Universiti Utara Malaysia

CONCEPTUAL MODEL OF MOBILE AUGMENTED REALITY FOR CULTURAL HERITAGE SITE TOWARDS ENJOYABLE INFORMAL LEARNING (MARCHSTEIL)

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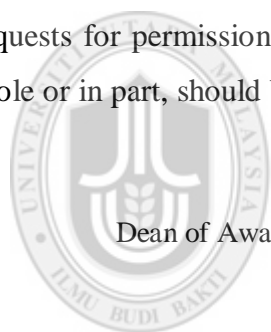
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Abstrak

Realiti luasan mudah alih (AR) adalah salah satu daripada teknologi termaju yang dapat menyediakan kandungan interaktif untuk pelancong di warisan budaya. Kajian lepas menunjukkan, pengalaman pembelajarantidak formal yang menyeronokkan amat diperlukan bagi pelancong bagi meluaskan pengetahuan dari lawatan mereka. Walaupun banyak aplikasi AR mudah alih telah dibangunkan untuk memaparkan maklumat tapak warisan budaya kerana kurangnya model menyeluruh yang mengambilkira elemen pengalaman pembelajaran tidak formal yang menyeronokkan. Oleh itu, kajian ini mencadangkan satu model konsep AR mudah alih yang komprehensif yang mengambilkira komponen-komponen pengalaman pembelajaran tidak formal yang menyeronokkan di tapak warisan budaya. Kajian ini menggunakan kaedah penyelidikan sains reka bentuk. Model konsep yang dicadangkan telah diteliti dan disahkan melalui penilaian pakar dan perbincangan kumpulan fokus. Penilaian telah dianalisis beradasarkan frekeunsi respon ke atas setiap komponen. Sebagai pembuktian konsep, suatu prototaip dinamakan sebagai (AR@Melaka) telah dibangunkan dan kemudian ianya dinilai dari aspek pembelajaran tidak formal menyerenokkan terhadap 200 orang pelancong di sebuah tapak warisan budaya terkemuka. Dari perspektif pengguna, prototaip AR@Melaka telah terbukti dapat memberikan pembelajaran tidak formal yang menyeronokkan. Kesimpulannya, dapatan ini membuktikan bahawa model konsep yang dicadangkan itu adalah berguna untuk membantu pelancong dalam pembelajaran di tapak warisan budaya dalam cara yang menyeronokkan. Kajian ini menyumbang kepada model konsep untuk dijadikan garis panduan dalam membangunkan realiti luasan mudah-alih yang mengambilkira komponen pembelajaran tidak formal yang menyeronokkan.

Kata kunci: Realiti luasan mudah-alih, Pembelajaran tidak formal yang menyeronokkan, Tapak warisan budaya

Abstract

A mobile augmented reality (AR) is one of the emerging technologies that may provide interactive content to tourists at cultural heritage sites. Past studies show enjoyable informal learning experience is highly needed for tourists to broaden knowledge for tourists. Although many mobile AR applications have been developed to expose cultural heritage site information, they are still lacking in providing such experience due to lack of comprehensive models which taking into consideration the elements of enjoyable informal learning experience in the development of such applications. Therefore, this study proposes a comprehensive conceptual model of mobile AR where it considers the components of enjoyable informal learning experience at cultural heritage site. This study followed design science research methodology. The proposed conceptual model is reviewed and validated through expert review and focus group discussion The review was analysed based on frequency of the responses on each component. As a proof-of-concept, the prototype (named as AR@Melaka) was developed and then evaluated on its enjoyable informal learning aspects to 200 tourists of a renowned cultural heritage site. From user perspective, it is proven that AR@Melaka provides enjoyable informal learning. In conclusion, these findings proved that the conceptual model is useful for assisting tourists in learning at cultural heritage site in an enjoyable way. This study contributes a conceptual model to serve as guidelines for developing a mobile augmented reality that considers an enjoyable informal learning component.

Keywords: Mobile augmented reality, Enjoyable informal learning, Cultural heritage site

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Ulka Chandini Pendit
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List of Abbreviations

API	Application Programming Interface
AR	Augmented Reality
ARCO	Augmented Reality for Cultural Object
ARCHEOGUIDE	Augmented Reality based-Cultural Heritage On-Site GUIDE
BWL	Butterfly Watching Learning System
EDA	Exploratory Data Analysis
EIL	Enjoyable Informal Learning
EULER	Environment of Ubiqitous Learning with Educational Resources
GLUT	OpenGL Utility Toolkit
GPS	Global Positioning System
iTACITUS	Intelligent Tourism and Cultural Information through Ubiquitous Service
LOL@	Local Location Assistant
MART	Mobile Augmented Reality Tour
MAR	Mobile Augmented Reality
MARS	Mobile Augmented Reality System
MARCH	Mobile Augmented Reality for Cultural Heritage
MARCHSTEIL	Mobile Augmented Reality for Cultural Heritage Site towards Enjoyable Informal Learning
MTG	Mobile Tourism Guide
OpenGL	Open Graphics Library
OpenGL ES	Open Graphics Library for Embedded Graphics
OS	Operating System
PoI	Point of Interest
RFID	Radio-Frequency Identification
SDK	Software Development Kit
SHMAR	Sutoon Hoo Mobile Augmented Reality

CHAPTER ONE
INTRODUCTION

Introduction

This chapter presents background of study followed by statement of problem, research questions, objectives of study, research scope and contributions of study.

1.1 Background of Study

Augmented reality (AR) overlays the virtual object to the real world without replacing the real environment (Azuma, 1997). It is usually done by augmenting virtual image or textual annotations to the real world (Pulli et al., 2009). It enhances user perception and interaction with the real world, and present information which user cannot detect directly (Carmigniani & Furht, 2011; Izkara, Pérez, Basogain, & Borro, 2007; Reitmayr & Schmalstieg, 2001).

AR on mobile was developed in 1997 by Steven Feiner and was named the Touring Machine. It can be built in many forms, namely, mobile workstation, tablet PCs, Ultra Mobile PCs (UMPCS), Personal Digital Assistants (PDA), smart-phones and handheld devices (Chen, Tsai, Vedantham, Grzeszczuk, & Girod, 2009; Craig, 2013; Höllerer & Feiner, 2004; Papagiannakis, Singh, & Magnenat-thalmann, 2008). The implementation of mobile AR for cultural heritage had started since fourteen years ago (Angelopoulou, Economou, Bouki, Jin, Pritchard, & Kolyda, 2011; Armanno, Bottino, & Martina, 2012; "iTACITUS,"2007; Kim & Park, 2011; Seo, Kim, & Park, 2011; "Techcooltour," 2013; Vlahakis et al., 2001). It provides image, text, animation, and video and has become alternative for common interpretive media

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(signs, interpretive board, and brochure). However, these mobile AR projects lack of enjoyable informal learning aspect. Enjoyable informal learning is based on interpretation theory (informal learning in cultural heritage) and enjoyment theory. It is a process where visitor engages in variety of media but also at the same time, learns and achieves new knowledge (Ariffin, 2009). The existing mobile AR projects lack of navigation and interface design, quality of content, use of questions, and physical orientation. This is regrettable, since mobile AR is created as interpretive media in order to help visitor to learn at cultural heritage site (Timothy & Boyd, 2002).

Furthermore, mobile AR for cultural heritage site should be enjoyable as learning at cultural heritage site is a voluntary learning as it relies on intrinsic motivation (Ham, 1992; Falk & Storksdieck, 2005; Lin, Fernandez, & Gregor, 2012).

Hence, this study attempts to create conceptual model which caters for informal learning for cultural heritage site. A conceptual model represents the key concepts and provides accurate, consistent, and complete representation of concepts (Churchill, 2007; Norman, 2014). The proposed conceptual model provides component of content, navigation and user interface design, interactivity, features, hardware, and process that is appropriate for enjoyable informal learning at cultural heritage site by using mobile AR.

In summary, it is hoped that the proposed conceptual model can be a guideline for developer in developing mobile AR for helping visitors learning in enjoyable way at

cultural heritage site. Moreover, some aspects have motivated this study being conducted as explain in the next section.

1.2 Research Motivations

The motivations consist of three factors, which are, the ability of mobile AR to support learning at cultural heritage site, the lack of mobile AR for cultural heritage site in South East Asia, and the high demand of mobile AR. These aspects are explained in next subsections.

1.2.1 Mobile AR Supports Visitor Learning at Cultural Heritage Site

Visitors learn about history, important people, and important events at cultural heritage site (Light, 1995a). This learning can be provided by mobile AR because it transfers information through virtual object which is overlaid on the real environment. Based on the result of survey at Heinz Nixdorf Museum, Germany, 74% of visitors prefer AR over traditional presentation and 95% of visitors want AR to be used for other exhibits (Grafe, Wortniann, & Westphal, 2002). In addition, it also makes visitors learn more and increase their knowledge (Elinich, 2011; Gargalakos & Rogalas, 2011). This has resulted from interaction and learning with AR exhibit (Elinich, 2011). Furthermore, in terms of content acquisition, it enables visitors to download and update information directly on their mobile device.

1.2.2 Lack of Mobile AR for Cultural Heritage Site in South East Asia

The result of preliminary studies found to date, there is no mobile AR being implemented at cultural heritage in South East Asia, particularly, in Melaka,

Malaysia (refer to Chapter 3 Page 122). However, this facility has been provided in Europe and East Asia since a decade ago (Angelopoulou et al., 2011; Armanno et al., 2012; "iTACITUS," 2007; "Techcooltour," 2013; Kim & Park, 2011; Seo et al., 2011; Vlahakis et al., 2001).

The first mobile AR for cultural heritage site is Augmented Reality based-Cultural Heritage On-Site GUIDE (ARCHEOGUIDE). It reconstructs Olympia Building into 3D simulation and provides personalized AR tour guide at Olympia Site, Greece (Vlahakis et al., 2001). Then, it is followed by, Intelligent Tourism and Cultural Information through Ubiquitous Service (iTACITUS). iTACITUS overlays multimedia content (3D model, text, image, sound, video) with superimposed environment, annotated landscape and spatial acoustic overlay technique at Reggia Venaria Reale Italy and Winchester Hall, UK ("iTACITUS," 2007). After that, MART (Mobile Augmented Reality Tour) is implemented at National Palace Museum, Korea. It provides different feature than previous projects, which are, intuitive interface with context-awareness and tour application (Kim & Park, 2011). Next, SkyLineDroid, is mobile AR project that enables content adaptivity (Armanno et al., 2012). It allows developer to create their own SkyLineDroid by changing the content. It also immerses visitors with virtual reconstruction at cultural heritage site. Next, Sutoon-Hoo Mobile Augmented Reality (SHMAR) is an AR education games at Sutoon-Hoo archaeological site, UK (Angelopoulou et al., 2011). And the recent mobile AR for cultural heritage is Techcooltour. It is a cross-media platform using AR and brochure for providing interactive experience in Roman and Byzantine cultural heritage site ("Techcooltour," 2013). Techcooltour presents 3D

reconstruction, 3D virtual character, video, and 360 degrees panorama related to the site.

1.2.3 Potential Market of Mobile AR

Mobile AR has been growing fast in the market. It is estimated to attract leading brands by $1.5 billion revenue by 2015 (Holden, 2011). In 2012, it grew over 295% per year (Marketing charts, 2011) that makes the forecast about this emerging technology predicted that it will reach in 1 billion users in 2020 (Ahonen, 2012). Furthermore, in Malaysia, the market of mobile AR is improving as shown in the increase of start-ups in the field of mobile AR (Tay, 2015; Lukman, 2013). These start-ups produce good products and services of AR. The potential market of mobile AR motivates research in this field.

1.2.4 Summary of Research Motivations

AR has advantages in supporting the learning process about cultural heritage. It helps visitors to learn more and increase their knowledge while visiting the cultural heritage site. However, this advantage has not been acquired by visitors in South East Asia, particularly, Melaka, Malaysia, since there is no mobile AR implemented at Melaka Heritage Site (refer to Chapter 3 Section 3.3.2). Therefore, this research has chosen Melaka as the place for conducting the study. Because Melaka is renowned by United Nations Educational, Scientific and Cultural Organization (UNESCO) as one of the world heritage sites in South East Asia. The potential of mobile AR market is an additional motivation also. All in all, these factors motivate

the execution of research in (mobile AR for cultural heritage site towards enjoyable informal learning).

Next section describes the preliminary study about perception of visitor towards AR usage at historical building.

1.3 Preliminary Study of Potential Visitor Perceptions on the Usage of AR at Historical Building

A preliminary study was conducted to determine the research focus from June 24[th]to June, 29th, 2012. The research focus is the AR implementation in assisting visitors at cultural heritage. Since AR is considered new, it is important to know perception of potential visitors towards AR. Moreover, demographic information and awareness level for visiting the cultural heritage site are also provided.

1.3.1 Method

This preliminary study used questionnaire as the instrument for data collection. The questionnaire consists of five-point which ranged from scales; 5-strongly agree, to 1-strongly disagree. The ten listed questions seek to measure perception of respondents in issues such as learning, understanding, informing, innovation, conservation, motivation and interest about AR at historical buildings/sites (refer to Table 1.1).

Table 1.1

Questionnaire Items

No	Questions
Q1.	AR application is a better medium than the traditional mode to inform visitors about history in historical sites/buildings.
Q2.	AR application is a better medium than the traditional mode to educate visitors about history in historical sites/buildings.
Q3	I learn better about history through AR in historical buildings/sites.
Q4.	I prefer to come to historical sites/buildings which provide AR application such as virtual tour guide.
Q5.	AR is an innovative way to conserve the historical sites/buildings.
Q6.	Including a storyline with AR application to conserve historical sites/buildings would motivate me more to learn about its history.
Q7.	I would be more interested to visit historical sites/buildings with AR application.
Q8.	Conservation of historical sites/buildings using visual technology is highly necessary.
Q9.	Informing visitors on historical sites/buildings is highly effective through visual communication.
Q10.	Visual communication allows learner to better understand the history of sites/buildings.

The respondents were randomly selected from the Universiti Utara Malaysia (UUM) community (student, lecturer, research assistant, tutor, and clerk) and were divided into three categories: people who are familiar with AR, new to AR and have no knowledge on AR. During the activity, two video demonstrations of AR projects which are iTACITUS ("iTACITUS," 2007) and AR-based on-site in Gyeongbokgung (Seo et al., 2011) were presented in order to give basic understanding about AR in four minutes. Descriptive analysis was used to analyse and process the result.

1.3.2 Findings and Discussion

There were 30 people consisted of 43% male and 57% female with 83% of them Malays who were respondents of study. They, in majority, aged from 19 to 25 years old (60 %), 26 to 32 years old (20%), 33 to 40 (17 %), and 41 to 47 years old (3%). They revealed that they had visited historical buildings (60%), they have not visited

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the historical building yet (30%) and they plan to visit historical building in the future (10%). The five states which they have been visited the most comprise of Kedah, Melaka, Kelantan, Perak, and Penang.

