design Feasibility Study. *JMIR mHealth and uHealth*, *4*(1), e4.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In *Handbook of research on educational communications and technology* (pp. 735-745). Springer New York.

Elwood, S. (2018, March). Augmented Reality Guided Video Tours for Greater Social to Cognitive Learner Engagement in Communities of Inquiry. In *Society for Information Technology & Teacher Education International Conference* (pp. 155-158). Association for the Advancement of Computing in Education (AACE).

Escalada, M., & Heong, K. L. (2011). Focus group discussion.

Escobedo, L., Nguyen, D. H., Boyd, L., Hirano, S., Rangel, A., Garcia-Rosas, D., ... & Hayes, G. (2012, May). MOSOCO: a mobile assistive tool to support children with autism practicing social skills in real-life situations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2589-2598). ACM.

Eve, S. (2012). Augmenting phenomenology: using augmented reality to aid archaeological phenomenology in the landscape. *Journal of archaeological method and theory*, *19*(4), 582-600.

Fabrigar, L.R., & Wegener, D.T. (2012). *Exploratory Factor Analysis*: OUP USA.

Falk, J., & Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. *Science Education*, *89*(5), 744-778.

Fedosov, A., Elhart, I., Niforatos, E., North, A., & Langheinrich, M. (2016, February). SkiAR: Wearable Augmented Reality System for Sharing Personalized Content on Ski Resort Maps. In *Proceedings of the 7th Augmented Human International Conference 2016* (p. 46). ACM.

Field, A.P. (2009). *Discovering Statistics Using SPSS* (3rd ed.): SAGE.

Fiore, A., Mainetti, L., Manco, L., & Marra, P. (2014). Augmented reality for allowing time navigation in cultural tourism experiences: a case study. In *Augmented and Virtual Reality* (pp. 296-301). Springer International Publishing.

Fogg, B. J. (2009, April). A behavior model for persuasive design. In *Proceedings of the 4th international Conference on Persuasive Technology* (p. 40). ACM.

Folch-Lyon, E., & Trost, J. F. (1981). Conducting focus group sessions. Studies in family planning, 443-449.

Fonseca, V. R., Marques, J., Panegalli, F., de Oliveira Gonçalves, C. G., & Souza, W. (2016). Prevention of the Evolution of Workers' Hearing Loss from Noise-Induced Hearing Loss in Noisy Environments through a Hearing Conservation Program. *International archives of otorhinolaryngology*, *20*(1), 43.

Forward, A., Badreddin, O., Lethbridge, T. C., & Solano, J. (2012). Model-driven rapid prototyping with Umple. *Software: Practice and Experience*, *42*(7), 781-797.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of educational research*, *74*(1), 59-109.

Furness, D. N., Johnson, S. L., Manor, U., Rüttiger, L., Tocchetti, A., Offenhauser, N. & Hackney, C. M. (2013). Progressive hearing loss and gradual deterioration of sensory hair bundles in the ears of mice lacking the actin-binding protein Eps8L2. *Proceedings of the National Academy of Sciences*, *110*(34), 13898-13903.

Ganga, A. M. (2009). *Conceptual-to-Object Schema Mapping.* Doctoral dissertation, Hamburg University of Science and Technology, Hamburg, Germany.

Gifford, R. H., Dorman, M. F., Shallop, J. K., & Sydlowski, S. A. (2010). Evidence for the expansion of adult cochlear implant candidacy. Ear and hearing, 31(2), 186.

Glasgow, R. E., Christiansen, S. M., Kurz, D., King, D. K., Woolley, T., Faber, A. J., ... & Dickman, J. (2011). Engagement in a diabetes self-management website: usage patterns and generalizability of program use. *Journal of medical Internet research*, *13*(1).

Goldman, A. E., & McDonald, S.S. (1987). The group depth interview: Principles and practices. Englewood Cliffs: Prentice-Hall.

Goodall, B. (2006). Disabled access and heritage attractions. *Tourism Culture & Communication*, *7*(1), 57-78.

Goodall, B., Pottinger, G., Dixon, T., & Russell, H. (2004). Heritage property, tourism and the UK Disability Discrimination Act. *Property Management*, *22*(5), 345-357.

Gopalan, V., Zulkifli, A. N., & Aida, J. A. (2016). A Study of Students' Motivation Based on Ease of Use, Engaging, Enjoyment and Fun Using the Augmented Reality Science Textbook. *Revista de la Facultad de Ingeniería*, *31*(5).

Goss, J., Kollmann, E. K., Reich, C., & Iacovelli, S. (2015). Understanding the Multilingualism and Communication of Museum Visitors who are d/Deaf or Hard of Hearing. *Museums & Social Issues*, *10*(1), 52-65.

Gravetter, F. J., & Forzano, L. A. B. (2018). *Research methods for the behavioral sciences*. Cengage Learning.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field methods*, *18*(1), 59-82.

Guttentag, D. A. (2010). Virtual reality: Applications and implications for tourism. *Tourism Management*, *31*(5), 637-651.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). *Multivariate data analysis* (Vol. 5): Prentice hall Upper Saddle River, NJ.

Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2014). *Multivariate Data Analysis*: Pearson Education Limited.

Hair, J.F., Celsi, M., Money, A., Samouel, P., & Page, M. (2016). *The Essentials of Business Research Methods* (3rd ed.): Taylor & Francis.

Hall, A. J. J. (2001). U.S. Patent No. 6,307,945. Washington, DC: U.S. Patent and Trademark Office.

Hammady, R., Ma, M., & Temple, N. (2017). Augmented Reality and Gamification in Heritage museums. In: Serious Games: Proceedings of Joint International Conference on Serious Games, Springer-Verlag Berlin Heidelberg., Brisbane, Australia.

Han, K., Shih, P. C., Rosson, M. B., & Carroll, J. M. (2014). Enhancing community awareness of and participation in local heritage with a mobile application. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing* (pp. 1144-1155). ACM.

Harmon, S., Waelde, C., & Whatley, S. (2014). Disabled Dance: Grounding the Practice in the Law of 'Cultural Heritage'. *European Journal of Current Legal Issues*, *20*(3).

Hassan, A., & Jung, T. (2016). Augmented Reality as an Emerging Application in Tourism Marketing Education. *Emerging Tools and Applications of Virtual Reality in Education*, 168.

Hatala, M., & Wakkary, R. (2005). Ontology-based user modeling in an augmented audio reality system for museums. *User Modeling and User-Adapted Interaction*, *15*(3-4), 339-380. DOI 10.1007/s11257-005-2304-5

Hatala, M., Kalantari, L., Wakkary, R., & Newby, K. (2004, March). Ontology and rule based retrieval of sound objects in augmented audio reality system for museum visitors. In *Proceedings of the 2004 ACM symposium on Applied computing* (pp. 1045-1050). ACM.

Haug, T., & Mann, W. (2008). Adapting tests of sign language assessment for other sign languages—A review of linguistic, cultural, and psychometric problems. *Journal of Deaf Studies and Deaf Education*, *13*(1), 138-147.

Haugstvedt, A. C. (2012). Accessing Cultural Heritage Resources on a Mobile Augmented Reality Platform: A Study on Technology Acceptance.

Haugstvedt, A. C., & Krogstie, J. (2012). Mobile augmented reality for cultural heritage: A technology acceptance study. In *Mixed and Augmented Reality (ISMAR), 2012 IEEE International Symposium on* (pp. 247-255). IEEE.

He, Z., Wu, L., & Li, X. R. (2018). When art meets tech: The role of augmented reality in enhancing museum experiences and purchase intentions. *Tourism Management*, *68*, 127-139.

Hector and Payel, "Analysis of Four Usability Evaluation Methods Applied to Augmented Reality Applications ", 2014.

Hefeneider, S. H., & McCoy, S. (2015). *A Novel Therapeutic for the Treatment and Prevention of Hearing Loss from Acoustic Trauma*. 13THERAPEUTICS INC PORTLAND OR.

Hendriks, D., Schiffelers, R. R., Hüfner, M., & Sonntag, C. (2011). *A Transformation Framework for the Compositional Interchange Format for Hybrid Systems*. Paper presented at the 18th International Federation of Automatic Control (IFAC2011) World Congress, Milano, Italy.

Herrington, J., Oliver, R., & Reeves, T. C. (2002). Patterns of engagement in authentic online learning environments.

Hill, A., MacIntyre, B., Gandy, M., Davidson, B., & Rouzati, H. (2010, October). Kharma: An open kml/html architecture for mobile augmented reality applications. In *Mixed and Augmented Reality (ISMAR), 2010 9th IEEE International Symposium on* (pp. 233-234). IEEE.

Hill-Feltham, P., Roberts, S. A., & Gladdis, R. (2014). Digital processing technology for bone-anchored hearing aids: randomised comparison of two devices in hearing aid users with mixed or conductive hearing loss. *The Journal of Laryngology & Otology*, *128*(02), 119-127.

Hong, R., Wang, M., Xu, M., Yan, S., & Chua, T. S. (2010, October). Dynamic captioning: video accessibility enhancement for hearing impairment. In *Proceedings of the 18th ACM international conference on Multimedia* (pp. 421-430). ACM.

Hsi, S. (2002). The electronic guidebook: A study of user experiences using mobile web content in a museum setting. In *Wireless and Mobile Technologies in Education, 2002. Proceedings. IEEE International Workshop on* (pp. 48-54). IEEE.

Hsi, S. (2003). A study of user experiences mediated by nomadic web content in a museum. *Journal of Computer Assisted Learning*, *19*(3), 308-319.

Hsi, S., & Fait, H. (2005). RFID enhances visitors' museum experience at the Exploratorium. *Communications of the ACM*, *48*(9), 60-65.

http://echo.iat.sfu.ca/library/bell_02_museum_ecology.pdf.

Huang, M. H. (2003). Designing website attributes to induce experiential encounters. *computers in Human Behavior*, *19*(4), 425-442.

Huang, M., Kantardzhieva, A., Scheffer, D., Liberman, M. C., & Chen, Z. Y. (2013). Hair cell overexpression of Islet1 reduces age-related and noise-induced hearing loss. *The Journal of Neuroscience*, *33*(38), 15086-15094.

Huang, T. L., & Liao, S. (2015). A model of acceptance of augmented-reality interactive technology: the moderating role of cognitive innovativeness. Electronic Commerce Research, 15(2), 269-295.

Huizenga, J., Admiraal, W., Akkerman, S., & Dam, G. T. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning*, *25*(4), 332-344.

Humes, L. E., Dubno, J. R., Gordon-Salant, S., Lister, J. J., Cacace, A. T., Cruickshanks, K. J., & Wingfield, A. (2012). Central presbycusis: a review and evaluation of the evidence. *Journal of the American Academy of Audiology*, *23*(8), 635-666.

Hussain, A., Abubakar, H. I., & Hashim, N. B. (2014, November). Evaluating mobile banking application: Usability dimensions and measurements. In *Information Technology and Multimedia (ICIMU), 2014 International Conference on* (pp. 136-140). IEEE.

Hussein, A. S., & dan Bisnis, F. E. (2016). The effect of trust and brand engagement on mobile telecommunication customer loyalty: The mediating effect of brand engagement.

Ibáñez, M. B., Di Serio, Á., Villarán, D., & Kloos, C. D. (2014). Experimenting with electromagnetism using augmented reality: Impact on flow student experience and educational effectiveness. *Computers & Education*, *71*, 1-13.

Ibrahim, N., & Ahmad, W. F. W. (2014, September). Heuristic evaluation of malay folktales animated courseware for childhood education. In *User Science and Engineering (i-USEr), 2014 3rd International Conference on* (pp. 131-136). IEEE.

Irizarry, J., Gheisari, M., Williams, G., & Walker, B. N. (2013). InfoSPOT: A mobile Augmented Reality method for accessing building information through a situation awareness approach. *Automation in Construction*, *33*, 11-23.

Jain, P., Manweiler, J., & Roy Choudhury, R. (2015, May). Overlay: Practical mobile augmented reality. In *Proceedings of the 13th Annual International Conference on Mobile Systems, Applications, and Services* (pp. 331-344). ACM.

Jankowska, A., Szarkowska, A., Krejtz, K., Fidyka, A., Kowalski, J., & Wichrowski, M. (2017). Smartphone app as a museum guide. Testing the Open Art application with blind, deaf, and sighted users. *Rivista internazionale di tecnica della traduzione*, *19*, 113-130.

Jiang, H., Liu, X. L., Peng, X., Tang, M. X., He, D., Chen, H. L., Xiang, K. & Man, B. (2017). 3D Models to Educated Museum Interactive Exhibition with Computing Techniques. In *Computer Science On-line Conference* (pp. 168-178). Springer, Cham.

Jiang, Z. D., Yin, R., & Wilkinson, A. R. (2015). Changes in hearing threshold between 28 and 42 weeks of age in babies born at under 30 weeks of gestation. *Acta Paediatrica*, *104*(4), e143-e147.

Johnson, J., & Henderson, A. (2002). Conceptual models: begin by designing what to design. *interactions*, *9*(1), 25-32.

Jones, M., Bench, N., & Ferons, S. (2014). Vocabulary acquisition for deaf readers using augmented technology. In *Virtual and Augmented Assistive Technology (VAAT), 2014 2nd Workshop on* (pp. 13-15). IEEE.

Jung, T. H., Lee, H., Chung, N., & tom Dieck, M. C. (2018). Cross-cultural differences in adopting mobile augmented reality at cultural heritage tourism sites. *International Journal of Contemporary Hospitality Management*, *30*(3), 1621-1645.

Jung, T., H. Lee, and N. Chung. "Cross-Cultural Differences in Adopting Mobile Augmented Reality at Cultural Heritage Tourism Sites." *International Journal of Contemporary Hospitality Management* 30, no. 8 (2018).

Jung, T., tom Dieck, M. C., Lee, H., & Chung, N. (2016). Effects of Virtual Reality and Augmented Reality on Visitor Experiences in Museum. In *Information and Communication Technologies in Tourism 2016* (pp. 621-635). Springer International Publishing.

Kaiser, Henry F. (1974). An index of factorial simplicity. *Psychometrika, 39*(1), 31-36. doi: http://dx.doi.org/10.1007/bf02291575

Kaiser, K. & Treptow, T. (2013). A Holistic Approach for Understanding and Improving Mobile Apps in Museums. *User Experience & Visitor Experience: How to Improve* Museum Apps, 1-38.

Kamat, V. R., & El-Tawil, S. (2007). Evaluation of augmented reality for rapid assessment of earthquake-induced building damage. *Journal of computing in civil engineering*, *21*(5), 303-310.

Karchmer, M. A., & Mitchell, R. E. (2004). Chasing the mythical ten percent: Parental

Karimi, A., & Lim, Y. P. (2010). Children, engagement and enjoyment in digital narrative. *Curriculum, technology & transformation for an unknown future. Proceedings ascilite Sydney*, 475-483.

Kearsley, G. (1997). The Virtual Professor: A Personal Case Study. Retrieved from http://home.sprynet.com/~gkearsley/virtual.htm

Kearsley, G., & Shneiderman, B. (1998). Engagement Theory: A Framework for Technology-Based Teaching and Learning. *Educational technology*, *38*(5), 20-23.

Kenteris, M., Gavalas, D., & Economou, D. (2011). Mytilene E-guide: a multiplatform mobile application tourist guide exemplar. *Multimedia Tools and Applications*, *54*(2), 241-262.

Kesser, B. W., Krook, K., & Gray, L. C. (2013). Impact of unilateral conductive hearing loss due to aural atresia on academic performance in children. *The Laryngoscope*, *123*(9), 2270-2275.

Kim, E., Chiang, L., & Tang, L. (2017). Investigating wellness tourists' motivation, engagement, and loyalty: in search of the missing link. *Journal of Travel & Tourism Marketing*, *34*(7), 867-879.

Kim, J. B., & Park, C. (2011). Development of mobile AR tour application for the National Palace Museum of Korea. In *Virtual and Mixed Reality-New Trends* (pp. 55-60). Springer Berlin Heidelberg.

Kim, M. J. (2013). A framework for context immersion in mobile augmented reality. *Automation in construction*, *33*, 79-85

Kim, Y. H., Kim, D. J., & Wachter, K. (2013). A study of mobile user engagement (MoEN): Engagement motivations, perceived value, satisfaction, and continued engagement intention. *Decision Support Systems*, *56*, 361-370.

Kim, Y., Han, S., Choi, S., & Jung, B. (2015). File-Based Closed Captioning System without Captioning Delay. In *Annual Technical Conference and Exhibition, SMPTE 2015* (pp. 1-8). SMPTE.

Kolbe, T. H. (2003). Augmented videos and panoramas for pedestrian navigation. In *Geowissenschaftliche Mitteilungen*.

Kosinski, L., Baum, C., Sorensen, M., Rosenberg, J., Sales, D., Blumenstein, B., & Haverty, M. (2016). P-208 Project Sonar: Improvement in Patient Engagement Rates Using a Mobile Application Platform. *Inflammatory Bowel Diseases*, *22*, S72.

Koskinen, P. S., Wilson, R. M., & Jensema, C. J. (1985). Closed-Captioned Television: A New Tool for Reading Instruction. *Literacy Research and Instruction*, *24*(4), 1-7.

Kourouthanassis, P. E., Boletsis, C., & Lekakos, G. (2015). Demystifying the design of mobile augmented reality applications. *Multimedia Tools and Applications*, *74*(3), 1045-1066.

Kožuh, I., Hintermair, M., Holzinger, A., Volčič, Z., & Debevc, M. (2015). Enhancing universal access: deaf and hard of hearing people on social networking sites. *Universal Access in the Information Society*, *14*(4), 537-545.

Kuenburg, A., Fellinger, P., & Fellinger, J. (2016). Health Care Access Among Deaf People. *Journal of Deaf Studies and Deaf Education*, *21*(1), 1-10.

Kujawa, S. G., & Liberman, M. C. (2009). Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss. *The Journal of Neuroscience*, *29*(45), 14077-14085.

Kujawa, S. G., & Liberman, M. C. (2015). Synaptopathy in the noise-exposed and aging cochlea: primary neural degeneration in acquired sensorineural hearing loss. *Hearing research*, *330*, 191-199.

Kwan, J., Chu, J. H., Harley, D., McBride, M., & Mazalek, A. (2016, February). Grasping Cultural Context through Multisensory Interactions. In *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 482-487). ACM.

Kyle, F. E., Campbell, R., Mohammed, T., Coleman, M., & MacSweeney, M. (2013). Speechreading development in deaf and hearing children: introducing the test of child speechreading. *Journal of Speech, Language, and Hearing Research*, *56*(2), 416-426.

Lalmas, M., O'Brien, H., & Yom-Tov, E. (2014). Measuring user engagement. *Synthesis Lectures on Information Concepts, Retrieval, and Services*, *6*(4), 1-132.

Landau, S., & Everitt, B.S. (2004). *A Handbook of Statistical Analyses Using SPSS*: Taylor & Francis.

Lanir, J., Kuflik, T., Dim, E., Wecker, A. J., & Stock, O. (2013). The influence of a location-aware mobile guide on museum visitors' behavior. *Interacting with Computers*, *25*(6), 443-460

Lazar, J., Feng, J. H., & Hochheiser, H. (2017). *Research methods in human-computer interaction*. Morgan Kaufmann

Le, Q. T., Pedro, A. K. E. E. M., Lim, C. R., Park, H. T., Park, C. S., & Kim, H. K. (2015). A framework for using mobile based virtual reality and augmented reality for experiential construction safety education. *Int. J. Eng. Educ*, *31*(3), 713-725.

Lederberg, A. R., Schick, B., & Spencer, P. E. (2013). Language and literacy development of deaf and hard-of-hearing children: successes and challenges. *Developmental psychology*, *49*(1), 15.

Lee, H., Chung, N., & Jung, T. (2015). Examining the cultural differences in acceptance of mobile augmented reality: Comparison of South Korea and Ireland. In *Information and communication technologies in tourism 2015* (pp. 477-491). Springer, Cham.

Lee, J. H., Tennis, J. T., Clarke, R. I., & Carpenter, M. (2013). Developing a video game metadata schema for the Seattle Interactive Media Museum. *International journal on digital libraries*, *13*(2), 105-117.

Lee, K. (2012). Augmented reality in education and training. *TechTrends*, *56*(2), 13-21.

Lee, K. Y. (2013). Pathophysiology of age-related hearing loss (peripheral and central). *Korean journal of audiology*, *17*(2), 45-49.

Lee, S., Lee, J., Lee, A., Park, N., Song, S., Seo, A., & Eom, K. (2013). Augmented reality intravenous injection simulator based 3D medical imaging for veterinary medicine. *The Veterinary Journal*, *196*(2), 197-202.

Lee, W., Woo, W., & Lee, J. (2005). Tarboard: Tangible augmented reality system for table-top game environment. In *2nd International Workshop on Pervasive Gaming Applications, PerGames* (Vol. 5, pp. 2-1).

Lekakos, G., Chambel, T., & Knoche, H. (2013). Special Issue on Social Recommendation and Delivery Systems for Video and TV Content. *Multimedia Syst.*, *19*(6), 475-476.

Lemole Jr, G. M., Banerjee, P. P., Luciano, C., Neckrysh, S., & Charbel, F. T. (2007). Virtual Reality in Neurosurgical Education: Part-Task Ventriculostomy Simulation With Dynamic Visual and Haptic Feedback. *Neurosurgery*, *61*(1), 142-149.

Leppaniemi, M., & Karjaluoto, H. (2005). Factors influencing consumers' willingness to accept mobile advertising: a conceptual model. *International Journal of Mobile Communications*, *3*(3), 197-213.

Lesar, I., & Vitulic, H. S. (2013). Personality traits of deaf and hard of hearing students from regular and special schools in Slovenia. *Solsko Polje*, *24*(3/4), 97.

Lester, P. (2013). *Visual communication: Images with messages*. Cengage Learning.

Leue, M., & Jung, T. H. (2014). A theoretical model of augmented reality acceptance. *E-review of Tourism Research*, *5*.

Levin, K., Ponomareva, I., Bulusheva, A., Chernykh, G., Medennikov, I., Merkin, N., & Tomashenko, N. A. (2014). Automated closed captioning for Russian live broadcasting. In *INTERSPEECH* (pp. 1438-1442).

Li, R. Y. C., & Liew, A. W. C. (2015). An interactive user interface prototype design for enhancing on-site museum and art gallery experience through digital technology. *Museum Management and Curatorship*, *30*(3), 208-229.

Li, X., Yi, W., Chi, H. L., Wang, X., & Chan, A. P. (2018). A critical review of virtual and augmented reality (VR/AR) applications in construction safety. *Automation in Construction*, *86*, 150-162.

Lin, A. C. H., Fernandez, W. D., & Gregor, S. (2012). Understanding web enjoyment experiences and informal learning: a study in a museum context. Decision Support Systems, 53(4), 846–858. doi:10.1016/j.dss.2012.05.020

Lin, C. L. (2016). Augmented Reality Interaction Design and User Experience of Hand Puppet Historical Museum in Taiwan. *International Journal of Humanities and Cultural Studies (IJHCS) ISSN 2356-5926*, *3*(2), 1044-1057.

Lin, C. Y., & Chang, Y. M. (2015). Interactive augmented reality using Scratch 2.0 to improve physical activities for children with developmental disabilities. *Research in developmental disabilities*, *37*, 1-8.

Lin, C. Y., Chai, H. C., Wang, J. Y., Chen, C. J., Liu, Y. H., Chen, C. W., & Huang, Y. M. (2015). Using free augmented reality app in teaching programs for children with disabilities. *Displays*.

Lin, H. F., & Chen, C. H. (2015). Design and application of augmented reality query-answering system in mobile phone information navigation. *Expert Systems With Applications*, *42*(2), 810-820.

Lindgren, R., Tscholl, M., Wang, S., & Johnson, E. (2016). Enhancing learning and engagement through embodied interaction within a mixed reality simulation. *Computers & Education*, *95*, 174-187.

Linge, N., Booth, K., & Parsons, D. (2016). Practicalities of developing and deploying a handheld multimedia guide for museum visitors. *Place-Based Spaces for Networked Learning*, 160.

Litman, J. A., & Spielberger, C. D. (2003). Measuring epistemic curiosity and its diversive and specific components. *Journal of personality assessment*, *80*(1), 75-86.

Liu, C., Huot, S., Diehl, J., Mackay, W., & Beaudouin-Lafon, M. (2012, May). Evaluating the benefits of real-time feedback in mobile augmented reality with hand-held devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2973-2976). ACM.

Lochrie, M., & Coulton, P. (2012). Sharing the viewing experience through second screens. In *Proceedings of the 10th European conference on Interactive tv and video* (pp. 199-202). ACM.

Löchtefeld, M., Böhmer, M., Daiber, F., & Gehring, S. (2013). Augmented reality-based advertising strategies for paper leaflets. In *Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication* (pp. 1015-1022). ACM.

Lorens, A., Zgoda, M., Obrycka, A., & Skarżynski, H. (2010). Fine structure processing improves speech perception as well as objective and subjective benefits in pediatric MED-EL COMBI 40+ users. International journal of pediatric otorhinolaryngology, 74(12), 1372-1378.

Lorenz, M., Busch, M., Rentzos, L., Tscheligi, M., Klimant, P., & Frohlich, P. (2015, March). I'm There! The influence of virtual reality and mixed reality environments combined with two different navigation methods on presence. In *Virtual Reality (VR), 2015 IEEE* (pp. 223-224). IEEE.

Lovelock, B. (2015). Sustainable mobility within natural areas from the perspectives of persons with disabilities. *Sustainable Transportation in Natural and Protected Areas*, 82.

Loy, S. C., Ta, L., & Zhao, F. (2015). Emergence of a Digital Mobile Museum–Reaching Underserved Audience. *Digital Presentation and Preservation of Cultural and Scientific Heritage*, (V), 243-255.

Loy, S. C., Zhao, F., & Jun, E. (2015). The Use of Digital Technologies to Enhance User Experience at Gansu Provincial Museum. *Digital Presentation and Preservation of Cultural and Scientific Heritage*, (V), 257-263.

Lu, Y., & Smith, S. (2007). Augmented reality e-commerce assistant system: trying while shopping. In *Human-Computer Interaction. Interaction Platforms and Techniques* (pp. 643-652). Springer Berlin Heidelberg.

Lund, A. M. (2001). Measuring usability with the use questionnaire12. *Usability interface*, *8*(2), 3-6

Luo, X., Han, M., Liu, T., Chen, W., & Bai, F. (2012, September). Assistive learning for hearing impaired college students using mixed reality: a pilot study. In *Virtual*

Reality and Visualization (ICVRV), 2012 International Conference on (pp. 74-81). IEEE.

Lynn, Mary R. (1986). Determination and Quantification Of Content Validity. *Nursing Research, 35*(6), 382-386.

MA, L. E. (2012). Assessing User Experience in Augmented Reality Applications Using the Positive Engagement Evaluation Model. In *Proceedings of the International Conference on e-Learning, e-Business, Enterprise Information Systems, and e-Government (EEE)* (p. 1). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp).

Mahat, J., Ayub, A. F. M., & Luan, S. (2012). An assessment of students' mobile self-efficacy, readiness and personal innovativeness towards mobile learning in higher education in Malaysia. *Procedia-Social and Behavioral Sciences*, *64*, 284-290

Mangold, W. G., & Faulds, D. J. (2009). Social media: The new hybrid element of the promotion mix. Business horizons, 52(4), 357-365.

MäNtymäKi, M., & Salo, J. (2011). Teenagers in social virtual worlds: Continuous use and purchasing behavior in Habbo Hotel. *Computers in Human Behavior*, *27*(6), 2088-2097.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. Decision support systems, 15(4), 251-266.

Marimon, D., Sarasua, C., Carrasco, P., Álvarez, R., Montesa, J., Adamek, T., & Gascó, P. (2010). MobiAR: tourist experiences through mobile augmented reality. *Telefonica Research and Development, Barcelona, Spain*.

Marschark, M., Leigh, G., Sapere, P., Burnham, D., Convertino, C., Stinson, M., & Noble, W. (2006). Benefits of sign language interpreting and text alternatives for deaf students' classroom learning. *Journal of deaf studies and deaf education*, *11*(4), 421-437.

Marschark, M., Shaver, D. M., Nagle, K. M., & Newman, L. A. (2015). Predicting the academic achievement of deaf and hard-of-hearing students from individual, household, communication, and educational factors. *Exceptional children*, *81*(3), 350-369.

Marutake, Y., Fukutome, T., & Asami, M. (1991). U.S. Patent No. 5,010,575. Washington, DC: U.S. Patent and Trademark Office.

Mason, R., McInnis, B., & Dalal, S. (2012, June). Machine learning for the automatic identification of terrorist incidents in worldwide news media. In *Intelligence and Security Informatics (ISI), 2012 IEEE International Conference on* (pp. 84-89). IEEE.

Mauk, K. L. (2017). Qualitative designs: Using words to provide evidence. *Evidence-Based Practice for Nurses*, 221.

McLean, S. N. (2015). Are all tourist dependant businesses meeting their statutory obligations and taking full advantage of the entire economic value of the tourist budget (An investigation into statutory compliance for providing reasonable adjustment to facilitate equal access for disabled customers to goods and services). *Journal of building surveying appraisal and valuation*, *4*(3).

McMahon, D., Cihak, D. F., & Wright, R. (2015). Augmented reality as a navigation tool to employment opportunities for postsecondary education students with intellectual disabilities and autism. *Journal of Research on Technology in Education*, *47*(3), 157-172.

Meinzen-Derr, J., Wiley, S., Bishop, S., Manning-Courtney, P., Choo, D. I., & Murray, D. (2014). Autism spectrum disorders in 24 children who are deaf or hard of hearing. *International journal of pediatric otorhinolaryngology*, *78*(1), 112-118.

Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. *IEICE TRANSACTIONS on Information and Systems*, *77*(12), 1321-1329.

Mirzaei, M., Ghorshi, S., & Mortazavi, M. (2012). Helping Deaf and hard-of-hearing people by combining augmented reality and speech technologies. In *Proc. 9th Intl Conf. Disability, Virtual Reality & Associated Technologies* (pp. 149-158).

Mishra, A., Nagarkar, A. N., & Nagarkar, N. M. (2018). Challenges in Education and Employment for Hearing Impaired in India. *Journal of Disability Management and Special Education*, *1*(1), 35

Mitzner, T. L., & Dijkstra, K. (2016). Evaluating User Centered Design of E-Health for Older Adults: Using Subjective Methods. *International Journal of Computers in Clinical Practice (IJCCP)*, *1*(2), 24-50.