The result shows 60% of respondents who have visited historical buildings perceived AR as a good medium to inform historical stories as well as an innovative way to conserve historical building (Q1 and Q5 = mean (4.30)) (refer to Figure 1.1).Visitors were also more interested to come to historical sites which provide AR application (Q7= mean (4.067)). In addition, visitors are more motivated to learn history through storytelling presented on AR application (Q6 = mean (4.033)). They think that visual communication is effective since it enables better understanding to learn history at historical sites (Q9 and Q10 = mean (4.033)). Furthermore, visitors believe that AR is better to educate visitors than the traditional mode (Q2= mean (4.275)) and visual technology is highly necessary for conservation of historical building (Q8= mean (4)).

However, the preference to come to historical sites which provide AR application such as virtual tour guide and effectiveness of learning with AR were found low (Q4 and Q3= mean (3.793 and 3.333)). Indicatively, this result is deduced because all respondents haven't had any experience using AR application at historical buildings.
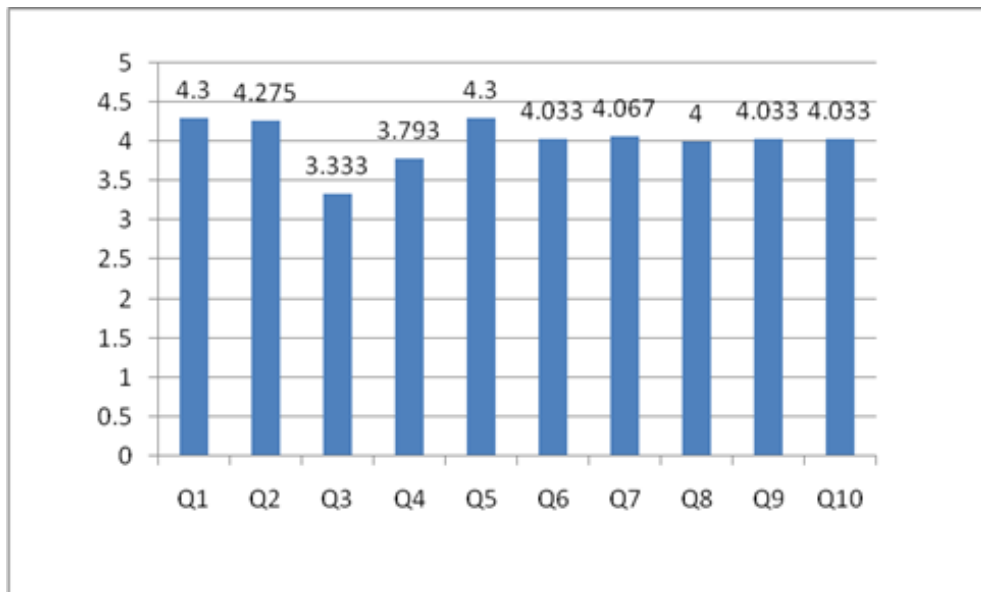
Figure 1.1. Mean scores for items in questionnaire

1.3.3 Significant Findings of Preliminary Study

The findings indicate that the overall mean score is leaning towards a positive perception. It is therefore safe to say that AR is a better medium to inform and educate visitors. This concludes that there is a huge potential in implementing AR technology at historical sites for information and education purpose. AR provides real-world scenarios and visualization of unseen phenomena and interaction between device and the real world which allows visitor to learn without feeling they are learning (enjoyable) (Liestøl, 2011; Chang, Hou, Pan, Sung, & Chang, 2015), and, at the same time, enable visitor to gain the new knowledge from augmented presentation (informal learning) (Dunleavy, Dede, &Mitchell, 2008; Klopfer& Squire, 2008; Liu, Tan, & Chu, 2009). Therefore, this study decides to combine enjoyable, informal learning and AR. In addition, the learning process would be more effective if AR is embedded on mobile phone. Since mobile phone is a personal device which may be effective for individualized learning (Elinich, 2011)

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and minimizes maintenance of Information and Communications Technology-related devices at cultural heritage site (Bakar, Kassim, & Mahmud, 2010).

The problem statement of the research is explained in the next section.

1.4 Problem Statement

Mobile AR for cultural heritage site has been developed for already a decade (Angelopoulou et al., 2011; Armanno, Bottino, & Martina, 2012; Chang et al., 2015; Ciurea, Zamfiroiu, & Grosu, 2014; "iTACITUS," 2007; Kim & Park, 2011; Seo et al., 2011; "Techcooltour," 2013; Vlahakis et al., 2001). However, these existing applications lack of enjoyable informal learning concept (Damala, 2009).

Enjoyable informal learning is based on interpretation theory (informal learning in cultural heritage) and enjoyment theory. Enjoyable informal learning enables visitor not to feel he/she is learning, but at the same time, he/she is achieving new knowledge (Ariffin, 2009). However, the existing mobile AR for cultural heritage site lack major components in enjoyable informal learning, namely, navigation and user interface, quality of content, use of questions, and physical orientation (Bellotti, Berta, Gloria, Margarone, 2002; Moscardo, 1996). This is critical as it can make the usage of mobile AR as interpretive media to help visitor to learn at cultural heritage site is far from being practical.

Interpretive media is media that assists visitor to obtain information at cultural heritage site (Timothy & Boyd, 2003). However, there is a lack criteria of features of

interpretive media in theory of informal education at cultural heritage (Light, 1995a) (refer to Chapter 2 Section 2.4.1). It does not provide clear criteria of presentation, specifically, presentation that is appropriate for visitor's understanding, presentation that is appropriate for informal learning environment, and presentation that contains appropriate element of entertainment. This lack is crucial as it intrudes the provision of informal learning at cultural heritage site.

Overall, the points are summarized as follows:

a. There is limited conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning

b. There are lacks of criteria of features of interpretive media in informal education theory

This study proposes a conceptual model that provides component for enjoyable informal learning at cultural heritage site. It helps developer to develop mobile AR that implements enjoyable informal learning at cultural heritage site that enable visitor to learn at cultural heritage site in enjoyable way.

1.5 Research Questions

Based on the problems discussed in the previous section, the following research questions have to be answered:

a. What are the components of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

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b. How to develop the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

c. How to validate the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

1.6 Research Aim and Objectives

In order to answer the research questions, the main objective has been formulated, which is, to propose a conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning that helps visitors learn at cultural heritage site in enjoyable way. The main objective is supported by sub-objectives, which are:

a. To determine the components of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

b. To develop the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

c. To validate the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

1.7 Research Scope

The focus of this study is to develop a conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning in these scopes:

a. Domain of mobile AR, enjoyment, and informal learning at cultural heritage site.

This study covers topics of mobile AR, enjoyment, and informal learning at cultural heritage site. All activities in the study are done within these scopes.

b. The prototype was developed for Melaka Heritage Site, Malaysia.

There is lack on study of mobile AR for cultural heritage site towards enjoyable informal learning in South East Asia. Most of the studies have been conducted in Europe (Etxeberria, Asensio, Vicent, & Cuenca, 2012), but less in Asia (Damala, 2009; Seo et al., 2011; Kim & Park, 2011), and very limited in South East Asia. Therefore, this study has selected Melaka Heritage Site as the case study. Melaka Heritage Site is one of the world heritage sites in South East Asia renowned by United Nations Educational, Scientific and Cultural Organization (UNESCO). It has stood out as multicultural trading port between East and South East Asia since 500 years ago. It blends the culture of Malay, Chinese, and India along with the three colonials (British, Portuguese, and Dutch) culture. This diverse culture is represented in the architectures, historical monuments, and cultural heritage sites along the city. In addition, the prototype is also developed based on these following aspects:

i. The content of prototype contains about Melaka Heritage Site.

ii. The target users are visitors with age ranging from 15-50 years old.

iii. It is a location based-AR application in mobile platform.

iv. The evaluation of the prototype focuses on enjoyable informal learning experience.

1.8 Contributions of the Study

This study contributes generally to the body of knowledge in the domain of AR technology and informal learning theory. It contributes to theoretical, practical, and functional contributions. The next subsection explains about theoretical contribution:

1.8.1 Theoretical Contribution

The followings are the results of study which contribute to the theory:

a. Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The main contribution of this study is the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. The conceptual model contains components which cater for enjoyable informal learning experience at cultural heritage site. It comprises two levels: the first level provides three structures of conceptual model and the second level provides component, element, and supporting element (refer to Chapter 4). The conceptual model is unique for its component which emphasizes enjoyable informal learning at cultural heritage site. It can be implemented for combination of three domains (mobile AR for cultural heritage site towards enjoyable informal learning) and also each domain (mobile AR, cultural heritage site, and enjoyable informal learning) individually.

b. Concept of enjoyable informal learning

Concept of enjoyable informal learning contains criteria for conducting enjoyable informal learning at cultural heritage site. This concept gathers theory of mindfulness

(Moscardo, 1996), design of enjoyable technology (Brandztæog, Følstad, & Heim, 2005), and definition of enjoyable (refer to Chapter 2 Section 2.7). The concept contributes to theoretical contribution for the researchers.

c. Review of Conceptual Model

Reviews of nine topics (conceptual model of mobile AR for cultural heritage, conceptual model of AR for cultural heritage, conceptual model of mobile tourism, conceptual model of mobile learning, design guideline of enjoyable informal learning, user requirement of mobile AR guide, categories of function of mobile AR guide, conceptual model of related mobile AR for cultural heritage, and conceptual model of mobile AR guide) were done to discover characteristics, limitations, and component of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. These reviews would help researcher to shape the background of knowledge in the area (as explained in Chapter 2).

d. Empirical Evidence on Enjoyable Informal Learning using Prototype

Evaluation of developed prototype was conducted based on enjoyable informal learning dimension. The evaluation result (Chapter 5 Section 5.4.5) shows that respondents agreed to experience enjoyable informal learning with overall mean score of 5.61 out of 7.00.This result and other significant result of evaluation can be used for future study and acts as literature background.

e. Criteria of Features of Interpretive Media

This study provides criteria of content for interpretive media (mobile AR) for informal learning at cultural heritage site. The criteria can be used by future researchers to improve the informal education theory developed by Light (1995a).

1.8.2 Practical Contribution

The followings are the results of study which act as practical contributions:

a. Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

Conceptual model is useful to develop mobile AR for cultural heritage site that is focus on enjoyable informal learning. It can be developed in any software of mobile AR development ranges from mobile AR offline tools and online platform, such as, Wikitude Software Development Kit (SDK), Vuforia, ARPA SDKs, Junaio, and Layar. Explanations about these tools are provided in the following:

i. Wikitude SDK supports 3D recognition tracking, online and offline image recognition, content augmentation (text, image, audio, video, 3D model, html), location-based services with geo-referenced data, visual search cloud recognition, and also native API for Android and iOS ("Wikitude," n.d.). Wikitude SDK is compatible with Unity3D, Apache Cordova, Xamarin, and Titanium.

ii. Vuforia enables combination of AR and VR, natural interaction with virtual buttons, and hands-free application that allows developer to view virtual content presented to real world ("Vuforia," 2015). It can be developed in Android and iOS. It is compatible with Eclipse (Java/C++), XCode (C++), and Unity3D. It also

supports Epson Moverio BT-200, ODG R-6 and currently Qualcomm snapdragon processors ODG-R7.

iii. ARPASDK supports 3D object interaction (selecting, rotating, and scaling), image multi detection and multi tracking (Social Compare, 2015). It is compatible with unity 3D and available in iOS and Android platform. ARPASDK is also provided both in free and commercial SDK option.

iv. Junaio Developer is AR browser developed by Metaio. It provides features of 3D models and animations, content augmentation (images and buttons, videos, sounds, and webpages), geo-located content, and simple user interface (Billinghurst, 2014). It allows developer to create channel that is location-based, GLUE channel (visual tracking), 2D tracking, and AREL channels (2D tracking and location based). It is free of charge for users, developers, and content providers.

v. Layar Creator is online platform of Layar for creating AR content. It provides easy to use drag and drop format, content augmentation (video, image, audio), social media interaction (Facebook, Twitter), result tracking and analysing (page views, unique users, users per country, page and button statistics) ("Layar," n.d.). Layar is available in iOS, Android, and Blackberry.

Those tools can be used to apply components and elements provided in the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

b. Instrument of Measuring Enjoyable Informal Learning at Cultural Heritage Site

The instrument to measure enjoyable informal learning was developed as an evaluation tool for the prototype in the dimension of informal and enjoyable learning. It is developed based on enjoyable informal learning concept (refer to Chapter 2 Section 2.7) and established instrument of measuring enjoyable web experiences in museum (Lin, Gregor, & Ewing, 2008). The instrument was proven to be reliable through reliability test and can be implemented by future researchers (refer to Appendix F).

1.8.3 Functional Contribution

The followings are the results of study which act as functional contribution:

a. Prototype of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The prototype of mobile AR for cultural heritage site towards enjoyable informal learning has been successfully developed based on the conceptual model. It contains historical and physical information about Melaka Heritage Site (AR@Melaka) that implements enjoyable informal learning. It has received awards and recognitions from various national and international exhibitions (refer to appendix A). Moreover, it also contributes to the practical contribution of the study that can be referred in Chapter 5.

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1.9 Theoretical and Research Framework

This study reviews theories related to mobile AR, enjoyable, AR learning, informal learning, and informal learning at cultural heritage site. The research methodology used in the study is design research methodology (Vaishnavi & Kuechler, 2008). This methodology comprises five phases; awareness of problem, suggestion, development, evaluation and conclusion. The first phase is awareness of problem where the preliminary study, literature review, content analysis and comparative study were conducted. It examined perceptions of visitor, related literature, related content and mobile projects (mobile AR for cultural heritage, mobile tourism, mobile learning, and mobile guide). The results of this phase are research problem, key issues of the study, and element of conceptual model of mobile AR for cultural heritage site. Then, the second phase is suggestion phase that is composed of literature review, extraction of concept of enjoyable informal learning, and comparative analysis. Literature review analyses the theory of learning, theory of enjoyable and theory of informal learning at cultural heritage site, guideline of enjoyable informal learning for cultural heritage and guideline in designing mobile AR guide for cultural heritage.

Then, extraction of concept of enjoyable informal learning transformed the factors of concept to the component of conceptual model. After the components have been determined, the process was continued by examining the elements of mobile AR for cultural heritage, mobile tourism guide, mobile learning, and mobile AR framework. Comparative analyses were done to determine the element of conceptual model. Mobile tourism guide and mobile learning were included to be analysed as they are

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related to the study, which are to the provision of tourist information and provision of learning process. These activities obtained concept of learning theories, concept of enjoyable informal learning, concept of informal learning at cultural heritage site, and component and element of conceptual model.

Then, all results were compiled and gathered in order to develop the conceptual model in the third phase. After the development phase, the conceptual model was ready. Next, the conceptual model was validated through expert review and focus group discussion. In the meantime, field study of enjoyable informal learning content and review of related conceptual model of mobile AR for cultural heritage and review of related mobile guide were conducted. Field study of enjoyable informal learning content was conducted after expert review to define novel component of conceptual model and review of related conceptual model of mobile AR for cultural heritage and review of related mobile guide were completed after the focus group discussion to add new component. All these steps produced the final version of conceptual model.

Then, based on the model, a prototype was developed to validate the conceptual model. The prototype was evaluated based on enjoyable informal learning experience. The result of evaluation was analysed and interpreted in the conclusion phase. The conclusion sums up all findings related to study. Then based on the findings, researcher wrote the publications for dissemination and communication of research outcomes. The illustration of research methodology of the study is exhibited in Figure 1.2.

1. AWARENESS OF PROBLEM

Preliminary Study

Visitors Perceptions on AR for Conservation at cultural heritage

Literature Study and Content Analysis

AR and Mobile AR Concepts and Theories

Informal Learning atCultural Heritage Site

Enjoyable Informal Learning Concepts and Theories

Review on Existing Models

Conceptual Model of Mobile AR for Cultural Heritage

Conceptual Model of AR for Cultural Heritage

2. PROPOSED SOLUTIONS

Research Problem & Key Issues

Literature Study

Theory of Learning

Theory of Enjoyment

Theory of Informal Learning at Cultural Heritage Site

Review on Existing Guidelines

Guideline of Enjoyable Informal Learning

Guideline of Designing Mobile AR Guide

Extraction of Concept for Enjoyable Informal Learning

Comparative Analysis

Mobile AR for Cultural Heritage

Mobile Tourism Guide

Mobile Learning

Mobile AR Framework

Obj 1

Component of conceptual model of MARCHSTEIL

3. DEVELOPMENT

Concept of AR learning theories

Enjoyable informal learning Concept

Concept of Informal Learning at cultural heritage

Develop Conceptual Model

First Version of Conceptual Model of MARCHSTEIL

Obj 2

4. EVALUATION

Obj 3

Expert Review

Development
Field Study of Enjoyable Informal Learning at Cultural Heritage Site

Focus Group Discussion

Development
Review of Conceptual Model of Related Mobile AR for Cultural Heritage and Review of Mobile Guide

Final Version of Conceptual Model of MARCHSTEIL

Prototype Development

Instrument Development

Evaluation based on enjoyable informal learning dimension

5. CONCLUSION

Report Writing and Research Publication

Analysis of Findings and Results

Figure 1.2. Research Methodology

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1.10 Operational Definition and Terminologies

The followings are operational definition and terminologies used throughout the thesis:

Augmented Reality

AR is a technology which (1) combines real and virtual, (2) is interactive in real time and (3) is registered in 3D (Azuma, 1997). Meanwhile, Vallino (1998) defines AR system as a system that superimposes 3D virtual object coexisting on a real world. Further, Milgram, Takemura, Utsumi, and Fumio (1994) define AR as a sub-field of mixed reality which adds virtual content to a predominantly real environment. This study refers to the first definition of AR besides other definitions.

Mobile Augmented Reality

AR that can be experienced through smart-phone or handheld devices (Craig, 2013). Details of definition of mobile AR are provided in Chapter 2 Section 2.1.

Cultural Heritage Site

Cultural heritage site is "a place, locality, natural landscape, settlement area, architectural complex, archaeological sites, or standing structures that are recognized and often legally protected as a place of historical and cultural significance" (International Council on Monuments and Sites [ICOMOS], 2008). However, this study defines cultural heritage site as architectural complex, archaeological sites, or ancient ruins that are recognized and often legally protected as a place of historical and cultural significance.

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Interpretive Media

Media that assists visitor to obtain information at cultural heritage site (Timothy & Boyd, 2003). This study defines interpretive media as media that helps visitor to learn at cultural heritage site, specifically, mobile augmented reality.

Enjoyable Informal Learning

Enjoyable informal learning is a process where visitor does not feel he/she is learning, but they are achieving knowledge at the same time (Ariffin, 2009). This study defines enjoyable informal learning as an experience where visitor feels pleased, satisfied, and does not know he/she is learning, but at the same time achieving some knowledge.

Enjoyable

According to Ariffin (2009), enjoyable is defined as not frustrating, enjoyable, and delighted. In addition, Oxford Thesaurus (Oxford Thesaurus, 2008), Roget's Super Thesaurus (Roget's Thesaurus, 2003), and Encarta Essential Thesaurus (Encarta Thesaurus, 2002) categorized enjoyable as word that has similar meaning with entertaining, amusing, delightful, pleasing, satisfying and agreeable. However, this study defined enjoyable as a feeling that is related to pleased and satisfied that is achieved while a person is using a product based on analysis on these two definitions provided in Chapter 2 Section 2.7.1.

Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The representation of components that comprises mobile AR technology, enjoyable informal learning, and cultural heritage site that helps developers to create mobile AR application for conducting enjoyable informal learning at cultural heritage site.

1.11 Thesis Structure

This thesis consists of six chapters. The followings are the content of each chapter:

Chapter 1: This chapter contains the introduction of thesis which is followed by research motivation, problem statement, research question, research objectives and research scope. Further on, this chapter also provides preliminary study, contributions of study, theoretical and research framework, and operational definition and terminologies.

Chapter 2: This chapter reviews literatures related to mobile AR, enjoyment and informal learning at cultural heritage site. There are fifteen conceptual models (seven conceptual models of mobile AR for cultural heritage, five conceptual models of AR for cultural heritage, and three related conceptual models of mobile AR for cultural heritage), seven guidelines (five guidelines of enjoyable informal learning for cultural heritage and two guidelines of designing mobile AR guide), nine projects (three projects of mobile tourism guide, three projects of mobile learning, three projects of mobile guide), and three frameworks of mobile AR are examined. In addition, theories related to AR learning, enjoyable informal learning, and informal learning at cultural heritage are also discussed.

Chapter 3: This chapter clarifies research methodology used throughout the study. It consists of five phases including activities and results. Furthermore, process of developing instrument, samples and unit of analysis of study are also explained.

Chapter 4: This chapter presents the main contribution of study which is a conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. It explains development process and validation phase of conceptual model. The development process includes comparative analysis and literature review. Validation phase consists of expert review and focus group discussion with field study of enjoyable informal learning at cultural heritage site and review of related conceptual model of mobile AR for cultural heritage and review of mobile guide execution before and after these two steps. The proposed conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning is exhibited at the end of this chapter.

Chapter 5: To validate the model, this chapter presents the prototype design and development based on conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. It describes three phases to develop prototype: pre-production, production and post-production. It also presents screenshots of prototype, the implementation of conceptual model in prototype, and result of evaluation of prototype.

Chapter 6: This chapter provides conclusion of the study. It answers research question and review the research objectives. Contribution, limitations and

recommendation of study are also presented. The end of this chapter provides the conclusion of the study.

1.12 Summary

This chapter focused on the main idea of the research, which comprises problem statement, research question, research objective, research scope, and contribution of study. It acts as the blueprint of the study. The problem statement as problem that will be tackled by the study, research objective as objective of the study, and research question as questions which guide the process of research. These three things are all of highly importance. Besides that, research scope and research contribution are also discussed to explain the scope of research and contribution of research.

The next chapter provides literature review of study.
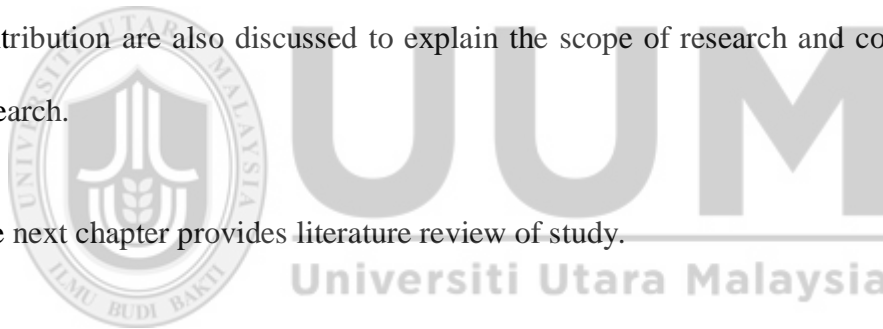
CHAPTER TWO
LITERATURE REVIEW

Introduction

This chapter examines the literatures related to mobile AR, informal learning at cultural heritage site, enjoyable informal learning, and learning theory. However, the main focus of this chapter relies on the review of the existing conceptual model of mobile AR for cultural heritage and guideline of enjoyable informal learning at cultural heritage. The review concludes that there is a need of designing conceptual model for mobile AR for supporting enjoyable informal learning at cultural heritage site.

2.1 Definition of Mobile AR

Mobile augmented reality system is defined by four criteria, which are, (a) incorporates real and virtual object in real world, (b) executes in real-time and mobile model, (c) adjusts real and virtual object, and (d) augments dynamic 3D objects (Papagiannakis et al., 2008). However, Höllerer and Feiner (2004) define mobile AR system as a system that is truly mobile where the system is away from conditioned environments that allows user to experience it anytime and anywhere, such as, in laboratories and special working site (Höllerer & Feiner, 2004). Other definition stated by Craig (2013) that mobile AR is the form of AR that is experienced through smart-phones or handheld devices. Lastly, Jaramillo, Quiroz, Cartagena, Vivares, and Branch Bedoya (2010) referred to mobile AR as an outdoor application that consists of wearable computers and special device for display which

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requires user to be mobile and system that utilizes handheld devices for visualization and interaction which is able to work or not able to work in structured environments (Jaramillo et al., 2010).

However, this study defines mobile AR as AR that is experienced through smart-phones or handheld devices as mentioned by Craig (2013). Further, this definition is also chosen because smart-phones or handheld devices are lightweight, smaller, flexible, available to large group of users, and normally carried everywhere.

The next section explains application requirements for mobile AR.

2.2 Application Requirement for Mobile AR

Mobile AR consists of five components, which are, computational platform, display, registration and tracking, wearable input and interaction technologies, wireless networking, and data storage and access (Höllerer & Feiner, 2004). Computational platform produces and controls the virtual object on real environment. The consideration of choosing platform includes computing power, mobility and robustness, graphic and multimedia capability, memory space, operating system, power supply, interface port and expansion availability, improvement of component, technical support, software development, and price (Jaramillo et al., 2010). Next, is the display. Display shows the visualization in the real world in three types: see-through Head-mounted Display (HMD), projection-based display, and hand-held display (Duh & Billinghurst, 2008; Höllerer & Feiner, 2004). Next, registration needs to align the virtual object with physical object in the real environment (Azuma,

1997). It can be done through tracking the position and orientation of head of user (Höllerer & Feiner, 2004). Then, tracking is supported by inertial, magnetic, ultrasonic or optical sensor for executing the process (Jaramillo et al., 2010). It varies from sensor-based tracking, vision-based tracking and hybrid-based tracking. Next, wearable input and interaction technologies are also used to allow user to select, access, visualize content that augments their surroundings, and also collaborate and communicate with others. Lastly, data storage and access technology provides information about current context to the user. Components of mobile AR are listed in Table 2.1.

Table 2.1

Components of Mobile AR

Components	Description
Computational Platform	Produces and controls the virtual object on physical environment. This component considers the aspect of computing power, mobility and robustness, graphic and multimedia capability, memory space, operating system, power supply, interface port and expansion availability, improvement of component, technical support, software development, and price.
Display	Presents virtual object in physical world. Display can be in the form of see-through HMD-s, projection-based display, and hand-held display.
Registration and Tracking	Aligns virtual object with physical object in the real environment. Registration is supported by tracking the position and orientation of user's view. Tracking needs inertial, magnetic, ultrasonic or optical sensor. It varies into three types: sensor-based tracking, vision-based tracking and hybrid-based tracking.
Wearable input and interaction technologies	Enable user to select, access, and visualize content. It also augments their surroundings. The interaction technologies allow user to communicate and collaborate with other user.
Data storage and access technology	Provides information about current context.

Source: (Duh & Billinghurst, 2008; Höllerer & Feiner, 2004; Jaramillo et al., 2010)

The following section examines definition of conceptual model followed by review of existing mobile AR for cultural heritage and AR for cultural heritage.

2.3 Conceptual Model of Mobile AR for Cultural Heritage Site and Conceptual Model of AR for Cultural Heritage Site

Conceptual model represents the key concepts or related concepts of subject (Churchill, 2007). It provides accurate, consistent, and complete representation of concepts (Norman, 2014). Therefore, this study analyses components, concept, and features of conceptual model of mobile AR for cultural heritage and conceptual model of AR for cultural heritage to determine the component of proposed conceptual model. The next section provides review of conceptual models of mobile AR for cultural heritage.

2.3.1 Conceptual Model of Mobile AR for Cultural Heritage Site

This study reviewed conceptual model of mobile AR for cultural heritage site from Google Scholar in the range of year 2000 until 2015 from various countries which used handheld devices (smart-phone, tablet or PDA) as display and conducted at museum and cultural heritage site. Google scholar is chosen as it provides precise cultural heritage site which used mobile AR and the reason why museum is included in the review is because it implements similar application to heritage site. The next subsection presents analysis of conceptual model of ARCHEOGUIDE. Furthermore, summary of all conceptual models is provided at the end of the subsection.

2.3.1.1 Personalized System Architecture of Augmented Reality-based Cultural Heritage On-site GUIDE(ARCHEOGUIDE)

ARCHEOGUIDE provides personalized tour guide, monument reconstruction, ancient life simulation, content creation, and content collection at Olympia Site,

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Greece (Vlahakis, Ioannidis, Karigiannis, Tsotros, & Gounaris, 2002). These features are represented through text, image, panoramic view, audio, video, 3D model, 3D character, and 360˚ panorama view. ARCHEOGUIDE's system architecture consists of three main components, which are, site information centre (SIS), mobile unit and communication infrastructure (refer to Figure 2.1).
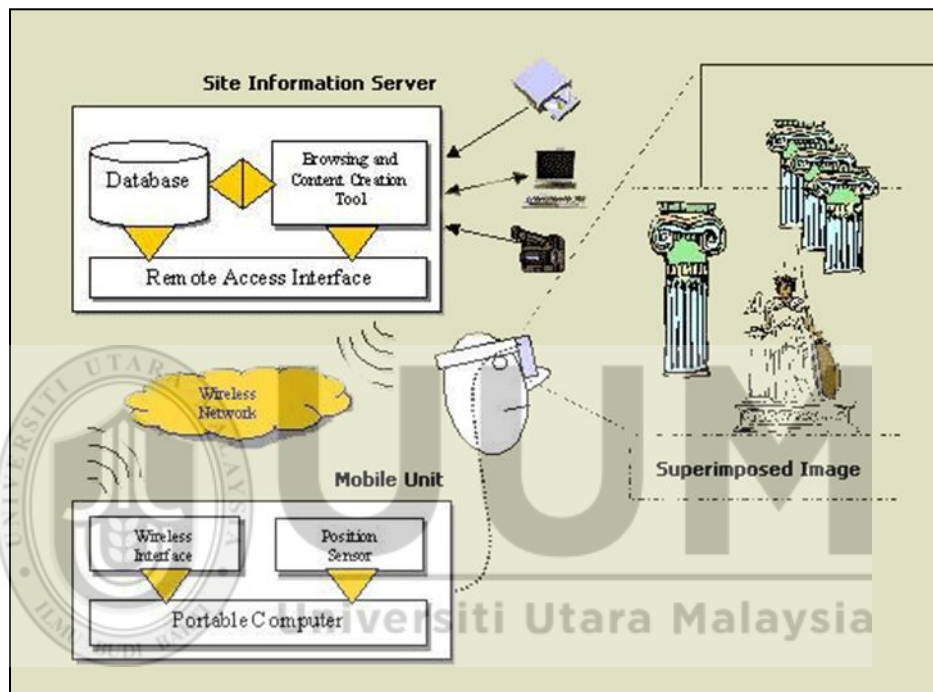
Figure 2.1. System Architecture of ARCHEOGUIDE
Source: (http://netzspannung.org/)

In addition ARCHEOGUIDE also provides various useful features, such as, physical orientation that shows visitor's current position and direction he/she is heading for, language support, personalization feature (description, interest, available time for visit, detail and level of information and language preferences) (refer to Figure 2.2).