Moreno Gil, S., & Ritchie, J. B. (2009). Understanding the museum image formation process: A comparison of residents and tourists. *Journal of Travel Research*, *47*(4), 480-493.

Mouratidis, A., Vansteenkiste, M., Lens, W., & Sideridis, G. (2008). The motivating role of positive feedback in sport and physical education: Evidence for a motivational model. *Journal of sport & exercise psychology*, *30*(2), 240.

Müller, J., Brill, S., Hagen, R., Moeltner, A., Brockmeier, S. J., Stark, T., & Nopp, P. (2012). Clinical trial results with the MED-EL fine structure processing coding strategy in experienced cochlear implant users. ORL, 74(4), 185-198.

Mun, Y. Y., & Hwang, Y. (2003). Predicting the use of web-based information systems: self-efficacy, enjoyment, learning goal orientation, and the technology acceptance model. *International journal of human-computer studies*, *59*(4), 431-449.

Nachairit, A., & SrisawasdI, N. (2015). Using Mobile Augmented Reality for Chemistry Learning of Acid-base Titration: Correlation between Motivation and Perception. In *Proceedings of the 23rd International Conference on Computers in Education*

Narciso, D., Pádua, L., Adão, T., Peres, E., & Magalhães, L. (2015). MixAR Mobile Prototype: Visualizing Virtually Reconstructed Ancient Structures In Situ. *Procedia Computer Science*, *64*, 852-861.

Nathan, S. S., Hussain, A., & Hashim, N. L. (2016, August). Deaf mobile application accessibility requirements. In *AIP Conference Proceedings* (Vol. 1761, No. 1, p. 020098). AIP Publishing

Nathan, S. S., Hussain, A., Hashim, N. L., & Omar, M. A. (2017, October). Dimensions for hearing-impaired mobile application usability model. In *AIP Conference Proceedings* (Vol. 1891, No. 1, p. 020108). AIP Publishing.

Nee, A. Y. C., Ong, S. K., Chryssolouris, G., & Mourtzis, D. (2012). Augmented reality applications in design and manufacturing. *CIRP Annals-Manufacturing Technology*, *61*(2), 657-679.

Nelissen, R. C., Mylanus, E. A., Cremers, C. W., Hol, M. K., & Snik, A. F. (2015). Long-term compliance and satisfaction with percutaneous bone conduction devices in patients with congenital unilateral conductive hearing loss. *Otology & Neurotology*, *36*(5), 826-833.

Neuman, W.L. (2014). *Social Research Methods: Pearson New International Edition: Qualitative and Quantitative Approaches* (7th ed.): Pearson Education Limited.

Nevatia, Y., Stoyanov, T., Rathnam, R., Pfingsthorn, M., Markov, S., Ambrus, R., & Birk, A. (2008, September). Augmented autonomy: Improving human-robot team performance in urban search and rescue. In *Intelligent Robots and Systems, 2008. IROS 2008. IEEE/RSJ International Conference on* (pp. 2103-2108). IEEE.

Ng, L. X., Wang, Z. B., Ong, S. K., & Nee, A. Y. C. (2013). Integrated product design and assembly planning in an augmented reality environment. *Assembly Automation*, *33*(4), 345-359.

Nilsen, T., Linton, S., & Looser, J. (2004). Motivations for augmented reality gaming. *Proceedings of FUSE*, *4*, 86-93.

Nilsson, S., & Johansson, B. (2007, November). Fun and usable: augmented reality instructions in a hospital setting. In *Proceedings of the 19th Australasian conference on Computer-Human Interaction: Entertaining user interfaces* (pp. 123-130). ACM.

Nincarean, D., Alia, M. B., Halim, N. D. A., & Rahman, M. H. A. (2013). Mobile augmented reality: The potential for education. *Procedia-Social and Behavioral Sciences*, *103*, 657-664.

Noh, Z., Sunar, M. S., & Pan, Z. (2009). A review on augmented reality for virtual heritage system. In *Learning by Playing. Game-based Education System Design and Development* (pp. 50-61). Springer Berlin Heidelberg.

Nunnally, J. (1978). Psychometric methods. In: New York: McGraw-Hill.

Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric Theory (McGraw-Hill Series in Psychology).

Nunnally, J.C. (1994). *Psychometric theory* (3rd ed.): McGraw-Hill.

Nysveen, H., Pedersen, P. E., & Thorbjørnsen, H. (2005). Explaining intention to use mobile chat services: moderating effects of gender. Journal of consumer Marketing, 22(5), 247-256

O'Brien, H. L. (2006). Measuring user engagement with information systems. *Dalhousie University, Canada*.

O'Brien, H. L., & Toms, E. G. (2013). Examining the generalizability of the User Engagement Scale (UES) in exploratory search. *Information Processing & Management*, *49*(5), 1092-1107.

O'Brien, H., & Cairns, P. (2015). An empirical evaluation of the User Engagement Scale (UES) in online news environments. *Information Processing & Management*, *51*(4), 413-427.

O'Brien, H. L. (2011). Exploring user engagement in online news interactions. *Proceedings of the American society for information science and technology*, *48*(1), 1-10.

O'Brien, H. L. (2017). Antecedents and learning outcomes of online news engagement. *Journal of the Association for Information Science and Technology*.

O'Brien, H. L., & Toms, E. G. (2008). What is user engagement? A conceptual framework for defining user engagement with technology. *Journal of the Association for Information Science and Technology*, *59*(6), 938-955.

O'Brien, H. L., & Toms, E. G. (2010). The development and evaluation of a survey to measure user engagement. *Journal of the American Society for Information Science and Technology*, *61*(1), 50-69.

Ohene-Djan, J., Wright, J., & Combie-Smith, K. (2007). Emotional Subtitles: A System and Potential Applications for Deaf and Hearing Impaired People. In *CVHI*.

Olsson, E. (2017). History Hunt: Raising User's Curiosity towards Places of Historical Value using Narrative-driven, Location-based Augmented Reality.

Olsson, T., Lagerstam, E., Kärkkäinen, T., & Väänänen-Vainio-Mattila, K. (2013). Expected user experience of mobile augmented reality services: a user study in the context of shopping centres. *Personal and ubiquitous computing*, *17*(2), 287-304.

Olwal, A., & Henrysson, A. (2007, November). Lumar: A hybrid spatial display system for 2d and 3d handheld augmented reality. In Artificial Reality and Telexistence, 17th International Conference on (pp. 63-70). IEEE.

Ong, S. C., & Ranganath, S. (2005). Automatic sign language analysis: A survey and the future beyond lexical meaning. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, *27*(6), 873-891.

Oppenheim, A.N. (1992). *Questionnaire Design, Interviewing, and Attitude Measurement*: Pinter Publishers.

Ortiz-Catalan, M., Sander, N., Kristoffersen, M. B., Håkansson, B., & Brånemark, R. (2014). Treatment of phantom limb pain (PLP) based on augmented reality and gaming controlled by myoelectric pattern recognition: a case study of a chronic PLP patient. *Frontiers in neuroscience*, *8*.

Osorio-Gómez, G., Viganò, R., & Arbeláez, J. C. (2016). An augmented reality tool to validate the assembly sequence of a discrete product. *International Journal of Computer Aided Engineering and Technology*, *8*(1-2), 164-178.

Othman, M. K., Petrie, H., & Power, C. (2011, September). Engaging visitors in museums with technology: scales for the measurement of visitor and multimedia guide experience. In *IFIP Conference on Human-Computer Interaction* (pp. 92-99). Springer, Berlin, Heidelberg.

Othman, M. K., Young, N. E., & Aman, S. (2015). Viewing Islamic Art Museum Exhibits on the SmartPhone: Re-examining Visitors' Experiences. *Journal of Cognitive Sciences & Human Development*, *1*(1), 102-118.

Oxman, A. D., & Guyatt, G. H. (1988). Guidelines for reading literature reviews. *CMAJ: Canadian Medical Association journal*, *138*(8), 697.

P Rutledge PhD, M. B. A., & M Neal MA, A. B. D. (2012). Positive Engagement Evaluation Model for Interactive and Mobile Technologies. In *Proceedings of the International Conference on e-Learning, e-Business, Enterprise Information Systems, and e-Government (EEE)* (p. 1). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp).

Pallant, J. (2010). SPSS survival manual: A step by step guide to data analysis using SPSS. Maidenhead (4th ed.): Open University Press/McGraw-Hill.

Pantano, E., Rese, A., & Baier, D. (2017). Enhancing the online decision-making process by using augmented reality: A two country comparison of youth markets. *Journal of Retailing and Consumer Services*, *38*, 81-95.

Park, M. K., Lim, K. J., Seo, M. K., Jung, S. J., & Lee, K. H. (2015). Spatial augmented reality for product appearance design evaluation. *Journal of Computational Design and Engineering*, *2*(1), 38-46.

Parton, B. S. (2015). Leveraging augmented reality apps to create enhanced learning environments for deaf students. *INSTRUCTIONAL TECHNOLOGY*, 21.

Parton, B. S. (2017). Glass Vision 3D: Digital Discovery for the Deaf. *TechTrends*, *61*(2), 141-146.

Patel, N., Clawson, J., Voida, A., & Lyons, K. (2009). Mobiphos: A study of user engagement with a mobile collocated–synchronous photo sharing application. *International Journal of Human-Computer Studies*, *67*(12), 1048-1059.

Patzer, B., Smith, D. C., & Keebler, J. R. (2014, September). Novelty and retention for two augmented reality learning systems. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 58, No. 1, pp. 1164-1168). SAGE Publications

Pavliscsak, H., Little, J. R., Poropatich, R. K., McVeigh, F. L., Tong, J., Tillman, J. S., ... & Fonda, S. J. (2016). Assessment of patient engagement with a mobile application among service members in transition. *Journal of the American Medical Informatics Association*, *23*(1), 110-118.

Pearn, M., Buhalis, D., & Darcy, S. (2011). Heritage Sites: Attitudinal and Experimental Differences of Disabled and Able-Bodied Visitors. In *Accessible tourism: concepts and issues* (pp. 201-213). Channel View Publications Ltd.

Pedersen, P. E., Methlie, L. B., & Thorbjornsen, H. (2002, January). Understanding mobile commerce end-user adoption: a triangulation perspective and suggestions for an exploratory service evaluation framework. In *System Sciences, 2002. HICSS. Proceedings of the 35th Annual Hawaii International Conference on* (pp. 8-pp). IEEE.

Peffers, K., Rothenberger, M., Tuunanen, T., & Vaezi, R. (2012, May). Design science research evaluation. In *International Conference on Design Science Research in Information Systems* (pp. 398-410). Springer, Berlin, Heidelberg.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2008). A design science research methodology for information systems research. Journal of management information systems, 24(3), 45-77.

Pendit, U. C, (2015). Conceptual Model of Mobile Augmented Reality for Cultural Heritage Site Towards Enjoyable Informal Learning (MARCHSTEIL). Doctoral Dissertation, Universiti Utara Malaysia, Sintok, Kedah, Malaysia.

Pendit, U. C., Shiratuddin, N., & Zaibon, S. B. (2012). Augmented reality in visual communication: innovation in conservation of historical buildings. In *Proceedings of 2nd International Conference of Communication & Media, Penang, Malaysia* (pp. 93-94).

Pendit, U. C., Zaibon, S. B., & Abubakar, J. A. (2015). DIGITAL INTERPRETIVE MEDIA USAGE IN CULTURAL HERITAGE SITES AT YOGYAKARTA. *Jurnal Teknologi*, *75*(4).

Pendit, U. C., Zaibon, S. B., & Bakar, J. A. A. (2014a). Mobile Augmented Reality for Enjoyable Informal Learning in Cultural Heritage Site. *International Journal of Computer Applications*, *92*(14).

Pendit, U. C., Zaibon, S. B., & Bakar, J. A. A. (2016). Enjoyable Informal Learning at Cultural Heritage Site using Mobile Augmented Reality: Measurement and Evaluation. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, *8*(10), 13-21

Pendit, U. C., Zaibon, S. B., Abubakar, J. A., & Ntroduction, I. (2014b). User Experience on Enjoyable Informal Learning via Mobile AR: Development and Evaluation. *International Journal of Interactive Digital Media (IJIDM)*, *2*(2), 29-34.

Pérez-Sanagustín, M., Parra, D., Verdugo, R., García-Galleguillos, G., & Nussbaum, M. (2016). Using QR codes to increase user engagement in museum-like spaces. *Computers in Human Behavior*, *60*, 73-85.

Permadi, D., & Rafi, A. (2015). DEVELOPING A CONCEPTUAL MODEL OF USER ENGAGEMENT FOR MOBILE-BASED AUGMENTED REALITY GAMES. *Jurnal Teknologi*, *77*(29).

Permadi, D., & Rafi, A. (2016). Empirical Analysis of Mobile Augmented Reality Games for Engaging Users' Experience. In *Intelligent and Evolutionary Systems* (pp. 343-355). Springer International Publishing.

Peter, J. P. (1979). Reliability: A review of psychometric basics and recent marketing practices. *Journal of marketing research*, 6-17.

Peters, C., Castellano, G., & de Freitas, S. (2009, November). An exploration of user engagement in HCI. In *Proceedings of the International Workshop on Affective-Aware Virtual Agents and Social Robots* (p. 9). ACM.

Plass, J., Guzman-Martinez, E., Ortega, L., Grabowecky, M., & Suzuki, S. (2014). Lip reading without awareness. *Psychological science*, *25*(9), 1835-1837.

Pollalis, C., Fahnbulleh, W., Tynes, J., & Shaer, O. (2017, March). HoloMuse: Enhancing engagement with archaeological artifacts through gesture-based interaction with holograms. In *Proceedings of the Tenth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 565-570). ACM.

Pollalis, C., Gilvin, A., Westendorf, L., Futami, L., Virgilio, B., Hsiao, D., & Shaer, O. (2018, May). ARtLens: Enhancing Museum Visitors' Engagement with African Art. In Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility (pp. 195-200). ACM.

Pollard, R. Q., Sutter, E., & Cerulli, C. (2013). Intimate partner violence reported by two samples of deaf adults via a computerized American Sign Language survey. *Journal of interpersonal violence*, 0886260513505703.

Poria, Y., Reichel, A., & Brandt, Y. (2010). The flight experiences of people with disabilities: an exploratory study. *Journal of Travel Research*, *49*(2), 216-227.

Preece, J., Rogers, Y., & Sharp, H. (2007). Interaction Design: beyond human-computer interaction 2nd edition. John Wiley& Sons, Ltd. England.

Pribeanu, C. (2014). Measuring the Effects of Usability Issues Affecting an Enjoyable Learning Experience–A Path Analysis Approach. *Journal of Applied Quantitative Methods*, 14.

Przybylski, A. K., Rigby, C. S., & Ryan, R. M. (2010). A motivational model of video game engagement. *Review of general psychology*, *14*(2), 154.

Pugliese, L., Woodriff, M., Crowley, O., Lam, V., Sohn, J., & Bradley, S. (2016). Feasibility of the "Bring Your Own Device" Model in Clinical Research: Results from a Randomized Controlled Pilot Study of a Mobile Patient Engagement Tool.

Rad, Y. T., & Jabbari, R. (2012). *Use of Global Consistency Checking for Exploring and Refining Relationships between Distributed Models: A Case Study.* Master's thesis, Blekinge Institute of Technology Karlskrona, Sweden.