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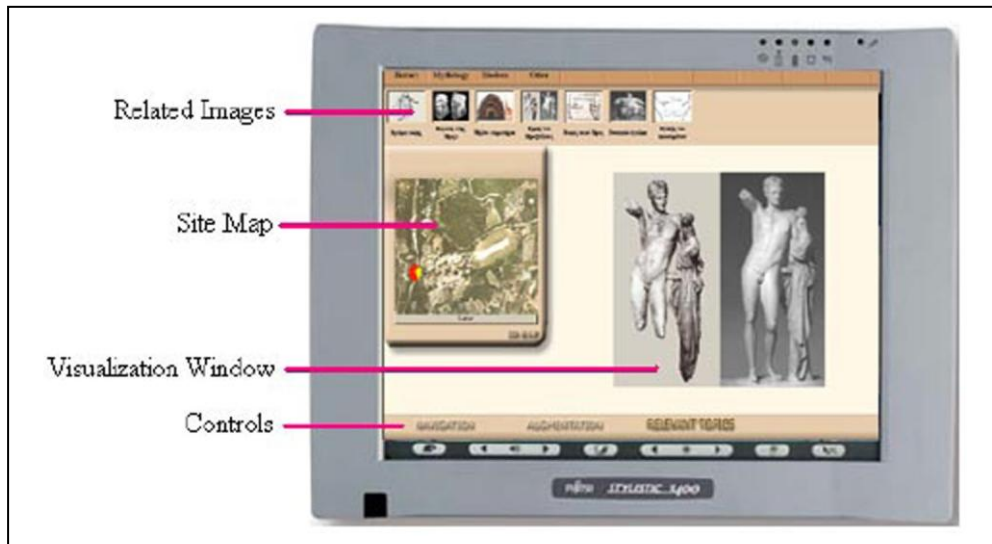
Figure 2.2. Screenshot of ARCHEOGUIDE
Source: (Vlahakis et al., 2001)

Although ARCHEOGUIDE provides good and complete content and features, it lacks enjoyable informal learning concept. It does not implement theory of interpretation and enjoyment. The components provided are presented without considering any interpretation theory or guideline of enjoyable informal learning. However, the components provided are taken into account in designing the proposed conceptual model.

2.3.1.2 Intelligent Tourism and Cultural Information through Ubiquitous Service (iTACITUS)

iTACITUS offers visitors to have meaningful experience at Winchester Castle, UK ("iTACITUS," 2007). It uses techniques of superimposed environment, annotated landscape and spatial acoustic overlays to present the AR information. Itsuperimposes 3D object and 3D character on missing statue, annotates multimedia elements (text, image, and video) on site, and overlays spatial audio clips in surrounding (refer to Figure 2.3). Furthermore, it also supports physical interaction

(direct interaction) and motion determination (indirect interaction); touch shoulder of virtual guide to start conversation; rub or shake dirt of artefact to view information; drag and drop 3D object to open the door; shake head to disapprove question of virtual guide; nod to approve question of virtual guide; lean the device to left or right to determine 3D object's direction; rotate the device to left or right to turn or roll up 3D object. In addition, it provides interactive itinerary planning tool that makes visitor easier to manage the trip based on their preferences. These preferences are also applied to the information that visitor would like to see and know more at the cultural heritage site. The information is chosen based on interest, location and history of visitor. It helps the visitor a lot to figure out the information they want to know detail about a certaat cultural heritage site.

iTACITUS is considered as one of the best mobile AR for cultural heritage site with the technique for content presentation, variety of interaction (physical interaction and motion determination), interactive itinerary planning tool feature and personalization feature. However, iTACITUS does not provide empirical evidence of enjoyable informal learning. It does not apply interpretation and enjoyment theory. All components are presented without any guideline in enjoyable informal learning. It also lacks criteria of content, navigation and user interface design, use of questions, and physical orientation. Yet, the provided content and features are taken into account in constructing the proposed conceptual model.

Figure 2.3. Screenshots of iTACITUS
Source: (http://itacitus.org)

2.3.1.3 Mobile Augmented Reality Tour (MART)

MART presents different features than other project. It provides semi-automatic recognition and multiple sensor context-awareness; in-situ authoring; commenting authoring; and content sharing at National Palace Museum of Korea (Kim & Park, 2011) (refer to Figure 2.4).

Semi-automatic recognition is a feature that enables visitors to search appropriate context that is not provided due to sensor's limitation, whereas, multiple sensors context-awareness facilitates visitors to create context ontology in order to determine more accurate contexts by using multiple sensors. These features make MART unique as they are not provided in other mobile AR for cultural heritage reviewed in this study. In terms of content, MART provides 3D model and 3D character to visitor. However, despite distinctive features, MART lacks empirical evidence in the context of enjoyable informal learning. It does not implement enjoyment and interpretation theory as guideline for the components.
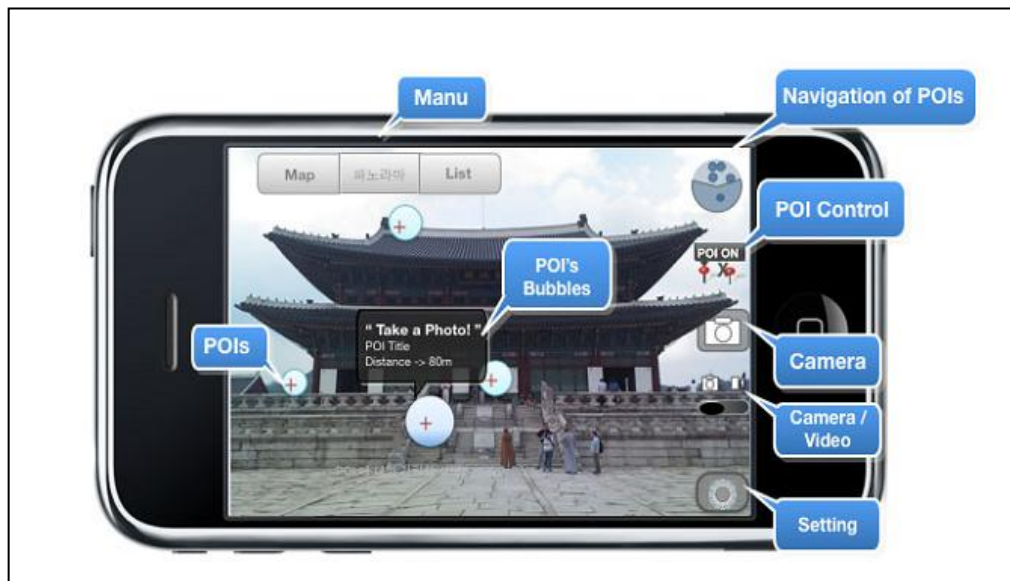
Figure 2.4. Screenshot of MART
Source:(Kim & Park, 2011)

2.3.1.4 AR Content Management of SkyLineDroid

SkyLineDroid focuses on immersing visitor in virtual reconstruction at cultural

heritage site in Las Vegas (Armanno et al., 2012). It has two main components: AR

content management and client-server architecture (refer to Figure 2.5).
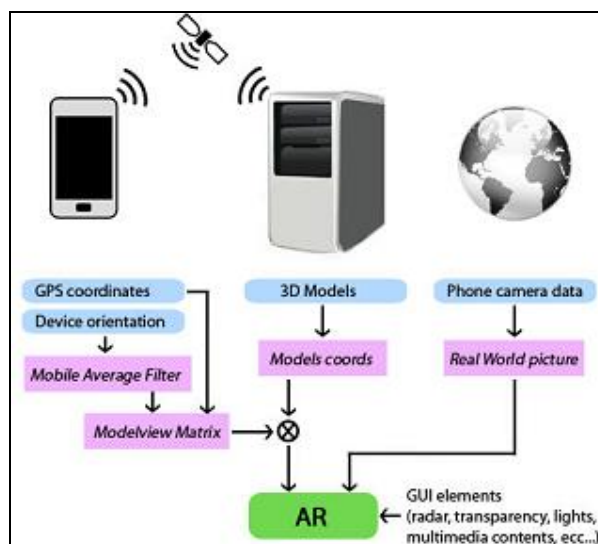
Figure 2.5. AR Content Management of SkyLineDroid
Source: (Armanno et al., 2012)

These components provide 3D reconstruction of cultural heritage in different periods of time and operate various features, namely, change of level of transparency of rendered objects, visibility region, multimedia content inquiry, and navigation (refer to Figure 2.6). Besides, SkyLineDroid also offers flexibility which allows developers to create their own application if the content is changed. All these dynamic features make SkyLineDroid considered in designing the proposed conceptual model despite the fact that it lacks empirical evidence of enjoyable informal learning where there is no enjoyable and interpretation theory applied.

Figure 2.6. Screenshot of SkyLineDroid
Source: (Armanno et al., 2012)

2.3.1.5 Framework and data flow of AR-based on-site Tour Guide

AR-based on-site tour guide reproduces past life that occurred at Gyeongbokgung Palace through simulation of human (Seo et al., 2011). It consists of four components: context-awareness, augmentation, input agent and output agent (refer to Figure 2.7).
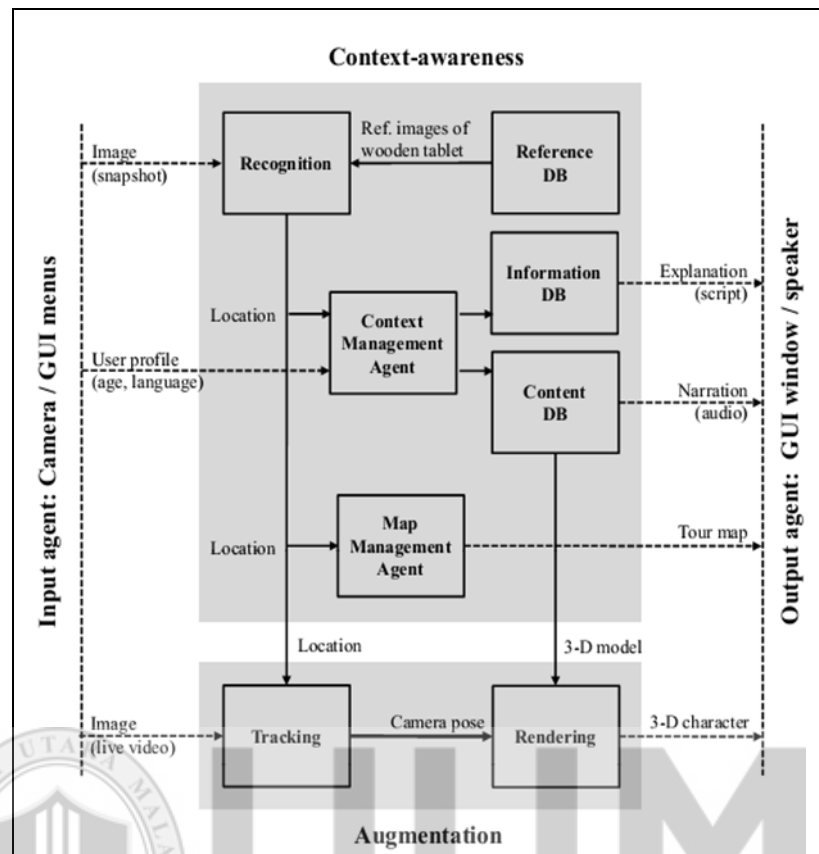
Figure 2.7. Framework and Data Flow of AR based-on-site Tour Guide
Source: (Seo et al., 2011)

This project stresses on 3D visualization of noble people who narrate history about Gyeongbokgung to visitors besides incorporating media of text, image, audio, and video (refer to Figure 2.8). Unfortunately, these contents do not present the enjoyable informal learning evidence as the components were developed without considering enjoyable and interpretation theory. They are provided without any guideline of enjoyable informal learning. Even so, the provided content (3D character) and features (context awareness of location and profile (age and language)) were considered in creating the proposed conceptual model.

Figure 2.8. Screenshot of AR-based on-site Tour Guide
Source: (Seo et al., 2011)

2.3.1.6 System Architecture of Sutton-Hoo Mobile Augmented Reality

    (SHMAR)

SHMAR is an AR education game provided at Sutoon Hoo archaeological site, United Kingdom (Angelopoulou et al., 2012). It provides puzzles and quizzes about object of site that purposes to assist visitors' understanding about the site and exhibition area. SHMAR's architecture system is divided into two components: initialization and object categorization (refer to Figure 2.9).

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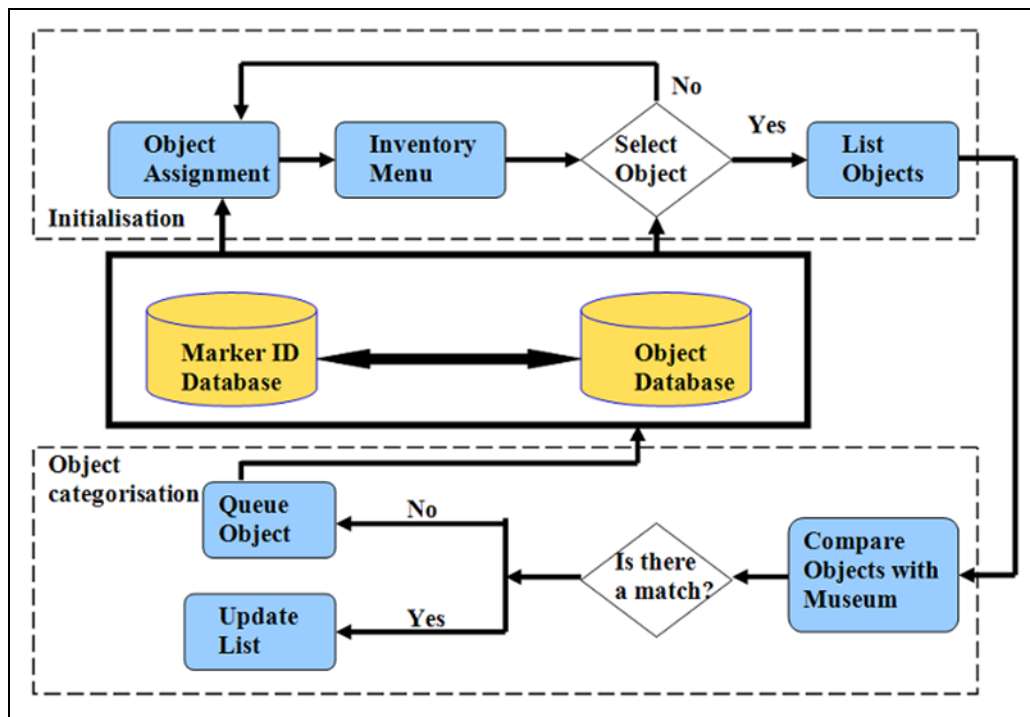
Figure 2.9. System Architecture of SHMAR
Source: (Angelopoulou et al., 2012)

The system contains flow of visualization of system. It includes object, inventory menu, and database. Nevertheless, not any of these components present enjoyable informal learning evidence. It does not apply enjoyable and interpretation theory. They were embedded to the system without any guideline of enjoyable informal learning. However, features of SHMAR which connect archaeological site and museum and support cross-place information sharing are noted for later analysis in developing the proposed conceptual model.