Raghunandhan, S., Agarwal, A. K., Natarajan, K., Murali, S., Kumar, R. A., & Kameswaran, M. (2013). Effect of intravenous administration of steroids in the management of sudden sensori-neural hearing loss: our experience. *Indian Journal of Otolaryngology and Head & Neck Surgery*, *65*(3), 229-233.

Rammon Oliveira De Almeida, D., Abadie Guedes, P., Oliveira Da Silva, M. M., Buarque Vieira e Silva, A. L., Lima, S. D. M., Paulo, J., & Teichrieb, V. (2015, May). Interactive Makeup Tutorial Using Face Tracking and Augmented Reality on Mobile Devices. In *Virtual and Augmented Reality (SVR), 2015 XVII Symposium on* (pp. 220-226). IEEE.

Rassweiler, J., Rassweiler, M. C., Müller, M., Lima, E., Petrut, B., Huber, J. & Häcker, A. (2015). Augmented Reality for Percutaneous Renal Interventions. In *Advances in Image-Guided Urologic Surgery* (pp. 203-220). Springer New York

Rattanarungrot, S., White, M., & Jackson, B. (2015). The application of service orientation on a mobile AR platform? a museum scenario. In *2015 Digital Heritage* (Vol. 1, pp. 329-332). IEEE.

Rautakoski, P., & Martikainen, K. K. (2014). Communication problems of Parkinson patients using sign language as their main communication method. *Parkinsonism & related disorders*, *20*(1), 128.

Reychav, I., Zhu, L., & Wu, D. (2017). identifying the relationship between technology curiosity and knowledge absorptive capability in an augmented reality smart class.

Ribeiro, A., & da Silva, A. R. (2012, September). Survey on cross-platforms and languages for mobile apps. In *Quality of Information and Communications Technology (QUATIC), 2012 Eighth International Conference on the* (pp. 255-260). IEEE.

Roes, I., Stash, N., Wang, Y., & Aroyo, L. (2009, April). A personalized walk through the museum: The CHIP interactive tour guide. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems* (pp. 3317-3322). ACM.

Rogers, K. D., Pilling, M., Davies, L., Belk, R., Nassimi-Green, C., & Young, A. (2016). Translation, validity and reliability of the British Sign Language (BSL) version of the EQ-5D-5L. *Quality of Life Research*, 1-10.

Rogowski, R.L., Wu, H.Y. and Clark, K.A. (2015). *Systems and methods for determining and displaying multi-line foreign language translations in real time on mobile devices*. U.S. Patent 8,965,129.

Ronnberg, J. (1993). Cognitive characteristics of skilled tactiling: The case of GS. *European Journal of Cognitive Psychology*, *5*(1), 19-33.

Roscoe, J. T. (1975). *Fundamental research statistics for the behavioral sciences*. New York, NY: Holt, Rinehart and Winston.

Rosen, R. S., Turtletaub, M., Delouise, M., & Drake, S. (2015). Teacher-as-Researcher Paradigm for Sign Language Teachers: Toward Evidence-Based Pedagogies for Improved Learner Outcomes. *Sign Language Studies*, *16*(1), 86-116.

Roy, A. T., Jiradejvong, P., Carver, C., & Limb, C. J. (2012). Musical sound quality impairments in cochlear implant (CI) users as a function of limited high-frequency perception. *Trends in amplification*, 1084713812465493.

Rubino, I. R. E. N. E., Barberis, C. L. A. U. D. I. A., Di Chio, L. A. R. A., Xhembulla, J. E. T. M. I. R., & Malnati, G. I. O. V. A. N. N. I. (2014). Enhancing a museum mobile application through user experience design: a comparative analysis. Recent Adv Electr Electron Eng, 295-300.

Ryu, J., Han, S., Yoon, J., & Ryu, S. (2016). The Effect of 3D Immersive Virtual Reality on Virtual Presence and Perceived Usefulness in Machining Center Learning for Hearing Impaired Learners. *2016 International Conference of Educational Technology, Seoul, South Korea*, *2016*(1), 16-17.

Sakkopoulos, E., Paschou, M., Panagis, Y., Kanellopoulos, D., Eftaxias, G., & Tsakalidis, A. (2015). e-souvenir appification: QoS web based media delivery for museum apps. *Electronic Commerce Research*, *15*(1), 5-24.

Salim, F. A., Haider, F., Conlan, O., Luz, S., & Campbell, N. (2015). Analyzing Multimodality of Video for User Engagement Assessment. In *Proceedings of the 2015 ACM on International Conference on Multimodal Interaction* (pp. 287-290). ACM.

Sandifer, C. (2003). Technological novelty and open-endedness: Two characteristics of interactive exhibits that contribute to the holding of visitor attention in a science museum. *Journal of research in science teaching*, *40*(2), 121-137

Santarelli, R., Magnavita, V., De Filippi, R., Ventura, L., Genovese, E., & Arslan, E. (2009). Comparison of speech perception performance between Sprint/Esprit 3G and Freedom processors in children implanted with nucleus cochlear implants. Otology & Neurotology, 30(3), 304-312.

Sarif, S. M., Ibrahim, N., & Shiratuddin, N. (2016, August). Design model of computerized personal decision aid for youth: An expert review. In *AIP Conference Proceedings* (Vol. 1761, No. 1, p. 020097). AIP Publishing.

Saunders, M., Lewis, P., & Thornhill, A. (2009). Research methods for business students. In: Prentice Hall.

Sauro, J. (2015). Measuring usability with the system usability scale (SUS). 2011. *Verfügbar unter: http://www. measuringusability. com/sus. php [22.04. 2013]*.

Scarles, C., Casey, M., & Treharne, H. (2016). Enriching the visitor experience: Augmented reality and image recognition in tourism. *CAUTHE 2016: The Changing Landscape of Tourism and Hospitality: The Impact of Emerging Markets and Emerging Destinations*, 1177.

Schaller, D. T., Allison-Bunnell, S., Chow, A., Marty, P., & Heo, M. (2004). To flash or not to flash? Usability and user engagement of HTML vs. Flash. In *Museums & the Web*

Schmidt, A. (2000). Implicit human computer interaction through context. Personal technologies, 4(2-3), 191-199.

Schoen, C. J., Burmeister, M., & Lesperance, M. M. (2013). Diaphanous homolog 3 (Diap3) overexpression causes progressive hearing loss and inner hair cell defects in a transgenic mouse model of human deafness. *PloS one*, *8*(2), e56520.

Schraw, G., Bruning, R., & Svoboda, C. (1995). Sources of situational interest. *Journal of reading behavior*, *27*(1), 1-17.

Seebens, Y., & Diller, G. (2011). Improvements in speech perception after the upgrade from the TEMPO+ to the OPUS 2 audio processor. ORL, 74(1), 6-11.

Sekaran, Uma, & Bougie, Roger. (2016). *Research methods for business: A skill building approach* (7th ed.): John Wiley & Sons.

Selvakumar, M., & Storksdieck, M. (2013). Portal to the public: Museum educators collaborating with scientists to engage museum visitors with current science. *Curator: The Museum Journal*, *56*(1), 69-78.

Seo B, Kim K, & Park, J-I. (2011) Augmented Reality-Based On-Site Tour Guide: A Study in Gyeongbokgung. Computer Vision - ACCV 2010 Workshops, R. Koch and F. Huang, Eds. Springer Berlin Heidelberg, p. 276–285.

Seppälä, K., Heimo, O. I., Korkalainen, T., Pääkylä, J., Latvala, J., Helle, S., & Viinikkala, L. (2016). Examining User Experience in an Augmented Reality Adventure Game: Case

Sharek, D., & Wiebe, E. (2015). Investigating real-time predictors of engagement: Implications for adaptive videogames and online training. *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS)*, *7*(1), 20-37.

SHAW, G., VEITCH, C., & Coles, T. I. M. (2005). Access, disability, and tourism: Changing responses in the United Kingdom. *Tourism Review International*, *8*(3), 167-176.

Sheatsley, P. B. (1983). Questionnaire construction and item writing. *Handbook of survey research, 4*(1), 195-230

Shelena A/P S. N. (2017). A Usability Evaluation Model for Hearing Impaired Mobile Applications Interfaces. (Doctoral dissertation, Universiti Utara Malaysia, Kedah, Malaysia, 2017).

Shernoff, D. J., Csikszentmihalyi, M., Schneider, B., & Shernoff, E. S. (2014). Student engagement in high school classrooms from the perspective of flow theory. In *Applications of flow in human development and education* (pp. 475-494). Springer, Dordrecht.

Shiratuddin, N., & Hassan, S. (2013). Design Research in Software Development: Constructing and Linking Research Questions, Objectives, Methods and Outcomes (Second Edi.). Sintok: UUM Press.

Shiver, B. N., & Wolfe, R. J. (2015). Evaluating Alternatives for Better Deaf Accessibility to Selected Web-Based Multimedia. In *Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility* (pp. 231-238). ACM.

Shneiderman, B. (1988), Relate-Create-Donate: An educational philosophy for the cyber-generation. Computers & Education, in press.

Shneiderman, B. (1994) Education by Engagement and Construction: Can Distance Education be Better than Face-to-Face? Retrieved from http://www.hitl.washington.edu/scivw/EVE/distance.html

Shroff, R. H., & Keyes, C. J. (2017). A proposed framework to understand the intrinsic motivation factors on university students' behavioral intention to use a mobile application for learning. *Journal of Information Technology Education: Research*, *16*, 143-168.

Shuo, Y., Kim, M., Choi, E. J., & Kim, S. (2015). A Design of Augmented Reality System based on Real-World Illumination Environment for Edutainment. *Indian Journal of Science and Technology*, *8*(25).

Sillence, E., Briggs, P., Harris, P., & Fishwick, L. (2006). A framework for understanding trust factors in web-based health advice. *International Journal of Human-Computer Studies*, *64*(8), 697-713.

Sirakaya, M., & Kilic Cakmak, E. (2018). Effects of augmented reality on student achievement and self-efficacy in vocational education and training. *International journal for research in vocational education and training*, *5*(1), 1-18.

Sliwinska-Kowalska, M., & Davis, A. (2012). Noise-induced hearing loss. *Noise and Health*, *14*(61), 274.

Sliwinska-Kowalska, M., & Pawelczyk, M. (2013). Contribution of genetic factors to noise-induced hearing loss: a human studies review. *Mutation Research/Reviews in Mutation Research*, *752*(1), 61-65.

Small, J., & Darcy, S. (2010). Tourism, disability and mobility. *Tourism and inequality: Problems and prospects*

Smith, R. J., Bale, J. F., & White, K. R. (2005). Sensorineural hearing loss in children. *The Lancet*, *365*(9462), 879-890.

Smith, R. J., Shearer, A. E., Hildebrand, M. S., & Van Camp, G. (2014). Deafness and hereditary hearing loss overview.

Spriet, A., Van Deun, L., Eftaxiadis, K., Laneau, J., Moonen, M., Van Dijk, B., ... & Wouters, J. (2007). Speech understanding in background noise with the two-microphone adaptive beamformer BEAM™ in the Nucleus Freedom™ cochlear implant system. Ear and hearing, 28(1), 62-72.

Stafford, Aaron; Piekarski, Wayne; Thomas, Bruce H. (2009). Hand of God. Archived from the original on 2009-12-07. Retrieved 2009-12-18.

Stevens, G., Flaxman, S., Brunskill, E., Mascarenhas, M., Mathers, C. D., & Finucane, M. (2013). Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries. *The European Journal of Public Health*, *23*(1), 146-152.

Stokoe, W. C. (2005). Sign language structure: An outline of the visual communication systems of the American deaf. *Journal of deaf studies and deaf education*, *10*(1), 3-37.

Straetz, K., Kaibel, A., Raithel, V., Specht, M., Grote, K., & Kramer, F. (2004). An e-learning environment for deaf adults. In *Conference proceedings 8th ERCIM workshop "user interfaces for all*.

Stuart, D., Christensen, K., Chen, A., Kim, Y., & Chen, Y. (2013). Utilizing Augmented Reality Technology for Crowd Pedestrian Analysis Involving Individuals With Disabilities. In *ASME 2013 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (pp. V004T08A004-V004T08A004). American Society of Mechanical Engineers.

Sutcliffe, A. (2009). Designing for user engagement: Aesthetic and attractive user interfaces. *Synthesis lectures on human-centered informatics*, *2*(1), 1-55.

Swan, J. E., & Gabbard, J. L. (2005, July). Survey of user-based experimentation in augmented reality. In *Proceedings of 1st International Conference on Virtual Reality* (pp. 1-9).

Sweetser, P., & Wyeth, P. (2005). GameFlow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE)*, *3*(3), 3-3.

Sylaiou, S., Killintzis, V., Paliokas, I., Mania, K., & Patias, P. (2014, June). Usability evaluation of virtual museums' interfaces visualization technologies. In *International Conference on Virtual, Augmented and Mixed Reality* (pp. 124-133). Springer, Cham.

Sylaiou, S., Mania, K., Karoulis, A., & White, M. (2010). Exploring the relationship between presence and enjoyment in a virtual museum. *International journal of human-computer studies*, *68*(5), 243-253.

Szafir, D., & Mutlu, B. (2012, May). Pay attention!: designing adaptive agents that monitor and improve user engagement. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 11-20). ACM.

Szymanski, M. H., Aoki, P. M., Grinter, R. E., Hurst, A., Thornton, J. D., & Woodruff, A. (2008). Sotto Voce: Facilitating social learning in a historic house. *Computer Supported Cooperative Work (CSCW)*, *17*(1), 5-34.

Tabachnick, Barbara G, & Fidell, Linda S. (2013). *Using multivariate statistics* (6th ed.): PEARSON.

Tang, C., Lorenzi, N., Harle, C. A., Zhou, X., & Chen, Y. (2016). Interactive systems for patient-centered care to enhance patient engagement. *Journal of the American Medical Informatics Association*, *23*(1), 2-4.

Tang, L. Z. W., Ang, K. S., Amirul, M., Yusoff, M. B. M., Tng, C. K., Alyas, M. D. B. M., & Folianto, F. (2015). Augmented reality control home (ARCH) for disabled and elderlies. In *Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 2015 IEEE Tenth International Conference on* (pp. 1-2). IEEE.

Ternier, S., Klemke, R., Kalz, M., Van Ulzen, P., & Specht, M. (2012). ARLearn: Augmented Reality Meets Augmented Virtuality. *J. UCS*, *18*(15), 2143-2164.

Tharpe, A. M., & Gustafson, S. (2015). Management of Children with Mild, Moderate, and Moderately Severe Sensorineural Hearing Loss. *Otolaryngologic Clinics of North America*, *48*(6), 983-994.

Theodorou, P., Kydonakis, P., Botzori, M. and Skanavis, C. (2018). Augmented Reality Proves to be a Breakthrough in Environmental Education. Conference: Protection and restoration of the environment XIV

Thompson, B. (2004). *Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications*: American Psychological Association.

Tomitsch, M., & Grechenig, T. (2007). Design Implications for a Ubiquitous Ambient Sound Display for the Deaf. In *CVHI*.

Torick, E. L., DiMattia, A. L., Staruk Jr, W. E., & Milner, P. (1975). A wearable master hearing aid. Journal of the Audio Engineering Society, 23(5), 361-368.

Tsai, M. K., Lee, Y. C., Lu, C. H., Chen, M. H., Chou, T. Y., & Yau, N. J. (2012). Integrating geographical information and augmented reality techniques for mobile escape guidelines on nuclear accident sites. *Journal of environmental radioactivity*, *109*, 36-44.