2.3.1.7 Techcooltour

Techcooltour is a cross-media platform for promoting Roman and Byzantine tourism ("Techcooltour," 2013). It combines website, mobile, and print media to increase visitors' interest to come to cultural heritage. The application is started when visitors open the map and view it using Techcooltour Mobile Application. The artifact of site

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will pop up and visitors can click on it, then the artifact links them to interactive Techcooltour Website.

Techcooltour provides a variety of media: 3D model, 3D character, video, and 360 degree panorama and print media (refer to Figure 2.10). All these media can be saved and shared to social media by visitors. However, Techcooltour does not have the empirical evidence of enjoyable informal learning. It does not implement any enjoyable and interpretation theory.The components presented without basis of guideline of enjoyable informal learning. Nonetheless, the concept and content were examined in constructing the proposed conceptual model.
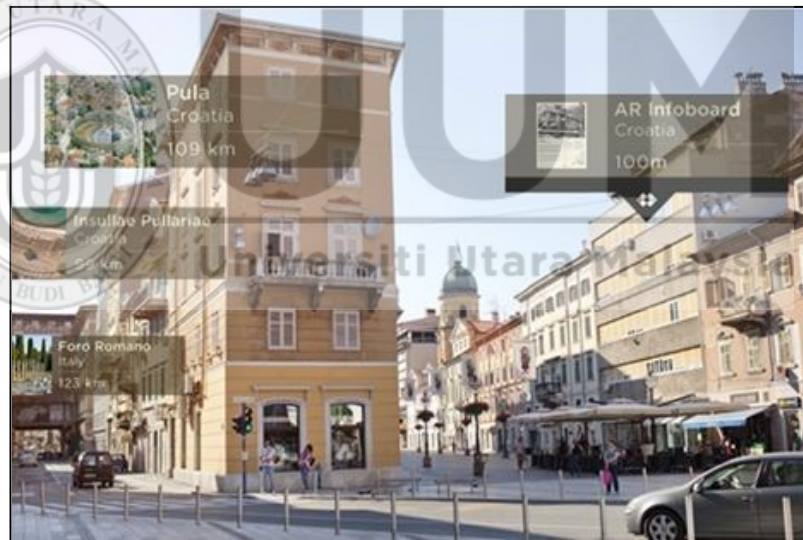
Figure 2.10. Screenshot of Techcooltour
Source: (http://digitalheritage2013/techcooltour)

2.3.1.8 Design Guideline for Mobile AR Systems for Heritage Interpretation and Visitor Guiding at Historic Sites

Design guideline for mobile AR system for heritage interpretation and visitor guiding at historic sites was proposed by Mohammed-Amin, Levy, and Boyd (2012). It consists of four requirements: technology, user interface, interactivity, and

connectivity between real and virtual world (refer to Table 2.2). It presents useful guideline for developing mobile AR application specifically for exploring cultural heritage site. The guideline is implemented in a prototype named Arbel Layers Uncovered (ALU). It provides virtual reconstruction for ancient site named Arbela that is located in Iraq (Figure 2.11). However, it lacks criteria of augmented virtual content heritage interpretation and features for enjoyable informal learning (use of questions, personalization, and physical orientation) that is necessary for heritage interpretation.

Table 2.2

Design Guideline for Mobile AR Systems for Heritage Interpretation and Visitor Guiding at Historic Sites

Technology	Lightweight devices
	Reliable OS
AR User interface:	
• **Augmented Virtual Content**	Augmented virtual contents
	Variety
	Visual cues
	Video usage
	Audiovisual usage
	3D model augmentation
• **User Interface Design**	Layering information
	Appropriate size
	Legibility
	Easy navigation and accessibility
Interactivity	Flexibility
	Interaction
	Exploration
	Spatial AR
Connection between Real and Virtual World	Geo-tagging ability
	Getting Updates
	Translation ability
	Working off-line
	Visual search

Source: (Mohammed-Amin et al., 2012)

Figure 2.11. Screenshot of ALU
Source: (Mohammed-Amin et al., 2012)

2.3.1.9 Mobile AR Museum Guide

Mobile AR museum guide was implemented for Museum of Fine Arts in Rennes, France. It provides thematic visit related to detail of painting, detail of artist, iconography of costumes and dressing, technique of creation, context of situation which are represented through text, audio, video, still images, slideshows and animation slideshows (Damala, Cubaud, Bationo, Houlier, & Marchal, 2008) (refer to Figure 2.12). This prototype has been evaluated to 12 participants in the range of age from 18 to 22 years old. The result reveals that personalization feature is required to present the right content for different profile of visitors. Personalization is a feature that enables visitors to do modification, construction, and adjustment to the system (Damala, Marchal, & Houlier, 2007). This is a good suggestion for developing mobile AR for cultural heritage in the future. In overall, components and features are useful for designing the conceptual model despite the fact that it lacks

empirical evidence on enjoyable informal learning as it does not apply theory of interpretation and enjoyment.

Figure 2.12. Screenshot of Mobile AR Museum Guide
Source: (Damala et al., 2008)

2.3.1.10 History Unwired

History Unwired provides tour to neighbourhood of Castello, a less travelled but culturally rich area in Venice, Italy. It involves five local famous characters as virtual guide, combines multimedia content (audio, video, and interactive map) and treasure hunt games, and narrative communication approach of storytelling (Epstein & Vergani, 2006) (refer to Figure 2.13).This project provides quality content of media which emphasizes sensitivity of elements of environments rather than technology which enables immersive feel in the environment. In addition, this project facilitates visitors to talk and interact with real character who acts as virtual guide that makes the visit more real and personal. In a nutshell, the content and features of History Unwired are considered helpful in developing the conceptual model besides its lack

of empirical evidence of enjoyable informal learning since it does not implement any theory of enjoyment and interpretation.

Figure 2.13. Screenshot of History Unwired
Source: (Epstein & Vergani, 2006)

2.3.1.11 Theoretical framework for AR-guidance System

Theoretical framework for AR-guidance system was proposed by Chang et al., (2015) to provide heritage guidance and educational activities that enhance sense of place (SOP). The framework was designed based on three constructs; place of attachment (PA), place dependence (PD), and place identity (PI) which are included in sense of place (SOP) (refer to Table 2.3). The system was evaluated to 87 respondents of three different groups, AR guidance, audio-guidance, and no-guidance in Tamsui District, Taiwan. It proved that respondents who used AR has learned about cultural heritage site and sense of place effects in significant way compare to respondents in other groups. This framework contributes major work to the study as it relates to interpretation and guiding. However, the framework does not provide criteria specific for AR content (3D model and 3D character) also other

features (navigation and user interface design, interactivity, and personalization) that affect enjoyment of learning at cultural heritage site. In spite of that, this framework is taken into consideration in developing the proposed conceptual model.

Table 2.3

Theoretical Framework for AR-guidance System

	Constructs	Nature of Content	Formation Factors	Interpretive Principles	Presentation Media and Styles
SOP (Senseof Place)	PA (Place Attachment)	Affective	Place affection	Ensure the association between visitors' personal characteristics and heritage also create affective bond between visitors and heritage site	Movie, images, and songs related to past living experience at cultural heritage site
			Place interest	Increase visitor's interest and allow visitor to experience joy of understanding a place	Image, audio, text that interact with physical environment
	PD (Place Dependence)	Conative Behavior	Place uniqueness	Demonstrate the uniqueness of cultural heritage site	Image, audio, and text related to natural, cultural, and unique atmosphere of cultural heritage site and landscape during respective colonial periods
			Encourage active exploration	Encourage visitor to explore and create meaning and significance actively	Text, audio, and image related to characteristics of cultural heritage site thereby create a bond with

Table 2.3 continued

PI (Place Identity)	Cognitive	Historical and geographical implication	Represent historical and geographical information and reveal the fundamental significance to enhance the connection between historical and geographical evolution and cultural heritage site	Text, audio, and image illustrates geographical and environmental shifts and historical context of cultural heritage site
				visitor
		Inspire PI	Encourage visitor to perceive self-worth and understand relationship of cultural heritage site to a place or setting and inspiring PI	Text, audio, and image are combined with the cultural heritage site to show the geographical and environmental shifts and historical background

2.3.1.12 Smart Exhibition

Smart Exhibition provides virtual exhibitions of coin collections in Roman Academic Library by (Ciurea et al., 2014). It was purposed to provide mobile virtual exhibition that increase national cultural heritage visibility. It consists of four features, which are, view collection by category, save objects as favorites and view them later, AR feature, and QR codes (refer to Figure 2.14). AR feature enable visitor to scan coins with mobile phone and view various augmented content, which are, video, audio, images, 3D models, and 3D animations. However, same with other reviewed applications; it does not provide specific criteria for augmented content which enable enjoyable informal learning. It does not implement theory of enjoyment and

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interpretation. The content presented without any basis of guideline of enjoyable

informal learning.

Figure 2.14. Screenshot of Smart Exhibition
Source: (Ciurea et al., 2014)

All models were examined and analysed in terms of characteristic and limitation.

Summary of these points is provided in Table 2.4.

Table 2.4

Review of Conceptual Model of Mobile AR for Cultural Heritage Site

Conceptual Model	Salient Features	Aims/Objective	Limitation
Personalized System Architecture of ARCHEOGUIDE (Vlahakis et al., 2001)	• It presents text, image, panoramic view, audio, video, 3D model and 3D character. • It provides five main features, personalized tour guide, monument reconstruction, ancient life simulation, content creation, and content collection.	• To connect education, recreation, and research at cultural heritage site.	• Despite its purpose for education, it lacks empirical evidence on enjoyable informal learning.
iTACITUS ("iTACITUS," 2007)	• It delivers content through annotated landscape, superimposed environment, and spatial acoustic overlays. • It presents 3D object, 3D character, text, old picture, sound, audio, and video. • It provides interactive itinerary planning tool. • It supports intuitive physical interaction and motion determination: touching, moving, rubbing, shaking, drag and drop, nodding, leaning, and rotating.	• To provide meaningful experience for visitor	• It does not provide empirical evidence of enjoyable informal learning.
MART (Kim & Park, 2011)	• It supports context-awareness, in-situ authoring and comment authoring. • It uses semi-automatic recognition and multiple sensor context-awareness. • It presents text, 3D model, and 3D character.	• To provide visitor a richer experience	• It does not present empirical evidence of enjoyable informal learning.
AR Content Management of SkyLineDroid (Armanno et al., 2012)	• It focuses on immersing visitor in virtual reconstruction at cultural heritage. • It consists of AR content management and client-server architecture. • The content is presented based on historical period of time. • It provides four features: change of level of transparency of rendered objects, visibility region, multimedia content inquiry, and navigation.	• To immerse visitor in virtual reconstruction at cultural heritage	• It has limitation on empirical evidence of enjoyable informal learning.

Table 2.4 continued

	• It presents 3D model, text, images, audio, and video. • It offers flexibility which can be easily adapted to other site simply by changing the content.		
Framework and data flow of AR-based on-site Tour Guide (Seo et al., 2011)	• It revives past life by simulating the human • The framework consists of four components. • It supports contextual information of visitor: location, age and language. • It displays tour map with visitor's location, AR service zones, and tour paths. • It emphasizes 3D visualization of noble people to narrate history about the site. • It presents text, image, audio, video, and 3D character.	• To reproduce past life occurred at Gyeongbokgung Palace through simulation of human	• The represented content and features lack empirical evidence of enjoyable informal learning.
Architecture System of SHMAR (Angelopoulou et al., 2012)	• It presents AR education games. • It purposes to assist visitor's understanding about the site and exhibition area. • The system consists of two components. • The system explains the flow of visualisation. • The system links the site (outdoor) and museum (indoor). • The project presents games in the form of puzzles and quizzes. • The project also supports cross-places information sharing.	• To assist visitor's understanding about the site and exhibition area	• Although it aims to help visitor to understand about cultural heritage site but it does not provide empirical evidence of enjoyable informal learning.
TechCoolTour "Techcooltour," 2013)	• It is presented in prototype. • It is developed for promoting Roman and Byzantine tourism. • It combines website, mobile and print. • It presents 3D character, 3D model, video, and 360 degree panorama. • It allows information sharing.	• To promote Roman and Byzantine tourism	• The provided elements do not represent the empirical evidence of enjoyable informal learning.

Table 2.4 continued

Design Guideline for Mobile AR Systems for Heritage Interpretation and Visitor Guiding at Historic Sites (Mohammed-Amin et al., 2012)	• It comprises five requirements, such, technology, content, user interface design, interactivity and features. • It is implemented for interpretation and visitor guidance at historic sites.	• To present useful guideline for developing mobile AR application specifically for exploring cultural heritage site	• Although this model caters interpretation aspect, it does not provide empirical evidence of enjoyable informal learning.
Mobile AR Museum Guide (Damala et al., 2008)	• It is presented in prototype. • It provides five themes: description, technique, iconography, context, and artist • It is purposed for guiding in museum. • It presents text, audio, image, slideshow and animation.	• To guide visitor in the museum	• It does not contain empirical evidence of enjoyable informal learning.
History Unwired (Epstein & Vergani, 2006)	• It presents five local famous characters act as virtual guide. • It combines multimedia presentation (audio, video, and interactive map) and treasure hunt. • It uses narrative approach for communicating the story. • It provides quality content of media that emphasize more on sensitivity of the elements of environments than technology that allows immersive feel in environment. • It provides break that allow visitor to pause the tour for experiencing interactive art event, talking with characters who acts as virtual guide, or enter local establishment that makes the visit more real and personal. • It provides not more than three clicks for navigating the menu. • It provides buttons that are operable with adult finger.	• To provide tour to neighbourhood of Castello, Italy	• It lacks empirical evidence of enjoyable informal learning.