Tscheu, F., & Buhalis, D. (2016). Augmented Reality at Cultural Heritage sites. In *Information and Communication Technologies in Tourism 2016* (pp. 607-619). Springer International Publishing.

Tye-Murray, N., Hale, S., Spehar, B., Myerson, J., & Sommers, M. S. (2014). Lipreading in school-age children: The roles of age, hearing status, and cognitive ability. *Journal of Speech, Language, and Hearing Research*, *57*(2), 556-565.

Vaishnavi, V. K., & Kuechler, W. (2015). Design science research methods and patterns: innovating information and communication technology. Crc Press

Vaishnavi, V. K., & Kuechler, W. J. (2008). Design science research methods and patterns: innovating information and communication technology. Boca Raton. FL: Taylor & Francis Groups.

van der Vaart, M., & Ray, C. A. (2014). Domus: An On-Gallery Digital Museum Experience in Two Parts. *Engaging SpacES*, 193.

Van Dijk, E. M., Lingnau, A., & Kockelkorn, H. (2012, October). Measuring enjoyment of an interactive museum experience. In *Proceedings of the 14th ACM international conference on Multimodal interaction* (pp. 249-256). ACM.

Van Krevelen, D. W. F., & Poelman, R. (2010). A survey of augmented reality technologies, applications and limitations. *International Journal of Virtual Reality*, *9*(2), 1.

van Rooij, S. W., & Zirkle, K. (2016). Balancing pedagogy, student readiness and accessibility: A case study in collaborative online course development. *The Internet and Higher Education*, *28*, 1-7.

van Vugt, H. C., Konijn, E. A., Hoorn, J. F., Keur, I., & Eliéns, A. (2007). Realism is not all! User engagement with task-related interface characters. *Interacting with Computers*, *19*(2), 267-280.

Varonis, E. M. (2015). From barriers to bridges: approaching accessibility in course design. *The International Journal of Information and Learning Technology*, *32*(3), 138-149.

Vaz, R. I. F., Fernandes, P. O., & Veiga, A. C. R. (2016). Proposal of a tangible user interface to enhance accessibility in geological exhibitions and the experience of museum visitors. *Procedia Computer Science*, *100*, 832-839.

Vedurmudi, A. P., Goulet, J., Christensen-Dalsgaard, J., Young, B. A., Williams, R., & van Hemmen, J. L. (2016). How Internally Coupled Ears Generate Temporal

and Amplitude Cues for Sound Localization. *Physical review letters*, *116*(2), 028101.

Vera, A. M., Russo, M., Mohsin, A., & Tsuda, S. (2014). Augmented reality telementoring (ART) platform: a randomized controlled trial to assess the efficacy of a new surgical education technology. *Surgical endoscopy*, *28*(12), 3467-3472.

Verma, JP. (2013). *Data analysis in management with SPSS software*: Springer Science & Business Media.

Vila, T. D., Darcy, S., & González, E. A. (2015). Competing for the disability tourism market–a comparative exploration of the factors of accessible tourism competitiveness in Spain and Australia. *Tourism Management*, *47*, 261-272.

Von Ameln, S., Wang, G., Boulouiz, R., Rutherford, M. A., Smith, G. M., Li, Y., & Borck, G. (2012). A mutation in PNPT1, encoding mitochondrial-RNA-import protein PNPase, causes hereditary hearing loss. *The American Journal of Human Genetics*, *91*(5), 919-927.

Vreeken, H. L., Rens, G. H., Knol, D. L., Reijen, N. A., Kramer, S. E., Festen, J. M., & Nispen, R. (2014). Dual sensory loss: A major age-related increase of comorbid hearing loss and hearing aid ownership in visually impaired adults. *Geriatrics & gerontology international*, *14*(3), 570-576.

Vyskocil, E., Riss, D., Honeder, C., Arnoldner, C., Hamzavi, J. S., Baumgartner, W. D., & Gstoettner, W. (2014). Vibroplasty in mixed and conductive hearing loss: Comparison of different coupling methods. *The Laryngoscope*, *124*(6), 1436-1443.

Wachelka, E. (2013). Techcooltour: Discover Ancient Empires with Augmented Reality. Available: http://www.techcooltour.com/en/.

Wakkary, R., Hatala, M., Muise, K., Tanenbaum, K., Corness, G., Mohabbati, B., & Budd, J. (2009, February). Kurio: a museum guide for families. In *Proceedings of the 3rd International Conference on Tangible and Embedded Interaction* (pp. 215-222). ACM.

Wald, M., Li, Y., Draffan, E. A., & Jing, W. (2013). Synote mobile HTML5 responsive design video annotation application. *UACEE International Journal of Advances in Computer Science and its Applications (IJCSIA)*, *3*(2), 207-211.

Waltz, CF, Strickland, OL, & Lenz, ER. (2010). Measurement in nursing and health research (4th ed.): New York: Springer Publishing Company.

Wang, J. (2010). *A first experiment in misplaced trust in augmented reality* (Doctoral dissertation, Miami University).

Wang, X., Truijens, M., Hou, L., Wang, Y., & Zhou, Y. (2014). Integrating Augmented Reality with Building Information Modeling: Onsite construction process controlling for liquefied natural gas industry. *Automation in Construction*, *40*, 96-105.

Webster, A., Feiner, S., MacIntyre, B., Massie, W., & Krueger, T. (1996). Augmented reality in architectural construction, inspection and renovation. In *Proc. ASCE Third Congress on Computing in Civil Engineering* (pp. 913-919).

Webster, J., & Ho, H. (1997). Audience engagement in multimedia presentations. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, *28*(2), 63-77.

Westin, J., Foka, A., & Chapman, A. (2018). Humanising places: exposing histories of the disenfranchised through augmented reality. *International Journal of Heritage Studies*, *24*(3), 283-286.

Weston, A., Morrison, L., Yardley, L., & Van Kleek, M. (2015). Measurements of engagement in mobile behavioural interventions?.

White, J., Lartigue, J., & Dutton, B. (2013). An Architecture for Real-time Lecture Transcription and Collaborative Annotation using Mobile Devices. In *Society for Information Technology & Teacher Education International Conference* (Vol. 2013, No. 1, pp. 1128-1132).

White, S. & Cansler, J.L., (2014). *System and method of analyzing internet protocol television content for closed-captioning information*. U.S. Patent 8,910,232.

Wiebe, E. N., Lamb, A., Hardy, M., & Sharek, D. (2014). Measuring engagement in video game-based environments: Investigation of the User Engagement Scale. *Computers in Human Behavior*, *32*, 123-132.

Wikipedia contributors, (2018). Subtitle (captioning). In *Wikipedia, The Free Encyclopedia*, Retrieved February 23, 2018, from https://en.wikipedia.org/w/index.php?title=Subtitle_(captioning)&oldid=825641480

Witteman, H. O., Dansokho, S. C., Colquhoun, H., Coulter, A., Dugas, M., Fagerlin, A. & Ivers, N. (2015). User-centered design and the development of patient decision aids: protocol for a systematic review. *Systematic reviews*, *4*(1), 1.

World Health Organization. (2015). Fact sheet. Deafness and hearing loss. Retrieved from http://www.who.int/mediacentre/factsheets/fs300/en/

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, *62*, 41-49.

Wu, S. C. (2016). u-Museum and u-learning: On Development of National Palace Museum's Mobile Apps. *perspective*, *9*(4).

Wu, Y., Wu, Y., & Yu, S. (2015). An Augmented-Reality Interactive Card Game for Teaching Elementary School Students. *World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, *10*(1), 37-41

Xhembulla, J., Rubino, I., Barberis, C., & Malnati, G. (2014). Intrigue at the Museum: Facilitating Engagement and Learning through a Location-Based Mobile Game. *International Association for Development of the Information Society*.

Xie, L., Antle, A. N., & Motamedi, N. (2008, February). Are tangibles more fun?: comparing children's enjoyment and engagement using physical, graphical and tangible user interfaces. In *Proceedings of the 2nd international conference on Tangible and embedded interaction* (pp. 191-198). ACM.

Yaman, F., Dönmez, O., Avci, E., & Yurdakul, I. K. (2016). Integrating Mobile Applications into Hearing Impaired Children's Literacy Instruction. *Education and Science*, *41*(188), 153-174.

Yamasoba, T., Lin, F. R., Someya, S., Kashio, A., Sakamoto, T., & Kondo, K. (2013). Current concepts in age-related hearing loss: epidemiology and mechanistic pathways. *Hearing research*, *303*, 30-38.

Yeh, M., & Wickens, C. D. (2001). Display signaling in augmented reality: Effects of cue reliability and image realism on attention allocation and trust calibration. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *43*(3), 355-365.

Yovcheva, Z., Buhalis, D., & Gatzidis, C. (2013). *Engineering augmented tourism experiences* (pp. 24-35). Springer Berlin Heidelberg.

Yusoff, Z., & Dahlan, H. M. (2013, November). Mobile based learning: An integrated framework to support learning engagement through Augmented Reality

environment. In *Research and Innovation in Information Systems (ICRIIS), 2013 International Conference on* (pp. 251-256). IEEE.

Zainuddin, N. M. M., Zaman, H. B., & Ahmad, A. (2009). Learning Science Using AR-Book by Blended Learning Strategies: A Case Study on Preferred Visual Needs of Deaf Students. *Journal of Educational Technology Development and Exchange*, *9*(2), 5-20.

Zainuddin, N. M. M., Zaman, H. B., & Ahmad, A. (2010, June). Developing augmented reality book for deaf in science: the determining factors. In *Information Technology (ITSim), 2010 International Symposium in* (Vol. 1, pp. 1-4). IEEE.

Zainuddin, N. M. M., Zaman, H. B., & Ahmad, A. (2011). Heuristic evaluation on augmented reality courseware for the deaf. In *User Science and Engineering (i-USEr), 2011 International Conference on* (pp. 183-188). IEEE.

Zajadacz, A., & Szmal, P. (2017). Accessible Tourism for Deaf People in Poland: The SITur and SITex Programs as Proposals for Accessible Urban Information. In *International Conference on Universal Access in Human-Computer Interaction* (pp. 348-359). Springer, Cham.

Zazove, P., Meador, H. E., Reed, B. D., & Gorenflo, D. W. (2013). Deaf Persons' English Reading Levels and Associations with Epidemiological, Educational, and Cultural Factors. *Journal of health communication*, *18*(7), 760-772.

Zikmund, William G, Babin, Barry J, Carr, Jon C, & Griffin, Mitch. (2013). *Business research methods* (9th ed.): Cengage Learning.

Zikmund, William G., Babin, Barry J., Carr, Jon C., & Griffin, M. (2010). *Business research methods* (Seventh Ed.). Cincinnati, Ohio, USA: South-Western College Pub.

Appendix A

Focus Group Form

College of Arts and Sciences

UNIVERSITI UTARA MALAYSIA

Focused Group

Measuring Engagement for Hearing Impaired Visitors in the Museum

Prepared by:
ESRAA JAFFAR BAKER

Assalammu'alaikum and Good Day,

Dear Participant,

We are delighted to inform you that you have been selected to participate in our research on "Mobile Augmented Reality for Engaging Hearing-Impaired Museum Visitors". The research focuses on the relationships between the elements of the Mobile Augmented Reality and engagement for hearing impaired museum visitors.

The following proposed elements of engagement aims to understand several aspects of the needs and requirements of the hearing impaired during their visit to the museum. Your participation in answering this question is very much appreciated in ensuring the success of this study. The information gathered will be treated as confidential and only be used for research purposes and may be reported anonymously in the academic publication.

I would like to thank you for your time and cooperation.

Objective of Focus Group:

To review the proposed elements of engagement for hearing-impaired museum visitors

Participant Details

Name: _____

Age: _____

Gender: _____

Education: _____

Field of work: _____

Experience (year): _____

Instruction: Answer **Yes** or **No** and write remarks to the needs and expectations of the following elements to be included in the MAR application for HI museum visit.

No	Elements	Description	Select one		Remark
			Yes	No	
1	Aesthetics	This is the concept of mixing the nature of beauty, art, and with the creation and appreciation of MAR.			
2	Novelty	The concept of using MAR to teach new behaviour and knowledge for the user.			
3	Usability	This is the concept of consistency of information and ease of use MAR application.			
4	Feedback	Positive information that will enhance passionate reactions which will promote positive performance.			
5	Motivation	An act which encourages action or target activity to be performed by a user.			
6	Focused Attention	The ability to involved and absorbed on a specific task by losing track of time without being distracted.			
7	Perceived Control	The act of dominating, commanding and regulating others, an activity, or a system			
8	Curiosity	This is when the human mind yearns for knowledge by investigates an environment, object, or situation in search of the knowledge.			
9	Enjoyment	The user experiencing fun, enjoy, and entertainment with the usage of the application.			
10	Social skill	Ability to facilitate interaction and communication with others.			

11	Self-efficacy	Confident in one's belief in one's ability to succeed in specific situations or accomplish a task.			
12	Felt Involvement	The users feeling involve during interaction with MAR application.			
13	Endurability	The likelihood of the user to returns back to the usage of the application.			
14	Interest	This when an object or system attract attention, provoke thought, intrigue, and fascinate a user.			
15	Immersion	The application should be able to cause deep mental involvement for the users.			
16	Challenge	The application should be able to provokes users to action.			
17	Satisfaction	This is act of being content and fond with an application.			
18	Concentration	The action or power of focusing the user attention on the action with the application.			
19	Trust	Users must have confident in the workability of the application.			
20	Interaction	Aware of being in control towards the application whereby interactivity, information and feedback are given upon an action.			

General Comments/Suggestions:

Appendix B

Focus Group Form in Arabic

كلية الآداب والعلوم

جامعة أتارا ماليزيا

استبيان

قياس مشاركة الزوار ضعفاء السمع في المتحف

من اعداد

اسراء جعفر باقر

السلام عليكم

أعزائي المشتركين:

يسعدنا إبلاغكم بأنه قد تم اختيارك للمشاركة في بحثنا حول "الواقع المعزز المتنقل من أجل إشراك زوار المتحف ذوي الإعاقة السمعية ."يركز البحث على العلاقات بين عناصر الواقع المعزز المتنقل والتفاعل مع زوار المتاحف الذين يعانون من ضعف السمع.

تهدف عناصر المشاركة المقترحة التالية إلى فهم جوانب عديدة لاحتياجات ومتطلبات ضعاف السمع أثناء زيارتهم للمتحف .إن مشاركتك في الإجابة على هذا السؤال تحظى بتقدير كبير في ضمان نجاح هذه الدراسة .

سيتم التعامل مع المعلومات التي يتم جمعها على أنها سرية ولن يتم استخدامها إلا لأغراض بحثية وقد يتم الإبلاغ عنها بشكل مجهول في المنشور الأكاديمي.

أود أن أشكرك على وقتك وتعاونك.

وأود ان اشكركم على وقتكم وتعاونكم

مع فائق الاحترام

هدف مجموعة التركيز:

مراجعة عناصر المشاركة المقترحة لزوار المتاحف الذين يعانون من ضعف السمع

<u>تفاصيل المشارك:</u>

الاسم: _____

العمر: _____

الجنس: _____

التعليم: _____

مجال العمل: _____

الخبرة(السنة): _____

التعليمات:

أجب ب (نعم) أو (لا)، واكتب ملاحظات لاحتياجات وتوقعات العناصر التالية ليتم تضمينها في طلب الحصول على تطبيق موبايل الواقع المعزز لضعاف السمع اثناء زيارتهم للمتحف.

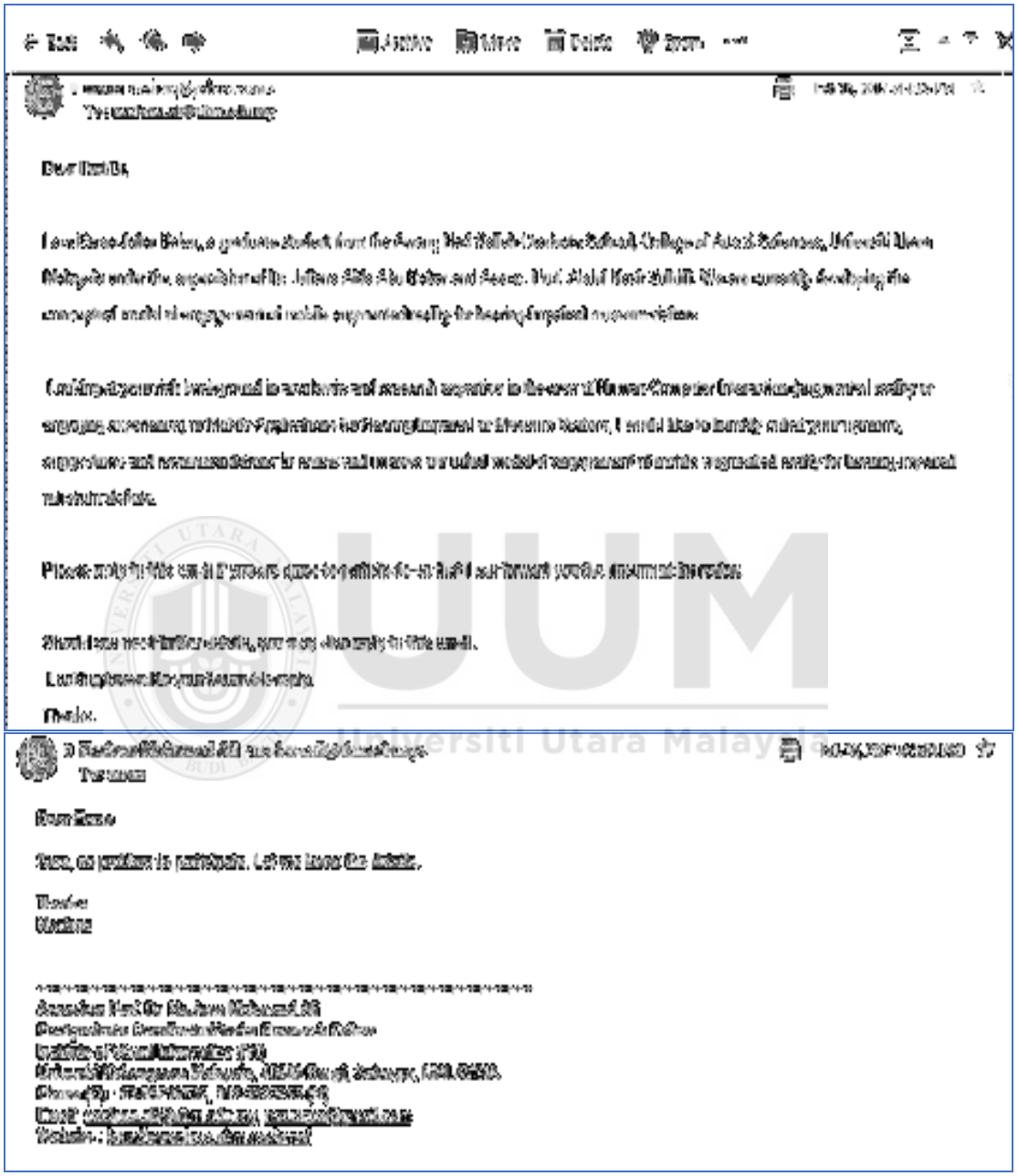
ت	العناصر	التعريف	نعم	لا	التعليق
1	الجماليات	هذا هو مفهوم خلط طبيعة الجمال والفن، مع خلق وإدراك موبايل الواقع المعزز			
2	الحداثة	مفهوم استخدام موبايل الواقع المعزز لتعليم السلوك والمعرفة الجديدة للمستخدم.			
3	سهولة الاستخدام	هذا هو مفهوم اتساق المعلومات وسهولة الاستخدام تطبيق موبايل الواقع المعزز.			
4	ردود الفعل /الاستجابة	المعلومات الإيجابية التي من شأنها تعزيز ردود الفعل العاطفية التي من شأنها تعزيز الأداء الإيجابي.			
5	الحافز	فعل يشجع النشاط أو هدف النشاط التي يتعين القيام بها من قبل المستخدم.			
6	تركيز الاهتمام	القدرة على المشاركة واستيعابها في مهمة محددة من خلال فقدان الوقت دون أن يصرف انتباهه.			
7	التحكم بالسيطرة	فعل الهيمنة والسيطرة وتنظيم الآخرين، نشاط أو نظام			
8	حب الاستطلاع	هذا هو عندما يتوق العقل البشري للمعرفة من خلال التحقيق في بيئة أو كائن أو موقف بحثًا عن المعرفة.			
9	المتعة	المستخدم الذي يجرب المتعة والاستمتاع والترفيه مع استخدام التطبيق.			
10	مهارات اجتماعية	القدرة على تسهيل التفاعل والتواصل مع الآخرين.			
11	الكفاءة الذاتية	ثقة في إيمان المرء بقدرة المرء على النجاح في مواقف محددة أو إنجاز مهمة ما.			
12	شعر بالارتباط	شعور المستخدمين بالارتباط خلال التفاعل مع تطبيق.			

13	إعادة الاستخدام	احتمالية عودة المستخدم إلى استخدام التطبيق.			
14	اهتمام	هذا عندما يجذب كائن أو نظام الانتباه، يثير الفكر، خداع، ويسحر مستخدم.			
15	الغمر	يجب أن يكون التطبيق قادراً على إحداث مشاركة عقلية عميقة للمستخدمين.			
16	التحدي	يجب أن يكون التطبيق قادراً على إثارة المستخدمين للعمل.			
17	الرضا	هذا هو كونه محتوى ومغرم مع تطبيق.			
18	التركيز	الإجراء أو القوة لتركيز انتباه المستخدم على الإجراء مع التطبيق			
19	الثقة	يجب أن يكون لدى المستخدمين ثقة في قابلية للتطبيق.			
20	التفاعل	أدراك في السيطرة على التطبيق حيث يتم إعطاء التفاعل والمعلومات وردود الفعل على هذا العمل.			

التعليقات العامة\الاقتراحات:

Appendix C

Sample of Experts' Invitation Email and Response



Appendix D

Expert Review phase 1 Form

EXPERT REVIEW ON CONCEPTUAL MODEL OF ENGANGEMENT MOBILE AUGMENTED REALITY FOR MUSEUM HEARING IMPAIRED VISITORS

A) Demographic

Areas of Expertise:

Years of Experience:

B) Research Work Explanation

My name is Esraa Jaffar Baker, a graduate student from the Awang Had Salleh Graduate School, College of Arts & Sciences, Universiti Utara Malaysia under the supervision of Dr. Juliana Aida Abu Bakar and Assoc. Prof. Abdul Nasir Zulkifli. We are currently developing the conceptual model of engagement of mobile augmented reality for hearing-impaired museum visitors.

Looking at your rich background in academic and research expertise in the area of Human-Computer Interaction (augmented reality or engaging experience) or Mobile Applications for Hearing Impaired or Museum Visitors, I would like to humbly solicit your opinions, suggestions, and recommendations to review and improve our initial model of engagement of mobile augmented reality for hearing-impaired museum visitors.

The listed elements and items are parts of the output for our first objective, in order to achieve the main objective of the study. Therefore, these model components (elements and items) have been identified to support the design and implementation of a mobile augmented reality application for hearing-impaired museum visitors.

The purpose of this task is to provide comments as well as necessary inputs to the basis of design model and their related elements with corresponding items.

This booklet contains five pages. Enclosed in next pages are the consent form and questionnaires related to the identified elements and items and thank you for your time.

C) Operational Explanation in the Context of the Study

Mobile Augmented Reality: The type of AR which platform is based on a smartphone or handheld devices.

Hearing Impaired: An incident of loss of hearing ability which means not receiving acoustic sound by the ear.

Engagement: Act of raising users' attractiveness and interest in a pleasing manner in order to get their attention to performing activities at the museums.

CONSENT FORM FOR EXPERT REVIEWER

1. With the expertise and the existing knowledge that I have, I volunteer to be an expert reviewer for this study as proposed by Esraa Jaffar Baker, a graduate student from the Awang Had Salleh Graduate School, College of Arts & Sciences, Universiti Utara Malaysia under the supervision of Dr. Juliana Aida Abu Bakar and Assoc. Prof. Abdul Nasir Zulkifli.
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 the 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 supervisors.
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 Awang Had Salleh Graduate School, College of Arts & Sciences, Universiti Utara
6. I have read and understood the explanation provided to me. I have had all my questions answered to my satisfactions, and I voluntarily agree to participate in this study.
7. I am given a copy of this consent form.

_____ _____

Printed Name and Official Stamp Date and Signature

Note: If an element is not relevant then there is no need to pick its items

Proposed Element	Element Description	Pick One			Proposed Items for Element	Pick One		
		Definitely not relevant	Maybe not relevant	Relevant		Definitely not relevant	Maybe not relevant	Relevant
Aesthetics	Visual beauty or the study of natural and pleasing (or aesthetic) computer-based environments. (Wiebe et al., 2014; O'Brien and Toms, 2010)				The app is attractive			
					The app appealed to my visual senses			
					The screen layout is visually pleasing			
Curiosity	This is when the human mind thirst for knowledge by investigates an environment, object or situation in search of the knowledge. (Reychav et al., 2017; Webster & Ho, 1997; O'Brien and Toms, 2010)				I felt curious to use the app			
					The app revealed hidden details in the museum			
Usability	This is the measurement of the suitability and ease of use app functionality as perceived by the users'. Othman et al., 2011; Hussain et al., 2015; Lund, 2001)				I feel like reusing the app			
					The app guide is not distractive			
					Provide consistent info			
					The app helps in navigation			
					Using the app guide enhanced my museum visit			
					The app is not complicated			
					It was difficult to select the option I wanted with the app guide			
Interaction	This is the act of being aware of the control of an app whereby the app gives initiative, information and feedback on an action. (Othman et al., 2011)				The app guide provide feedback about my actions			
					The app offer initiative and information I needed			
					I became unaware that I was even using any controls on the app guide			

Proposed Element	Element Description	Pick One			Proposed Items for Element	Pick One		
		Definitely not relevant	Maybe not relevant	Relevant		Definitely not relevant	Maybe not relevant	Relevant
Motivation	Motivation is an act which encourages someone to do some action (a fun and enjoy) a target (learning or playing). (Chapman, 1997); Fogg, 2009).				The app is really easy to use			
					The app increases my involvement in museum information			
					I enjoyed the process of learning museum history with the app			
					Touring the museum is more fun with the use of the app			
Satisfaction	This is act of being contend and fond with an app. (Alqahtani & Mohammad, 2015; Chin, Diehl, & Norman, 1988; Abdinnour-Helm, Chaparro and Farmer, 2005).				Generally, I am satisfied with the app			
					I became fond with the app during interaction			
					I will recommend the app to others			
Self-Efficacy	One's belief in one's ability to succeed in specific situations or accomplish a task. (Beaudin, 1998; Mahat, Ayub, and Luan, 2012).				I get a rising feeling during my interaction with the app			
					I think that it takes a shorter time for my interaction with the app			
					The app encourage my interaction			
Perceived Control	Act of dominating, commanding and regulating others, an activity, or a system. (O'Brien & Toms, 2008); Boberg et al., 2015).				I had the capability to influence what was happening on the app			
					I felt fulfilled when using the app			
					The app make me be in control			
Enjoyment	The user experiencing fun, joy, satisfaction, peace and fulfilment with the usage of apps. (MäNtymäKi and Salo, 2011; Nysveen et al., 2005; Pendit et al., 2014b)				I enjoy using the app			
					I like the short and simple learning content provided by app			
					I feel fulfilled after using the application for learning at museum			
					I have the feeling of pleasure while using the app			

Proposed Element	Element Description	Pick One			Proposed Items for Element	Pick One		
		Definitely not relevant	Maybe not relevant	Relevant		Definitely not relevant	Maybe not relevant	Relevant
Focused Attention	The concentration of mental activity; concentrating on one stimulus only and ignoring all others. (Wiebe et al., 2014; O'Brien and Toms, 2010)				I forgot about my immediate surroundings while using the app			
					I was so involved in the app task that I ignored everything around me			
					I lost myself in the app experience			
					I was so involved in that I almost lost track of time			
					I blocked out things around me when using the app			
Interest	This when an object or system is attract attention, provoke thought, intrigue and fascinate a user. (Schraw, Bruning, and Svoboda1995)				The app got my interest			
					I'd like to discuss the app with others at some point			
					I would use the app again if I had the chance			
					I'll probably think about the implications of the app experience for some time to come			
					The app interaction was fascinating			
					I am sure that others would find the app interesting			
					The app really grabbed my attention during interaction			

Thank you

Appendix E

Expert Review phase 2 Form

EXPERT REVIEW ON CONCEPTUAL MODEL OF ENGANGEMENT MOBILE AUGMENTED REALITY FOR MUSEUM HEARING IMPAIRED VISITORS

A) Demographic

Areas of Expertise:

Years of Experience:

B) Research Work Explanation

My name is Esraa Jaffar Baker, a graduate student from the Awang Had Salleh Graduate School, College of Arts & Sciences, Universiti Utara Malaysia under the supervision of Dr. Juliana Aida Abu Bakar and Assoc. Prof. Abdul Nasir Zulkifli. We are currently developing the conceptual model of engagement of mobile augmented reality for hearing-impaired museum visitors.

Looking at your rich background in academic and research expertise in the area of Human-Computer Interaction (augmented reality or engaging experience) or Mobile Applications for Hearing Impaired or Museum Visitors, I would like to humbly solicit your opinions, suggestions, and recommendations to review and improve our initial model of engagement of mobile augmented reality for hearing-impaired museum visitors.

The listed elements and items will be used in the development of the study conceptual model of engagement of mobile augmented reality for hearing-impaired museum visitors. Therefore, these model components (elements and items) have been identified to support the design and implementation of a mobile augmented reality application for hearing-impaired museum visitors.

The purpose of this task is to provide comments as well as necessary inputs to the basis of design model and their related elements with corresponding items.

This booklet contains five pages. Enclosed in next pages are the consent form and questionnaires related to the identified elements and items and thank you for your time.

C) Operational Explanation in the Context of the Study

Mobile Augmented Reality: The type of AR which platform is based on a smartphone or handheld devices [1].

Hearing Impaired: A condition of loss of hearing ability where the ear is not able to receive acoustic sound [2].

Engagement: A quality of user experience with technology which is measured using a multidimensional construct. [3].

CONSENT FORM FOR EXPERT REVIEWER

1. With the expertise and the existing knowledge that I have, I volunteer to be an expert reviewer for this study as proposed by Esraa Jaffar Baker, a graduate student from the Awang Had Salleh Graduate School, College of Arts & Sciences, Universiti Utara Malaysia under the supervision of Dr. Juliana Aida Abu Bakar and Assoc. Prof. Abdul Nasir Zulkifli.
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 the 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 supervisors.
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 Awang Had Salleh Graduate School, College of Arts & Sciences, Universiti Utara
6. I have read and understood the explanation provided to me. I have had all my questions answered to my satisfactions, and I voluntarily agree to participate in this study.
7. I am given a copy of this consent form.