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Table 2.4 continued

Theoretical Framework of AR-guidance System (Chang et al., 2015)	• Designed based on three constructs that are included in sense of place (SOP): place of attachment (PA), place dependence (PD), and place identity (PI). • Combines interpretation and guiding theory.	• To provide heritage guidance and educational activities that enhance sense of place (SOP)	• Lack of empirical evidence of enjoyable informal learning • Lack of specific criteria for AR content also other features that affect enjoyment of learning at cultural heritage site
Smart Exhibition (Ciurea, et al., 2014)	• Provide virtual exhibition of coin collection in Roman Academic Library. • Consists of four features, which are view collection by category, save objects as favourites and view them later, AR feature, and QR codes. • AR feature enable visitor to scan coins with mobile phone and view various types of augmented content, which are, video, audio, images, 3D models, and 3D animations. • System architecture provides three components: web content management platform, web platform for content presentation, and mobile application for accessing virtual exhibition.	• To provide mobile virtual exhibition that increase national cultural heritage visibility	• Lack of enjoyable informal learning concept

The analysis in Table 2.4 shows that the existing conceptual models have diverse aims, content, features and technique. This is because they were developed based on different purposes, which are, to improve situation of cultural heritage; to enhance visitors experience; to reproduce ancient life at cultural heritage. These aims are the foundation to build mobile AR project by incorporating related media representation, technique, technology, navigation and user interface design, content, interactivity and feature.

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Nevertheless, among all conceptual models there are limited models that provide empirical evidence of enjoyable informal learning. This limitation becomes the gap that will be overcome by this study. The following subsection examines conceptual model of AR for cultural heritage.

2.3.2 Conceptual Model of AR for Cultural Heritage Site

There are five conceptual models of AR for cultural heritage site which were reviewed in the year 2002 until 2006, which are: GEIST (Braun, 2003; Kretschmer et al., 2001), Mobile System Architecture and Content Database of LIFEPLUS (Papagiannakis et al., 2002), System Configuration of Immersive Tour Post **(Park, Nam, & Shi, 2006),** System of PRISMA (Fritz, Susperregui, & Linaza, 2005), and White System of ARCO (White et al., 2004). The next subsection describes GEIST project while the summary of review is provided at the end of the subsection.

2.3.2.1 GEIST

GEIST (English: ghost) refers to the ghost or spirit of history. This project provides unique experience for exploring cultural heritage site through interactive AR storytelling (Kretschmer et al., 2001) that tells about thirty year war happened in Heiderlberg, Germany. It presents cultural and social life, politic and clerical change data, 3D reconstruction, character and clothes (Braun, 2003) (refer to Figure 2.15). In this project, visitors can interact with virtual ghosts and take role in the story. It is a feature that is not implemented in many projects, which makes GEIST unique. However, the project lacks empirical evidence of enjoyable informal learning. It does not provide any theory of enjoyment and interpretation. The components presented

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without any basis of guideline of enjoyable informal learning. In spite of that, concept and features (interaction and visitor's take part in the story) are considered in developing the proposed conceptual model.

Figure 2.15. A visitor is using GEIST to watch a ghost (Katarina) in real world
Source: (Braun, 2003)

2.3.2.2 Mobile System Architecture & Content Database of LIFEPLUS

LIFEPLUS reproduces the ancient frescos paintings by simulations of human, flora and fauna at Pompeii, Italy. Proposed by Papagiannakis et al., (2002), the system consists of two components, mobile system architecture (track run time engine) and content database (visual run time engine) (refer to Figure 2.16). It also supports a variety of content and features, namely, narrative simulation, multiple language, personalized tour (profile, availability for visit, and reactions), and multimodal interaction (refer to Figure 2.17). However, the system also lacks enjoyable informal learning as it does not apply enjoyable and interpretation theory. The content and features presented without any guideline of enjoyable informal learning. Therefore, this project suggested development of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning (Papagiannakis et al., 2002).
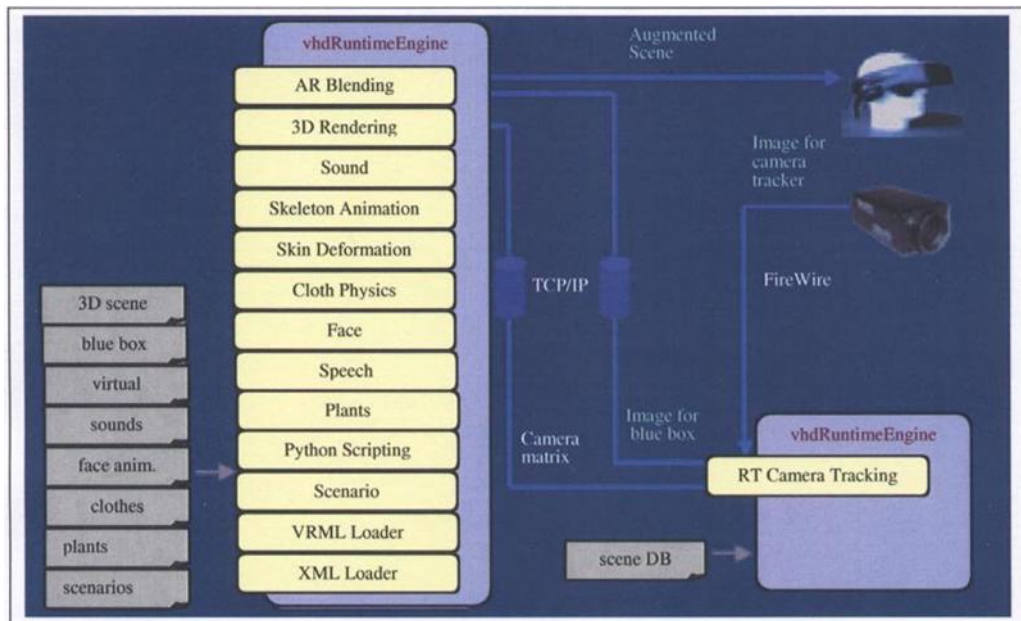
Figure 2.16. Mobile System Architecture & Content Database of LIFEPLUS
Source: (Papagiannakis et al., 2002)

Figure 2.17. Screenshot of LIFEPLUS
Source: Vlahakis, Demiris, &Ioaniddis (2004)

2.3.2.3 System of Augmented Reality for Cultural Object (ARCO)

ARCO provides alternative for creating, managing, and presenting virtual exhibition (White et al., 2004). The system has three main components; content production, content management and content visualization (refer to Figure 2.18). It produces a variety of multimedia elements, for instance, 3D model, text, image, audio and video. It also has two unique features, which are 3D model that can be manipulated from different angles and distances and AR interactive quiz (refer to Figure 2.19).
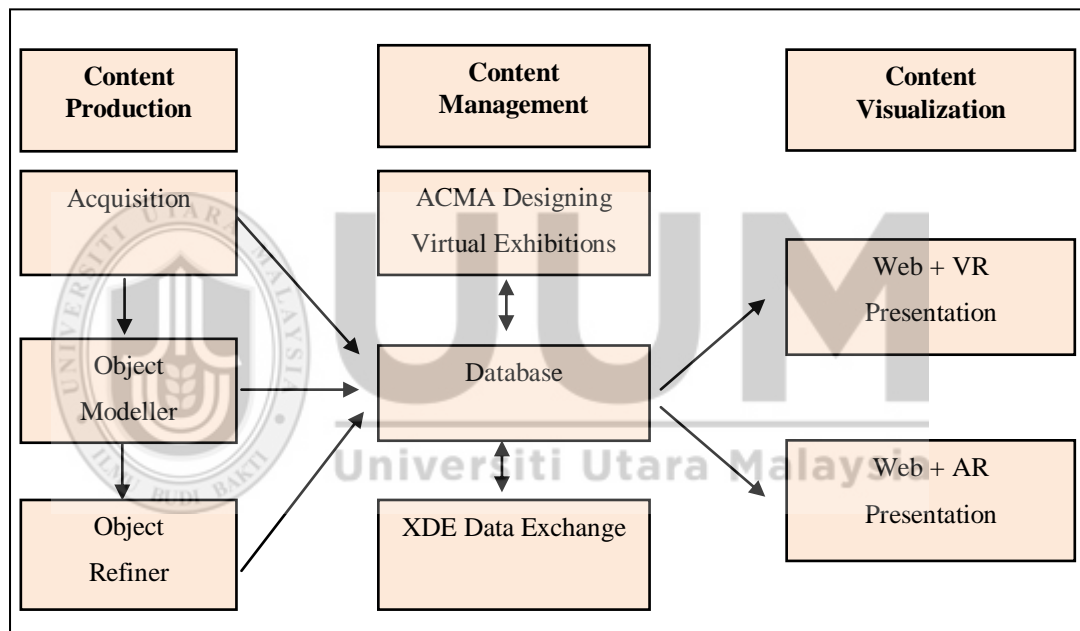
Figure 2.18. System of ARCO
Source: (White et al., 2004)

The main limitation of this model is the absence of empirical evidence on enjoyable informal learning. It does not implement any theory of interpretation and enjoyment. The component presented without any guideline of enjoyable informal learning. Nevertheless, components and features have been taken into consideration in developing the proposed conceptual model.
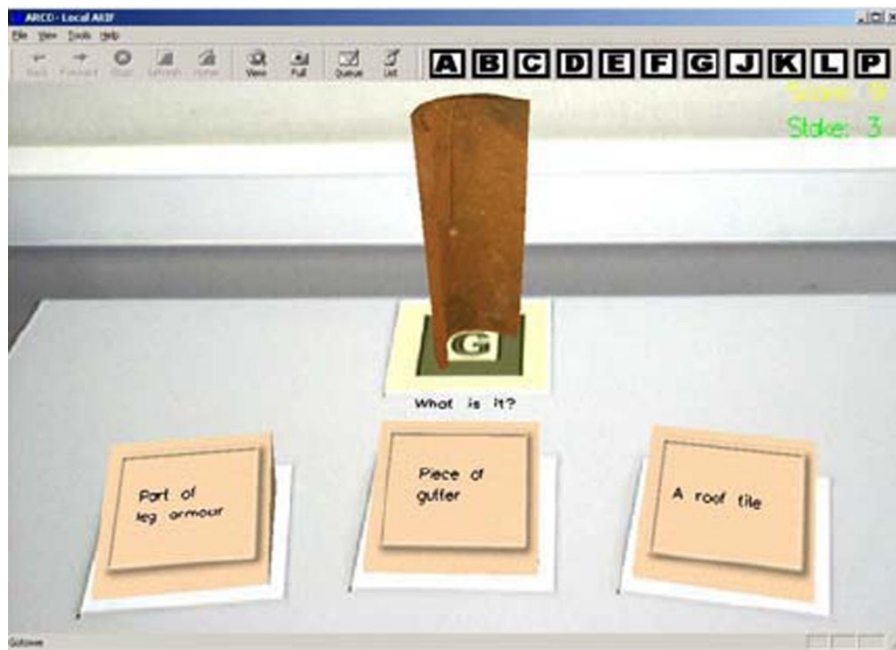
Figure 2.19. Screenshot of ARCO

Source: (White et al., 2004)

2.3.2.4 System of PRISMA

PRISMA has no abbreviation. It is a project that presents a variety of media to enhance visitor's experience through the use of AR binocular (Fritz et al., 2005). The system consists of database and sensors (refer to Figure 2.20). The process starts with the field of view of visitors that is tracked by binoculars which later brings pictures, 3D animations, movie and panoramic view in the database to the screen. The location of presentation is obtained by inertial sensors which capture and record the current location and orientation of binoculars. Then, central processing unit converts these data in an orientation vector. Next, vector is sent to virtual camera in order to enable synchronization of the images with the real world. Then, the synchronization renders augmented view and presents it to visitors. The main drawback of PRISMA relies on the unavailability of empirical evidence on enjoyable informal learning. It does not provide any theory of enjoyment and interpretation. The component presented

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without any guideline of enjoyable informal learning. However, available components are still considered in creating the proposed conceptual model.
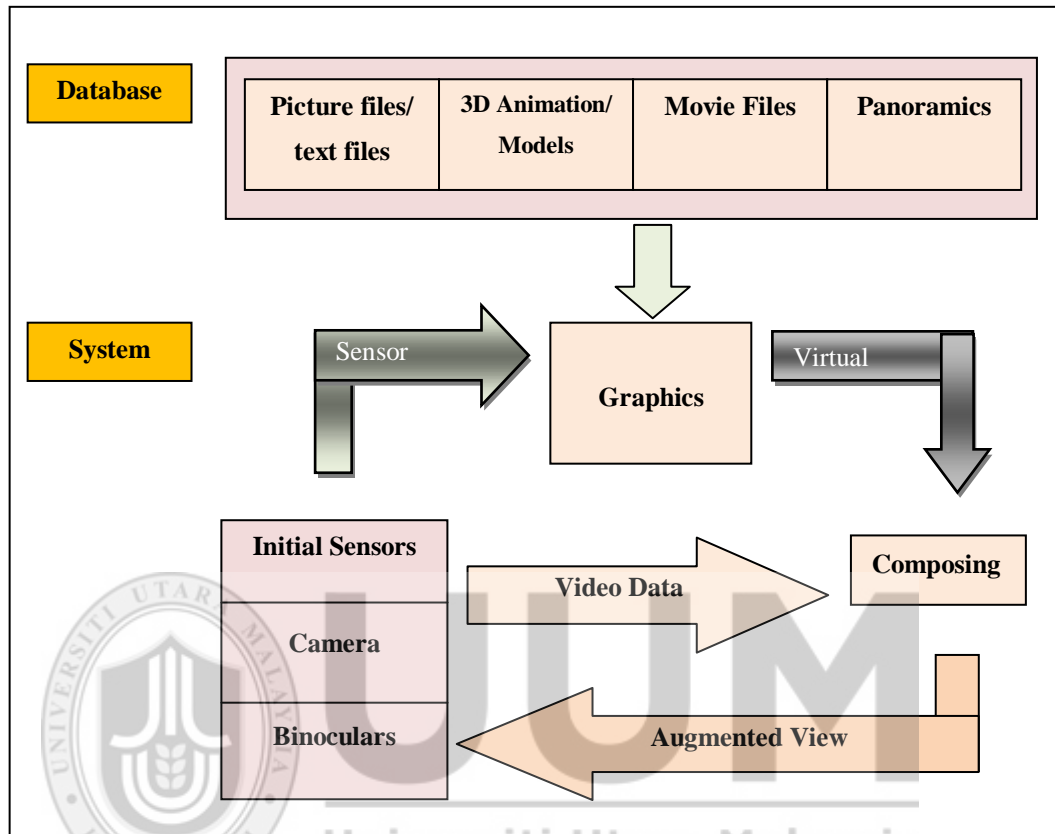
Figure 2.20. System of PRISMA
Source: (Fritz et al., 2005)

2.3.2.5 System Configuration of Immersive Tour Post

Immersive tour post provides authentic experience through AR post at cultural heritage site (Park et al., 2006). The system comprises one server and several posts (refer to Figure 2.21). Each post supplies the view of the real environment captured by the camera to the server. With this data, the server retrieves the relevant data from the content database and renders it to create an AR environment. These data are video and audio content which are rendered based on the topography and direction of view respectively. The augmented content is visualized through the display and

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speakers of the post. The content is sent to the rendering program and processed in the digital signal before going to the communication interface. After that, the content is presented to visitors (refer to Figure 2.22).
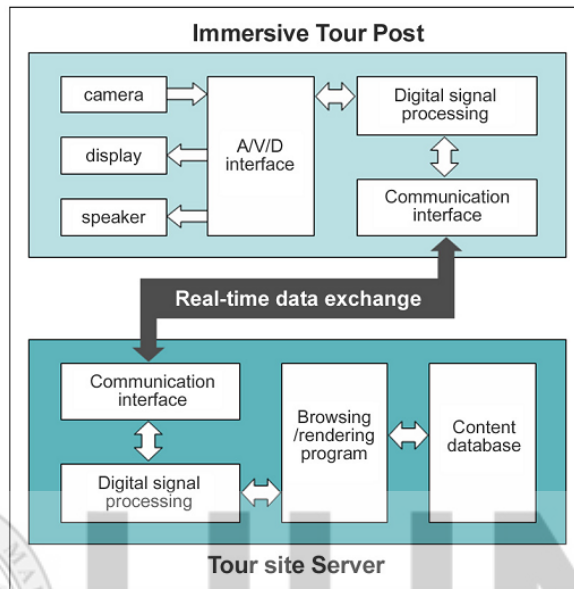
Figure 2.21. System of Immersive Tour Post
Source: (Park et al., 2006)

Although it aims to increase understanding of visitor, it does not provide empirical evidence of enjoyable informal learning as it does not apply any theory of enjoyment and interpretation.