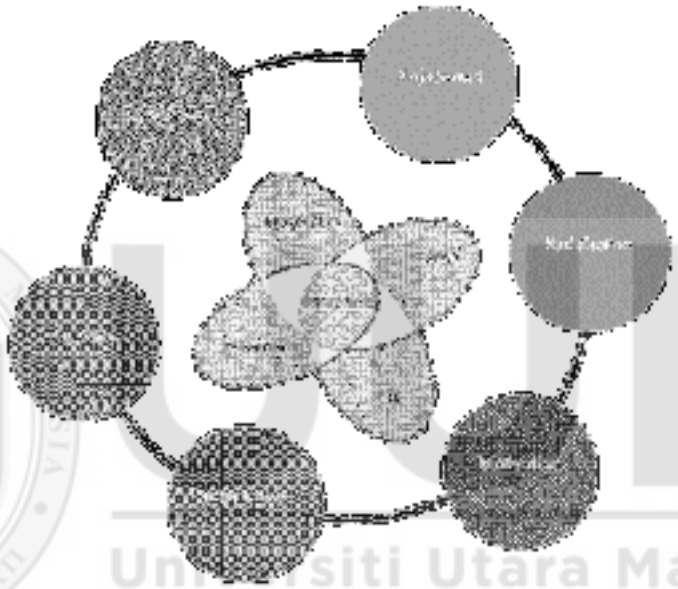
Printed Name and Official Stamp	Date and Signature

Note: If an element is not relevant then there is no need to pick its items

Proposed Element	Element Description	Pick One			Proposed Items for Element	Pick One		
		Definitely not relevant	Maybe not relevant	Relevant		Definitely not relevant	Maybe not relevant	Relevant
Aesthetics	Visual beauty or the study of natural and appealing computer-based environments. [1]				The app is attractive			
					The app is appealing to my visual senses.			
					The screen layout is suitable			
Usability	Suitability and ease of use based on the app functionality as perceived by the users'[2].				The app is easy to use.			
					The app provides me the required guidance to perform my task			
					The app provides consistent information.			
Interaction	Aware of being in control towards the app whereby interactivity, information and feedback are given-up-on an action. [2]				The app provided control through my actions.			
					The app provided responses that I need.			
					The app provided feedback smoothly.			
Motivation	An act which encourages action or target activity to be performed by a user. [3]				The app increased my excitement with the museum exhibition			
					I feel more motivated to do an activity with the app			
					Touring the museum was more encouraging with the use of the app			

Proposed Element	Element Description	Pick One			Proposed Items for Element	Pick One		
		Definitely not relevant	Maybe not relevant	Relevant		Definitely not relevant	Maybe not relevant	Relevant
Satisfaction	Act of being content and fond with an app. [4]				Generally, I am satisfied with the app			
					I became fond with the app			
					I will recommend the app to others			
Enjoyment	The user experiencing fun, enjoy, and entertaining with the usage of apps. [5], [6], [7] and [8]				I enjoy using the app.			
					The app provides me an entertaining experience.			
					It is fun using the app.			
					I do not feel the time has passed while using the app.			

Note: The following is the Initial Conceptual Model derived based on the above proposed elements.



Appendix F

Expert Review Phase 1 Responses

Element	Items	Relevant(R)	Maybe not Relevant(M)	Definitely not Relevant(D)
Aesthetics	*AES 1*	8	0	0
	AES 2	6	1	0
	AES 3	7	0	0
Usability	*USA 1*	4	2	1
	USA 2	5	1	1
	USA 3	7	0	0
	USA 4	4	2	1
	USA 5	4	3	0
	USA 6	4	2	0
	USA 7	3	2	1
Interaction	*INT 1*	7	1	0
	INT 2	7	0	0
	INT 3	5	2	0
Motivation	*MOT 1*	3	2	1
	MOT 2	6	1	0
	MOT 3	6	0	1
	MOT 4	6	0	1
Satisfaction	*SAT 1*	8	0	0
	SAT 2	6	0	1
	SAT 3	7	1	0
Enjoyment	*ENJ 1*	8	0	0
	ENJ 2	5	1	1
	ENJ 3	6	0	1
	ENJ 4	6	1	0

Appendix G

Questionnaire for Mobile Augmented Reality for Engaging Hearing-Impaired Museum Visitors

College of Arts and Sciences

UNIVERSITI UTARA MALAYSIA

Questionnaire

Measuring Engagement for Hearing Impaired Visitors in the Museum

Prepared by:
ESRAA JAFFAR BAKER

Assalammu'alaikum and Good Day,

Dear participants,

We are delighted to inform you that you have been selected to participate in our research on "Mobile Augmented Reality for Engaging Hearing-Impaired Museum Visitors". The research focuses on the relationships between the elements of the Mobile Augmented Reality and engagement for hearing impaired museum visitors. A **Mobile Augmented Reality for Hearing impaired museum engagement** (**MARHIME**) app has been developed for that purpose.

The following questionnaire aims to understand several aspects of the MARHIME app. Your participation in answering this questionnaire is very much appreciated in ensuring the success of this study. The information gathered will be treated as confidential and only be used for research purposes and may be reported anonymously in academic publication.

I would like to thank you for your time and cooperation.

Yours Truly,

ESRAA JAFFAR BAKER

SECTION I: PARTICIPANTS' BACKGROUND

Please tick (√) in the appropriate box.

1. **Gender**:

   Male □

   Female □

2. **Age:**

   <20 years □

   21-29 years □

   30-39 years □

   40-49 years □

   over 50 years □

3. **Educational Level:**

   Primary school □

   Seconday school □

   Graduate □

   Postgraduate □

   None of the Above □

4. **Your Experience on Mobile Applications**:

   One year or less □

   More than one year □

SECTION II: ELEMENTS OF ENGAGEMENT

Please indicate your degree of agreement on the following statement, by circling the most appropriate choice using the scale below:

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

AESTHETICS

Aesthetics refers to visual beauty or the study of natural and appealing mobile environments. This section aims to understand the aesthetics of the MARHIME app.

Items	Scale				
1. The MARHIME app is attractive	1	2	3	4	5
2. The MARHIME app is appealing to my visual senses.	1	2	3	4	5
3. The MARHIME app screen layout is suitable	1	2	3	4	5

USABILITY

Usability refers to consistent information and ease of use based on the app functionality as perceived by the users'. This section aims to understand the usability of the MARHIME app.

Items	Scale				
1. The MARHIME app was easy to use.	1	2	3	4	5
2. The MARHIME app provides me the required guidance to perform my task	1	2	3	4	5
3. The MARHIME app provides consistent information.	1	2	3	4	5

INTERACTION

Interaction refers to aware of being in control towards the app whereby interactivity, information and feedback are given upon an action. This section aims to understand the interaction while using the MARHIME app.

Items	Scale				
1. The MARHIME app provided control through my actions	1	2	3	4	5
2. The MARHIME app provided responses that I need.	1	2	3	4	5
3. The MARHIME app provided feedback smoothly	1	2	3	4	5

MOTIVATION

Motivation refers to an act which encourages action or target activity to be performed by a user. This section aims to understand the motivation after using the MARHIME app.

Items	Scale				
1. The MARHIME app increased my excitement with the museum exhibition	1	2	3	4	5
2. I feel more motivated to do an activity with the MARHIME app.	1	2	3	4	5
3. Touring the museum was more encouraging with the use of the MARHIME app.	1	2	3	4	5

SATISFACTION

Satisfaction refers to act of being content and fond with an app. This section aims to understand the satisfaction after using the MARHIME app.

Items	Scale				
1. Generally, I am satisfied with the MARHIME app.	1	2	3	4	5
2. I became fond with the MARHIME app.	1	2	3	4	5
3. I will recommend the MARHIME app to others.	1	2	3	4	5

ENJOYMENT

Enjoyment refers to the user experiencing fun, enjoy, and entertaining with the usage of the app. This section aims to understand the enjoyment while using the MARHIME app.

Items	Scale				
1. I enjoyed using the MARHIME app.	1	2	3	4	5
2. The MARHIME app provided me an entertaining experience.	1	2	3	4	5
3. It was fun using the MARHIME app.	1	2	3	4	5
4. I did not feel the time has passed while using the MARHIME app.	1	2	3	4	5

Appendix H

Questionnaire for Mobile Augmented Reality for Engaging Hearing-Impaired Museum Visitors (Arabic Language)

كلية الآداب والعلوم

جامعة أتارا ماليزيا

استبيان

قياس مشاركة الزوار ضعفاء السمع في المتحف

من اعداد

اسراء جعفر باقر

السلام عليكم

أعزائي المشتركين:

الهدف من هذا لاستبيان هو جمع معلومات حول "الواقع المعزز للجوال لمشاركة الزوار الذين يعانون من ضعف في السمع". الباحثة تكون شاكرة وممتنة لمشاركتكم في هذا البحث. ويركز البحث على العلاقة بين تطبيق عناصر الواقع المعزز في الجوال ومشاركته في تحسين السمع لزوار المتحف الذين يعانون من ضعف في السمع. وقد تم تطوير تطبيق **الواقع المعزز في الجوال (مارهيمي) لمشاركة زوار المتحف ضعيفي السمع** والذي اعد لهذا الغرض. نرجو منكم قراءة الاسئلة بعناية واختيار الاجابة الدقيقة قدر الامكان للمساعدة في ضمان نجاح هذه الدراسة. مشاركتكم وتعاونكم هو موضع تقدير كبير لنا وسيتم التعامل مع اجاباتكم بسرية تامة وسوف تستخدم فقط لأغراض انجاز البحث.

وأود ان اشكركم على وقتكم وتعاونكم

مع فائق الاحترام

الباحثة

اسراء جعفر باقر

القسم الاول: خلفية المشارك

الرجاء وضع علامة (✔) في المربع المناسب.

1- الجنس

ذكر □

انثى □

2- العمر

اقل من 20 سنة □

21-29 سنة □

30-39 سنة □

40 -49 سنة □

فوق 50 سنة □

3- المستوى الدراسي

الدراسة الابتدائية □

الدراسة الثانوية □

خريج جامعي □

دراسات عليا □

لا شيء مما ذكر أعلاه □

4- تجربتك في استخدام تطبيقات الهاتف المحمول

سنة او اقل □

أكثر من سنة □

القسم الثاني: عناصر المشاركة

من فضلك، ضع دائرة لخيار واحد فقط من كل بند والذي يؤكد الاجابة الاكثر ملائمة لاهتمامك مستخدما الخيارات ادناه:

1	2	3	4	5
لا أوافق بشدة	**لا اوافق**	**محايد**	**اوافق**	**أوافق بشدة**

الجماليات

الجماليات تعني الجمال البصري أو دراسة بيئات المحمول الطبيعية والجذابة. ويهدف هذا القسم لفهم جماليات التطبيق (مارهيمي)

العبارة	**الاختيار**				
1- التطبيق مارهيمي جذاب.	1	2	3	4	5
2- التطبيق مارهيمي يجذب حواسي البصرية.	1	2	3	4	5
3- نسق شاشة التطبيق مارهيمي مناسبة.	1	2	3	4	5

سهولة الاستخدام

سهولة الاستخدام تعني معلومات متسقة وسهولة استخدام وظائف التطبيق من قبل المستخدمين ويهدف هذا القسم إلى فهم قابلية تطبيق مارهيمي.

العبارة	**الاختيار**				
1- التطبيق مارهيمي سهل الاستخدام.	1	2	3	4	5
2- التطبيق مارهيمي يوفر التوجيه المطلوب لأداء مهمتي.	1	2	3	4	5
3- التطبيق مارهيمي يوفر معلومات متناسقة.	1	2	3	4	5

التفاعل

التفاعل يشير إلى إدراك ما يجري في التطبيق حيث يتم إعطاء التفاعل والمعلومات وردود الفعل على العمل. ويهدف هذا القسم لفهم التفاعل أثناء استخدام التطبيق مارهيمي.

العبارة	الاختيار				
1- قدم التطبيق مارهيمي السيطرة حول افعالي.	1	2	3	4	5
2- قدم التطبيق مارهيمي الاستجابة التي احتاج اليها.	1	2	3	4	5
3- قدم التطبيق مارهيمي رد فعل على نحو سلس.	1	2	3	4	5

التحفيز

التحفيز يشير إلى الفعل الذي يشجع العمل او الفعاليات الهادفة التي ينجزها المستخدم. يهدف هذا القسم الى فهم الحافز بعد استخدام التطبيق مارهيمي.

العبارة	الاختيار				
1- التطبيق مارهيمي ساعد في زيادة تحفيزي مع معرض المتحف	1	2	3	4	5
2- اشعر بحافز أكثر للقيام بنشاط مع التطبيق مارهيمي.	1	2	3	4	5
3- التجول في المتحف كان مشجعا جدا مع استخدام التطبيق مارهيمي.	1	2	3	4	5

القناعة والارتياح

القناعة والارتياح تشير إلى احساس الرضا لكون التطبيق مضمونا والمستخدم مولعا مع التطبيق. ويهدف هذا القسم لفهم الارتياح بعد استخدام التطبيق مارهيمي.