Figure 2.22. A Visitor is using Immersive Tour Post
Source: (Park et al., 2006)

After all models have been examined, a summary that includes components, contents, features, and limitations of conceptual models are provided in Table 2.5.

Table 2.5

Review of Conceptual Model of AR for Cultural Heritage Site

Conceptual Model	Salient Features	Aims/Objective	Limitation
GEIST (Braun, 2003; Kretschmer et al., 2001)	• It provides interactive AR storytelling for exploring cultural heritage site. • It presents cultural and social life, politic and clerical change data, 3D reconstruction, character and clothes. • Visitor is able to interact with virtual character and take part in the story.	• To provide more information about historical facts, to entertain, and to tell stories.	• The problem with the model exists on the dearth to provide empirical evidence of enjoyable informal learning.
Mobile System Architecture and Content Database of LIFEPLUS (Papagiannakis et al., 2002)	• It presents 3D reconstruction of ancient frescos paintings by simulations of human, flora and fauna. • The model has ability to perform heavy tasks in parallel. • It supports variety of features: narrative simulation, multiple language, personalized tour (profile, availability for visit, reaction), and multimodal interaction.	• To push the limits of current AR technologies, explore the processes of narrative design of fictional space where visitor can experience a high degree of realistic interactive immersion.	• The model lacks empirical evidence of enjoyable informal learning.
System of ARCO (White et al., 2004)	• It provides alternative for creating, managing and presenting virtual exhibition in museum. • It presents 3D model, text, image, audio, and video. • It enables visitor to manipulate marker and look object from different angle and distance. • It provides interactive AR quiz.	• To provide digitization, management, and presentation of heritage artefacts in virtual exhibition.	• The main limitation of the model is located at the absence of empirical evidence of enjoyable informal learning.
System of PRISMA (Fritz et al., 2005)	• It presents variety of media to enhance visitor's experience through AR binocular. • The system comprises database and sensor. • It provides 3D model, text, maps, and old photograph.	• To enhance cultural tourism experience with AR technology	• The main drawback of model relies on the absence of empirical evidence of enjoyable informal learning.

Table 2.5 continued

		• To provide immersive tour experience that allows visitor to have lively experience as if they traveled to the past and to increase understanding of visitor.	• Although it aims to increase visitor's understanding of visitor, it does not have empirical evidence of enjoyable informal learning.
System of Immersive Tour Post (Park et al., 2006)	• It provides immersive tour post to present authentic experience. • It provides audio and video content.		

Identical to conceptual model of mobile AR for cultural heritage, conceptual model of AR for cultural heritage also does not apply enjoyable informal learning in the model. They are more focused on media presentation and technology aspect than enjoyable learning. However, their content and features provide useful contribution for constructing the proposed conceptual model.

The following section discusses guideline of enjoyable informal learning for cultural heritage and guideline of designing mobile AR guide for cultural heritage.

2.4 Guideline of Enjoyable Informal Learning for Cultural Heritage Site and Guideline of Designing Mobile AR Guide for Cultural Heritage Site

This section analyses guidelines of enjoyable informal learning at cultural heritage site and guidelines of designing mobile AR guide to examine the existing components of conceptual model. The subsequent subsection presents guideline of enjoyable informal learning for cultural heritage site.

2.4.1 Guideline of Enjoyable Informal Learning for Cultural Heritage Site

There are five guidelines of enjoyable informal learning at cultural heritage site, which are Informal Education at Cultural Heritage Site (Light, 1995a), Learning for Fun for Educational Leisure Experience (Packer, 2006), Conceptual Design Model of Reality Learning Media (RLM) (Ariffin, 2009), Design Guideline for Online Enjoyable Informal Learning (Lin et al., 2012), and Design Principles for AR Learning (Dunleavy, 2014). The next subsection provides guideline of informal learning at cultural heritage site. Meanwhile, the review of all guidelines are exhibited at the end of subsection (refer to Table 2.6).

2.4.1.1 Informal Education at Cultural Heritage Site

Informal learning at cultural heritage site is usually considered as interpretation that combines theory of education and tourism (Packer, 2004). Interpretation is an educational activity to explore meanings and relationships by using the object and media but factual information (Tilden, 1977). On top of that, interpretation is a voluntary activity (Light, 1995a). It needs motivation from the visitor itself in order to learn and explore the cultural heritage. Therefore, the factors that influence the informal learning must be observed (refer to Figure 2.23). This theory provides important factors that influence the provision of informal education at cultural heritage site. Nevertheless, the provided factors are not clear and detail. It does not provide criteria of presentation for visitors' understanding, presentation of informal learning and presentation that contains element of entertainment. However, the factors presented are categorized into motivation, knowledge, and content. These factors are usable in developing the proposed conceptual model.

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2.4.1.2 Learning for Fun for Educational Leisure Experience

According to Packer (2006), there are four conditions for learning for fun at cultural heritage, which are, sense of discovery or fascination, appeal to multiple senses, the appearance of effortlessness and the availability of choice. The followings explain about these conditions:

a. A sense of discovery or fascination

   Visitor would like to have different, new and unique learning experience that also can be referred as discovery. Discovery can be considered as something new and different that visitor has not found or learned before.

b. Appeal to multiple senses

   The enjoyable experience is applied to multiple senses (see, hear, touch and feel). Visitors have an experience that is enjoyable when they are able to feel the multi-sensory experience that covers all their senses.

c. The appearance of effortlessness

   Visitors like to get knowledge with less of effort. It makes them easier to get the information and make them learn something without any force or pressure. In addition, the process of learning happens naturally because visitor doesn't feel they are learning.