العبارة	الاختيار				
1- انا راض عن التطبيق مارهيمي بصورة تامة.	1	2	3	4	5
2- أصبحت مولع باستخدام التطبيق مارهيمي.	1	2	3	4	5
3- سأوصي الاخرين باستخدام التطبيق مارهيمي.	1	2	3	4	5

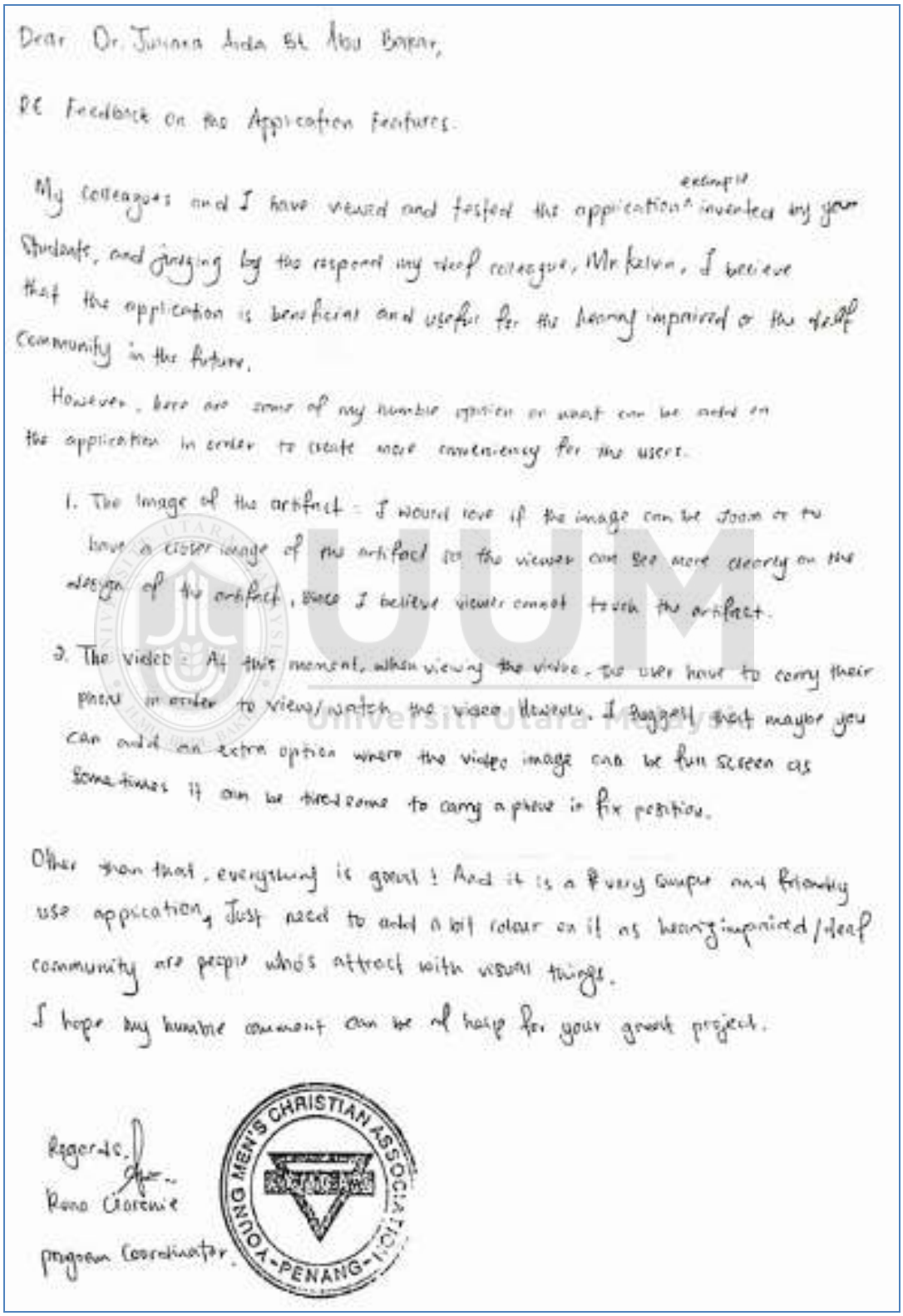
متعة الاستخدام

متعة الاستخدام تشير الى ان مستخدم لاقى تجربة مسلية وممتعة ومثيرة مع استخدام التطبيق. ويهدف هذا القسم لفهم المتعة أثناء استخدام التطبيق مارهيمي.

العبارة	الاختيار				
1- لقد استمتعت باستخدام التطبيق مارهيمي.	1	2	3	4	5
2- التطبيق مارهيمي قدم لي تجربة مثيرة.	1	2	3	4	5
3- استخدام التطبيق مارهيمي قدم لي تجريه مسلية.	1	2	3	4	5
4- لم اشعر بمرور الوقت اثناء استخدام التطبيق مارهيمي.	1	2	3	4	5

Appendix I

Interface Evaluation Hearing Impaired



Dear Dr Juliana Aida Bt Abu Bakar,

RE Feedback on the Application Features.

My colleagues and I have viewed and tested the application example inventea by your Students, and judging by the response my deaf colleague, Mr Kelvin, I believe that the application is beneficial and useful for the hearing impaired or the deaf community in the future.

However, here are some of my humble opinion on what can be added on the application in order to create more convenience for the users.

1. The Image of the artifact - I would love if the image can be zoom or to have a closer image of the artifact so the viewer can see more clearly on the design of the artifact, since I believe viewer cannot touch the artifact.

2. The video - At this moment, when viewing the video, the user have to carry their phone in order to view/watch the video. However, I suggest that maybe you can add an extra option where the video image can be full screen as sometimes it can be tired/some to carry a phone in fix position.

Other than that, everything is good! And it is a very simple and friendly use application, just need to add a bit colour on it as hearing impaired/deaf community are people who's attract with visual things.

I hope my humble comment can be of help for your great project.

Regards,

Rena Clarence

program Coordinator

YOUNG MEN'S CHRISTIAN ASSOCIATION PENANG

Dear Dr. Juliana Aida Bt Abu Bakar,

RE: Opinion on the Esraa' application features.

Thank you for the opportunity to enable us to test this application. Ms. Esraa has been lovely to explain to us regarding the application.

As I understand the features as she explains. There were 3 examples of artifacts, each showing different barcodes and different features, such as pictures (images), videos, 3d, text explanation.

Here are my contribution opinion for the app:

1. I like that images are of different angles of the same artifacts with caption.
2. Even though the app was in Arabian language, I was able to interact with the app clearly.
3. The video app is good, perhaps to include a 'full loading' of video, instead of scanning again if I walk away from the app.
4. The 3D features were interesting, as I was able to 'play' with it.

I hope that my opinion will be able to help Esraa in her study for

Yours sincerely,

Janice Chong
Asst. Program Exec.

Janice Celia Chong.
Assistant Program Coordinator
YMCA Penang.

YOUNG MEN'S CHRISTIAN ASSOCIATION - PENANG -

Appendix J

Evaluation by HI Experts in Iraq

(Expert 1)

I hereby certify that the **MARHIME App** has been produced by Esraa Jaffar from the College of Arts and Sciences, University Utara Malaysia. It has been checked by me in terms of the validity of the interface and the general comments are as follows:

General Comments:

I am one of the trainers of Al-Amal Institute for the Deaf and Mute in Baghdad. During my knowledge of the application provided by the researcher and through my seven years of experience with the deaf and mute and hearing impaired, brief of my comments below:

1- The application is a new idea and encourages the hearing impact to visit the museum without the need of help from the others.
2- All the contents of the application of videos, images, and 3D drawings clear texts and understandable.
3- The presentation is attractive and entertaining, especially when using mobile and the use of new technology.
4- The hearing impaired have a desire to learn and get out of the ordinary and this application will help them to do so.
5- The application was easy to handle.
6- I suggest adding additional antiquities to the application.

Thank you to the researcher for the effort and attention to this segment of society.

Expert (2)

I hereby certify that the **MARHIME App** has been produced by Esraa Jaffar from the College of Arts and Sciences, University Utara Malaysia. It has been checked by me in terms of the validity of the interface and the general comments are as follows:

General Comments:

Through the study of the application, its tools and its impact on our students with special needs (hearing impaired) and responses to their actions show us the following:

The idea of the application is a great concern for this segment of society in overcoming their problems and their integration among social circles and breaking the psychological factor.

The clarity of the application tools and their ease of use show them the fun of the game in the application.

The presentation of information (video, texts, images, 3D forms) was clear and understandable.

The application gives them the opportunity to communicate on social media sites

Appendix K

Evaluation by Museum Expert

Evaluation by Museum Expert

I, hereby certify that the **MARHIME App** has been produced by Esraa Jaffar from the College of Arts and Sciences, University Utara Malaysia. It has been checked by me in terms of the validity of the contents and the general comments are as follows:

General Comments:

I am an employee of the Iraqi Museum, I have watched the videos, text, images, and the 3D model. The information was excellent and correct, and the application excellent and has a unique name.

The application helps the Museum's visitors that have hearing impaired to understand, enjoy and consolidate with the artefact, knowing and learning from the previous civilizations. The artefacts were used in the application are the most important and well-known artefacts in the Museum, like (The Ishtar Gate, The winged bull and Hill Hermel). The information was very valuable to the visitors and helps them understand these artefacts.

I wish to apply this application in the Iraqi Museum and the other World Museums, so it can have information of more artefacts and support more languages and can be used by the normal people in general.

Department of Educational Guidance

Evaluation by Museum Expert

I, hereby certify that the **MARHIME App** has been produced by Esraa Jaffar from the College of Arts and Sciences, University Utara Malaysia. It has been checked by me in terms of the validity of the contents and the general comments are as follows:

General Comments:

I consider this kind of modern applications has a positive effect on the locations. I believe this application will have the significant positive effect on hearing impaired.

The work is integrated in terms of information, videos, and images, it contains everything that benefits the visitor.

I suggest that the work is translated into several languages and would be the main world languages.

I see that the entertainment aspect of this program has added to it another advantage where the information sometimes needs demonstration tools to reach the other party and sometimes be pure information, so the presence of a game in the application removes boredom and helps overcome the boredom.

My sincere greetings and wishes for success in this application

July 29th, 2017

Appendix L

Expert Interface Academic Form

I hereby certify that the MARHIME application has been produced by Esraa Jaffar from the College of Arts and Sciences, University Utara Malaysia. It has been checked by me in terms of the validity of the interface and the general comments are as follows:

Heuristic and Subheuristics				
Interface (IN)		Pick one		Commands
		Yes	No	
IN1	The instruction given is clear and easy to understand.			
IN2	The interface design is attractive.			
IN3	The MARHIME application is easy to use.			
IN4	the colour scheme used is appropriate.			
IN5	Attractive display of the screen design.			
IN6	Appropriate interface.			
IN7	The readability of text suits the target.			
Multimedia (Image, Video, Text, and 3D model) (MM)		Pick one		Commands
		Yes	No	
MM1	Each multimedia elements used serves a clear purpose.			
MM2	Usage of multimedia elements is suitable with the content.			
MM3	The presentation of multimedia elements is well managed.			
MM4	The use of multimedia elements supports meaningfully the information provided.			
MM5	The quality of multimedia elements used is good.			
MM6	The use of multimedia elements enhances the content presentation.			
Interactivity (IV)		Pick one		Commands
		Yes	No	
IV1	The interactivity is easy to understand.			
IV2	The interactivity is not misleading.			
IV3	The help functions provided may be useful.			

Appendix M

Statistical Expert Form

UUM

SQS STATISTICAL CONSULTING
SCHOOL OF QUANTITATIVE SCIENCES
UUM COLLEGE OF ARTS AND SCIENCES
www.sqs.uum.edu.my
Email: sqscas@uum.edu.my

File No: ________

Consultation Appointment Form

Name: ________
Staff/Matric no: ________ School/Department: ________
Institution: ________ Email: ________
Tel no (Office): ________ Mobile: ________

Type of consultation (please tick):

- [ ] Research project
- [ ] Journal Article/Conference presentation
- [x] Dissertation/Thesis (Msc/PhD)
- [ ] Final year project (Undergraduate)

Title of project: ________
Analysis/software applications plan to use: ________

Signature of client:

Date:

Consultation Bill

Date	Time	Duration	Charge	Consultant's signature and stamp
	11-12	1	25	DR. SUZILAH ISMAIL Associate Professor School of Quantitative Sciences UUM College of Arts and Sciences Universiti Utara Malaysia

Fees rate (per hour) – * Please bring exact amount

Student	RM 25
UUM Staff/ Others	RM 50

*Note for consultant:
Submit this form to Secretary of SQS Statistical Consulting
Dr. Muhammad Mat Yusof (Tel no: 049286316, ...@uum.edu.my)

FOR OFFICE USE ONLY

Appendix N
Results for Exploratory Factor Analysis

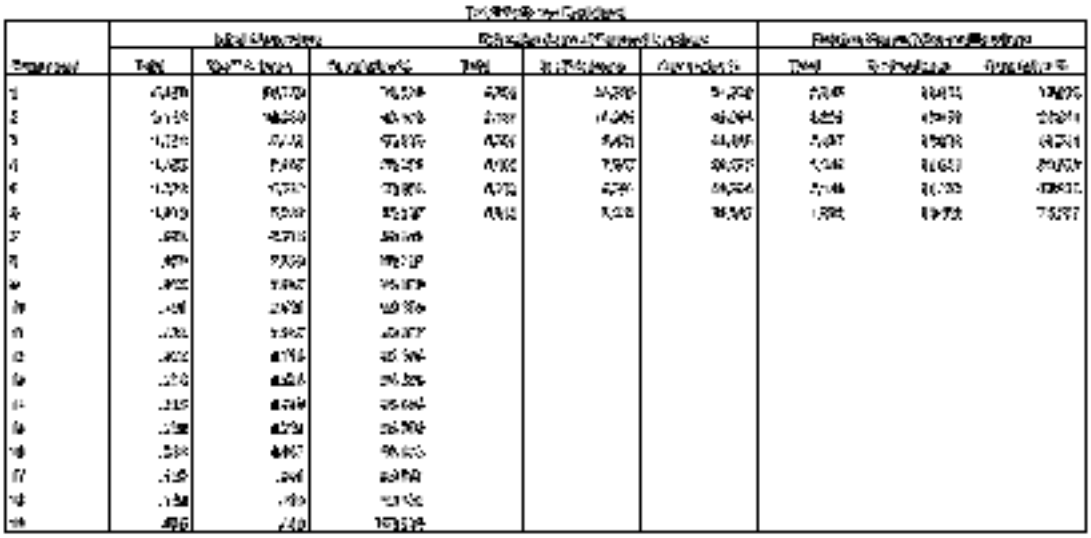
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.779
Bartlett's Test of Sphericity	Approx. Chi-Square	762.619
	df	171
	Sig.	.000

Communalities

	Initial	Extraction
AES.1	1.000	.729
AES.2	1.000	.793
AES.3	1.000	.759
USA.1	1.000	.762
USA.2	1.000	.812
USA.3	1.000	.809
INT.1	1.000	.714
INT.2	1.000	.864
INT.3	1.000	.619
MOT.1	1.000	.683
MOT.2	1.000	.814
MOT.3	1.000	.767
SAT.1	1.000	.797
SAT.2	1.000	.754
SAT.3	1.000	.680
ENJ.1	1.000	.732
ENJ.2	1.000	.730
ENJ.3	1.000	.775
ENJ.4	1.000	.715

Extraction Method: Principal Component Analysis.



Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
AES.3	.833					
AES.1	.774					
AES.2	.774					
ENJ.3		.831				
ENJ.2		.762				
ENJ.4		.759				
ENJ.1		.678				
MOT.2			.829			
MOT.3			.720			
MOT.1			.667			
SAT.3				.787		
SAT.2				.748		
SAT.1				.729		
USA.3					.848	
USA.2					.827	
USA.1					.704	
INT.3						.753
INT.1						.670
INT.2						.667

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
AES.1	73	3.00	5.00	4.4247	.68552
AES.2	73	2.00	5.00	4.1781	.78780
AES.3	73	3.00	5.00	4.3288	.72753
USA.1	73	3.00	5.00	4.1507	.81088
USA.2	73	3.00	5.00	4.5616	.62330
USA.3	73	3.00	5.00	4.3973	.63987
INT.1	73	2.00	5.00	4.2740	.94664
INT.2	73	1.00	5.00	4.1507	1.15074
INT.3	73	2.00	5.00	4.0959	.98833
MOT.1	73	2.00	5.00	4.5205	.70926
MOT.2	73	2.00	5.00	4.3151	.81440
MOT.3	73	2.00	5.00	4.2192	.78610
SAT.1	73	2.00	5.00	4.2740	.80382
SAT.2	73	2.00	5.00	4.2466	.74126
SAT.3	73	2.00	5.00	4.2466	.81276
ENJ.1	73	2.00	5.00	4.2329	.99332
ENJ.2	73	2.00	5.00	4.0000	1.01379
ENJ.3	73	2.00	5.00	3.9589	.96377
ENJ.4	73	2.00	5.00	3.9452	.92632
AESTHETICS	73	2.67	5.00	4.3105	.63908
USABILITY	73	3.33	5.00	4.3699	.56809
INTERACTION	73	1.67	5.00	4.1735	.85906
MOTIVATION	73	2.33	5.00	4.3516	.66177
SATISFACTION	73	2.00	5.00	4.2557	.66323
ENJOYMENT	73	2.00	5.00	4.0342	.76978
Valid N (listwise)	73				