d. The availability of choice

   Visitors like to choose what they want to learn and personalize the experience. For implementing this, they like to be challenged by the right level that is appropriate for them.

```
┌─────────────────────────┐
│  Some degree of prior   │
│    interest in history  │
└─────────────────────────┘
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Figures showing flowchart:

- Some degree of prior interest in history
  - Motives for visiting
  - Background Knowledge
  - Extent of interest and attention to interpretative media
    - Features of interpretative media that can assist or hinder informal learning
      1. Presentations designed with an appropriate understanding of visitor
      2. Presentations appropriate to an informal learning environment
      3. Dynamic presentations with an appropriate element of entertainment
         → Effective communication, informal education and understanding among visitors
      1. Presentations designed with a poor understanding of visitors
      2. Presentations too lengthy or too complicated for an informal learning situation
      3. Excessive emphasis on entertainment, overwhelming display media
         → Poor communication, little informal learning and little understanding among visitors

Figure 2.23. Influencing factors in informal education at cultural heritage sites
Source: (Light, 1995a)

Learning for fun for educational experience provides essential conditions which are related to content, interaction, medium, and features: sense of discovery, appeal to multiple senses, and the availability of choice. These conditions are useful in constructing proposed conceptual model.

2.4.1.3 Conceptual Design Model of RLM (Reality Learning Media)

Conceptual design model of RLM (Reality Learning Media) was proposed by Ariffin (2009). It aims to provide learning through video that invokes entertainment and fun.

This model consists of six components, which are learning theories, structural component, content composition component, learning approaches, technologies and process of developing (refer to Figure 2.24).These components contribute to content, approach, technology and process. Therefore, this model is taken into account in designing the proposed conceptual model.

Learning Approaches
Structural Component
Content Composition Component
Learning Approaches
Technologies
Process Developing
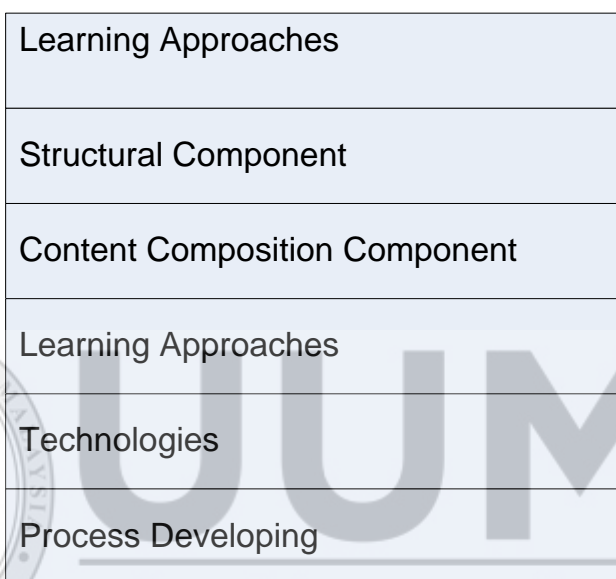
Figure 2.24. Conceptual Design Model of RLM
Source: (Ariffin, 2009)

2.4.1.4 Design Guideline for Online Enjoyable Informal Learning

There are five design guidelines of online enjoyable informal learning developed by Lin et al., (2012) (refer to Figure 2.25). The following are explanations of the guidelines:

a. Designing multisensory learning experiences

People learn best according to their perceptual strength (Lin et al., 2012). Some people learn easily by reading and listening but some others perform better in doing the experience and go into the field. Therefore, providing multisensory

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experience (visual, auditory, kinesthetic and tactile) is important. This experience will help learners to enjoy the process of informal learning optimally.

b. Creating storyline

Story helps people to enjoy the process of learning. It is able to create the sense of involvement and ownership (Carbo, 1996). Narrative-style content helps visitors to learn something from the content, indirectly. If this is built with a good storyline, visitors will visit the website frequently. Not only that, it also builds a good connection between visitors and organization.

c. Mood building

A positive mood makes the learning process easier and faster. Therefore, maintaining a positive mood is important to create an enjoyable learning environment (Lin et al., 2012). A positive mood stimulates brain to catch, process and memorize the information.

d. Fun in learning

Since most visitors at heritage sites consider learning as a fun and enjoyable activity (Lin et al., 2012), the website should be a place for visitors to have fun. It can be realized by providing interesting and pleasurable content.

e. Establishing social interaction

Visitors want website to be the platform where they can discuss the learning process with others (Lin et al., 2012). This discussion process includes creating, sharing, and exchanging the content of learning (Jokisalo & Riu, 2004) also interact and collaborate with the society.

This guideline contributes essential concepts for content (designing multisensory experiences, creating storyline, mood building, and fun in learning) and social interaction for providing enjoyable informal learning at cultural heritage site.

Designing Multisensory Learning Experiences
Creating a storyline
Mood Building
Fun in Learning
Establishing Social Interaction

Figure 2.25. Design Guideline for Online Enjoyable Informal Online Learning
Source: (Lin et al., 2012)

2.4.1.5 Design Principles for AR Learning

Dunleavy (2014) suggests three design principles for AR learning, which consist of enable then challenge (challenge), drive by gamified story (fantasy), and see the unseen. These principles are explained in the following:

a. Enable then challenge (challenge)

Firstly, teacher should allow learners to access and attempt the AR experience. After that, they can push learners and challenge learners to accomplish higher-level problem. There are some strategies that can be applied to achieve this situation are:

- Create simple structure in the beginning and increase its level of complexity during the progress (Perry, Klopfer, Norton, & Ave, 2008)

- Bridge aim of each task precisely to meet the learning objective (Klopfer & Squire, 2008)

- Replace text with audio (Perry, Klopfer, Norton, & Ave, 2008)

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- Use video which has narrator who is in the same age with students as "guide" (Dunleavy, 2013, as cited in Dunleavy, 2014).

- Apply collaborative pedagogical techniques such as role play, reciprocal teaching and other aspects of socio-cultural learning.

b. Drive by gamified story (fantasy)

Drive the player's interaction and learning through gamified stories or narratives. The narrative provides structure for AR experience and it has a profound impact on experience (Shea, Mitchell, Johnston, & Dede, 2009; (Klopfer & Squire, 2008).

c. See the unseen (curiosity)

AR is useful for students to view the invisible things that students wish to see during learning process (Kamarainen et al., 2013). This applies to the environment of the Biology class where students can view parts of bacteria and molecules by using AR which usually cannot be witnessed directly.

Design principles of AR are appropriate to be implemented for designing AR. However, it is more appropriate for AR games which conducted in formal learning environment. Nevertheless, the principles of challenge and curiosity supports strategies and content which are necessary in designing the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

All guidelines of enjoyable informal learning have been examined based on characteristics and limitations. These characteristics and limitations are documented in Table 2.6.

Table 2.6

Review of Guidelines of Enjoyable Informal Learning for Cultural Heritage Site

Guideline	Description	Limitations
Informal Education at Cultural Heritage (Light, 1995a)	• This theory is implemented for informal learning at cultural heritage. • The provided factors and criteria are categorized into three main components: motivation, knowledge, and content.	• This theory does not provide empirical evidence of enjoyable informal learning. • The provided factors refer to general interpretive media which is not specific to mobile AR. • The provided presentation for interpretive media is not explained in detail.
Learning for Fun for Educational Leisure Experience (Packer, 2006)	• This concept is implemented for informal learning at educational leisure place, such as, museum, aquarium, and national park. • The provided conditions are related to content, interaction, medium, features.	• This theory proposes conditions for learning for general which provides genera learning theory that is not specific for learning using mobile AR.
Conceptual Design Model of RLM (Reality Learning Media) (Ariffin, 2009)	• The provided components are related to content, approach, technology, and process.	• This model is purposed to provide learning through video not mobile AR.
Design Guideline for Online Learning for Enjoyment (Lin et al., 2012)	• It is implemented for enjoyable informal learning using website at museum. • The provided guidelines are related to content and social interaction.	• This guideline is purposed for enjoyable learning using website and not using mobile AR. • The guideline is implemented at museum not cultural heritage site.
Design Principles for AR Learning (Dunleavy, 2014)	• It is implemented for learning using AR games. • The provided principles are related to strategies and content.	• This principle is appropriate to be implemented for AR games and not for AR for learning at cultural heritage site. • The provided principles do not have empirical evidence of enjoyable informal learning.

Review of guideline of enjoyable informal learning at cultural heritage site provides general view about the concept of enjoyable learning at cultural heritage site. Furthermore, it also provides 'Content' as the component of conceptual model that is contributed & all guidelines. Besides 'Content', the guidelines also share 'Motivation', 'Knowledge', 'Interaction', 'Medium', 'Features', 'Approach', 'Technology', 'Process', 'Social interaction', and 'Strategies'. All components may

contribute a significant support in constructing conceptual model despite the fact that only three guidelines cater learning at cultural heritage and one guideline applies enjoyable informal learning.

Subsequent section examines the guidelines of designing mobile AR guide for cultural heritage.

2.4.2 Guideline of Designing Mobile AR Guide for Cultural Heritage Site

Besides having a quality content, enjoyable learning at cultural heritage requires good physical orientation. This makes the guidelines of designing mobile AR guide for cultural heritage reviewed in order to define the component of physical orientation and also other useful components. The guidelines were User Requirement of Designing Mobile AR Guide at Cultural Heritage (Toh, Jeung, & Pan, 2010) and Categories of Functions for Mobile AR Guide (Damala et al., 2007). The justification of user's requirement of designing mobile AR guide at cultural heritage is provided in the next subsection. Meanwhile, a summary of review is provided at the end of the subsection (refer to Table 2.8).

2.4.2.1 User Requirement of Designing Mobile AR Guide at Cultural Heritage Site

User requirement of designing mobile AR guide at cultural heritage was proposed by Toh et al., (2010). It provides list of criteria for developing mobile AR guide obtained from combined user research techniques. The requirements consist of: language, navigation and user interface, physical orientation, content, communication, and activity. For language feature, visitors would like to have text

recognition which can translate into specific language. Next, for navigation and user interface, it is better if visitor is allowed to do one-handed controls, such as, shaking and blowing. For physical orientation, which is the main function for mobile AR guide, it may provide visitors to insert query of destination that is followed by displaying virtual arrows that overlays on real path of cultural heritage site. This function is followed by displaying visitors visited path and guides them back to previous visited place by request. Virtual arrows are also suggested for showing route during bad weather condition, track friend's location and show direction to special event.

Besides showing the virtual path, chatting feature may be an alternative for tracking location of visitors which also displays virtual foot prints of visitor. In addition, the content should consist of a variety of media, namely video, 3D character, animation, photograph, and AR panorama photos for crowded spots by giving options of push content and pull content for active and passive visitors. These options of viewing content (push content and pull content) enable visitors to control the information they receive. Then, information they obtain also can be shared to social media and among desktop users. List of requirements of designing mobile AR guide is provided in Table 2.7.

Table 2.7

User Requirement of Designing Mobile AR Guide

Criteria	Description
Language	Provide text recognition feature to translate the language to visitor's language.

Table 2.7 continued

Navigation and UI	Provide user friendly navigation and simple UI for one-handed controls, such as shaking and blowing.
Physical Orientation	a. Allow visitors to insert to destination query and guide them to the place with virtual arrows overlaying on the real path. b. Display visitors the visited path and guide them back to the previously visited places upon request. c. Use virtual arrows to access content, such as new route for bad weather condition, visitors' footprints of visited path and notifications, directions to an event venue.
Content	a. Provide virtual content for enrichment of visitor's experience, for example: video, 3D character, animation, photograph, and visual time machine. b. Provide push and pull content for active and passive visitors. c. Augment AR panorama photos merged with real environment to show the view of crowded spots.
Communication	Provide chatting feature for communication and location tracking through virtual foot prints among group of visitors.
Activity	Allow visitors to upload and share their photos to social media as well as to share it with desktop users.

Source: (Toh et al., 2010)

These requirements provide extensive criteria of 'Language', 'Navigation and user interface', 'Physical orientation', 'Content', 'Communication', and 'Activity' in designing mobile AR for visitor guiding at cultural heritage site. These criteria are relevant for the proposed conceptual model as well. Therefore, this guideline is highly taken into account in developing the conceptual model.

2.4.2.2 Categories of Functions for Mobile AR Guide

According to Damala et al., (2007), there are five functions that should be embedded for mobile AR guide at museum:

a. Contextualization

Contextualization helps visitors to situate museum's object in the original context. It includes representing the object through visualization, animation, video, audio and 3D model and website. Furthermore, the function to edit and add information

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as well as manipulating the 3D model of artefact should also be included in this category.

b. Communication

Provide the communication link between museum and visitors, visitors and museum, and visitors with other co-visitor. The staff may also provide the link for pre-visit, during visit, and after visit consultation in order to strengthen the bonds between museum and public. The communication function also includes the ability to comment the exhibit that has chances to enhance the public dialogue and platform for staff to communicate about general information, such as closing hours, rules and regulations and special events.

c. Personalization

Personalization may vary with different types, such as age groups, learning styles, disabilities, level of learning attention, available time for visit (Damala, 2007). It also includes the customization, configuration, adaptivity of system which can be done by visitors. In terms of technical, the preferences to choose terminal and the available bandwidth may also be included.

d. Museum data management

Database of museum is authorized only by museum staff. It covers storage, transmission and processing of data. In addition, it also enables staff to do content creation, content management and content update.

This criteria provides functions related to content (contextualization), activity (communication), and feature (personalization). These functions are useful in developing the proposed conceptual model.

After all guidelines were reviewed, summary of characteristic and limitations is provided in Table 2.8.

Table 2.8

Review of Guideline of Mobile AR Guide for Cultural Heritage

Guideline	Description
User Requirement in Designing Mobile AR Guide at Cultural Heritage (Toh et al., 2010)	• This guideline is purposed for designing mobile AR guide at cultural heritage. • Requirements contributes to component of language, navigation and UI, physical orientation, content, communication, and activity.
Categories of Functions for Mobile AR Guide (Damala et al., 2007)	• This concept is purposed for mobile AR museum guide. • The provided functions that supports component of content, activity, communication, and feature.

This review resulted certain requirements and functions that can be embedded in the proposed conceptual model, such as, language, navigation and UI, physical orientation, content, activity, communication, and feature. All the requirements and functions give significant contribution in developing the proposed conceptual model.

In order to examine some aspects of the learning concept at cultural heritage site, the analyses of similar mobile projects and mobile AR frameworks are provided in the next section.

2.5 Mobile Applications and Mobile AR Frameworks

As mobile AR for cultural heritage mostly relies on reconstruction and visualization, review on mobile tourism guide, mobile learning, and mobile guide is mandatory. These applications are chosen since they provide activity component at tourist attraction, learning component at learning place, also and activity and learning

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component at cultural heritage. The next subsection provides explanation about mobile tourism guide.

2.5.1 Mobile Tourism Guide Application

There are three mobile tourism guide applications which have been reviewed: Lol@ (Local Location Assistant) (Pospischil, Umlauft, & Michlmayr, 2002.), Cyberguide (Abowd et al., 1997), and Context Aware Smart Tourist Guide (Park, Hwang, Kim, & Chang, 2007). Details of these applications are elaborated in the next subsections.

2.5.1.1 Local Location Assistant (Lol@)

Local Location Assistant (Lol@) is a mobile tourist guide developed for City of Viena, Italy (Pospischil et al., 2002). Lol@ can be used for planning the journey (pre-visit), exploring attractions (on visit) and accessing back the journey (post-visit). Visitors can gain information, in the form of description, address, contact information, opening hours, entrance fees, historical information, architecture description, list of events and multimedia data. The multimedia data is provided in the form of photos, audio and video. The suggestion on accessing certain media is based on visitors' interest/profile.

Lol@ offers a unique feature which is called "My data" (refer to Figure 2.26). This feature allows visitors to access personal diary of their journey. It can be accessed by downloading the application on their personal computer. Besides, Lol@ also provides "Tour Diary" which shows that the media related to the place that has been visited, such as, a photo in Colloseum Roma and voice notes in Eiffel Tower.

However, among all these advantages, Lol@ has these shortcomings: lack of accurate information of current location method, small and low resolution display, and dependency on mobile internet packet.

Lol@ supports "My Data" feature which allows visitor to reflect on the visit when they are back home. This feature can be implemented in designing the conceptual model as the need of visitors to bring something home is highly necessary (Papagiannakis et al., 2008).

Figure 2.26. Local Location Assistant (Lol@)
Source: (Pospischil et al., 2002)

2.5.1.2 Cyberguide

Cyberguide is a mobile context-aware tourist guide (Abowd et al., 1997). It is developed for outdoor and indoor purpose. Cyberguide consists of four main components, cartographer (map component), librarian (information component), navigator (positioning component), and messenger (communications component). The map component shows the entire map of the location (refer to Figure 2.27). The information component contains information about the place. Then, communication information component enables visitors to send and receive information related to the

place. The position component is used to sense the location of visitor. Cyberguide has two unique features which are questionnaire and messenger services. The questionnaire contains feedback for the place which can be directed to owner's email. Since sometimes, visitor comes to the place when owner is not around. Besides, messenger service enables visitors to communicate with their friends. In addition, it also provides travel diary which records all visited places and suggests recommended places to visitors.

The main components of Cyberguide (map component, information component, positioning component, and communication component) can be adapted to design the proposed conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. In addition, the features of questionnaire and messenger services are also possible to be implemented in the proposed conceptual model despite its lack in personalization feature.

2.5.1.3 Context-aware Smart Tourist Guide

Context-aware smart tourist guide is a smart context-aware tourist guide developed for Deoksung Old Palace, Seoul (Park et al., 2007). This guide has four main features: location-based services based on PDA and GPS, simple and easy user interface, POI, nearby user's position, guide's modes depending on visitor's
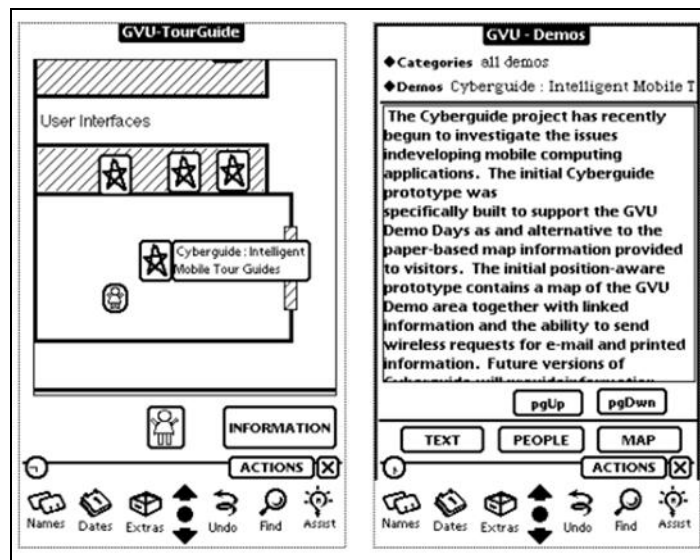
Figure 2.27. Interfaces of Cyberguide

Source: (Abowd et al., 1997)

profile (children mode, adult mode and old people mode), and multilingual audio guide (refer to Figure 2.28).

There are three unique features in context-aware smart tourist guide, which are, a map that shows visited path, guide based on the age of visitors, and scrap page. Map that shows visited path is able to show visited building besides providing convenience on facility and current position. Then, the guide is able to guide visitors based on their group of age; children, adult or old people. This guide can be selected according to visitors' preference: children mode is set to be a friend, adult mode as a guide and guides for old person mode are referred as teacher. Lastly, the scrap page allows visitor to save important pages. The pages that are clipped can be compiled into a scrapbook to be displayed later. However, this is not followed by the personalization feature and smart-phone as hardware.

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In designing the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning, the three unique features can be considered to be applied, which are: the visited building allows visitor to track the route, the audio guide helps visitors to explore the place, and the scrap page that is useful to reflect on the visit.

Figure 2.28. Smart Tourist Guide
Source: (Park et al., 2007)

The analysis of components of mobile tourism guides is featured in Table 2.9.

Table 2.9

Review of Mobile Tourism Guides

Project	Salient Features	Limitation
Lol@ (Local Location of Assistant) (Pospischil et al., 2002)	• It has unique feature named My data which allows visitors to access personal diary of their journey.	• It has limited accuracy information of current location method. • It has limited display with small screen size and low resolution. • It depends largely on mobile data service.
Cyberguide (Abowd et al., 1997)	• It has two unique features: questionnaire service and messenger service. • It also provides travel diary which records all visited places and act as recommendation for visitors to choose the POI.	• It lacks of personalization feature.

Table 2.9 continued

System of Context-aware Smart Tourist Guide (Park et al., 2007)	• It has three unique features, which are, scrap page, visited building, and audio guide.	• It lacks of personalization feature. • It is not implemented in smart-phone.

The analysis above shows that the existing mobile tourism provides a variety of features that help visitor to enjoy and learn from the visit, such as personal diary, messenger service, scrap page, and audio guide. Personal diary and scrap page allow visitors to record their moments (image and page) during the visit and enable visitors to reflect on these moments when they are back home. Meanwhile, messenger service allows visitors to connect and track the location of their friends. Lastly, audio guide provides convenience to know their location and to accompany them to do the visit. All these features are useful in developing the proposed conceptual model, specifically in enjoyable learning. The next section provides review of mobile learning.

2.5.2 Mobile Learning Application

There are three mobile learning applications reviewed in this study, which are, Mobile and Interactive Learning Environment (MILE) (Boticki, Hoic-bozic, & Budiscak, 2009), Mobile Butterfly-Watching system (BWL) (Chen, Kao, Yu, & Sheu, 2004), and Environment of Ubiquitous Learning with Educational Resources (EULER) (Liu et al., 2009). Details about these applications are provided in the next subsections.

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2.5.2.1 Mobile and Interactive Learning Environment (MILE)

MILE is developed to support mobile learners by providing multiple pedagogical approaches to learning (Boticki et al., 2009). It has nine modules: MCollaboration, MWhiteboard, MNotebook, MClassroom, MSchedule, MSurvey, MAccessibility, MVirtual Board, MGuide. These modules aim to enhance learning by engaging interaction and collaboration in a blended approach. However, there are three modules which emphasizes learning process: MCollaboration (to support collaboration and interaction between students, such as meetings or virtual communication); MWhiteboard (as an alternative to blackboard available in students; and teachers' mobile devices, for example: students can draw ideas or notes) and MNotebook (used to tag slide bullets and save presentation on server or locally also to deliver PowerPoint presentations to mobile devices) (refer to Figure 2.29). Besides, MILE also has other interesting modules:

a. MClassroom (to control a "virtual classroom" that covers the function: in-class real time student surveying, record of class attendance, storage for presentation with the possibility of direct launching.

b. MSchedule: used to make schedule in mobile devices

c. MSurvey: used to create instant in-class mobile assessment and survey

d. MAccessibility: to provide accessibility features for learners with special needs

e. MVirtual Board: to provide notice board that is available anytime and anywhere

f. MGuide: to guide the current education-related events

MILE has component contribute to the development of the conceptual model, named "MCollaboration". This component can be implemented in designing the conceptual model as it holds collaboration principle.
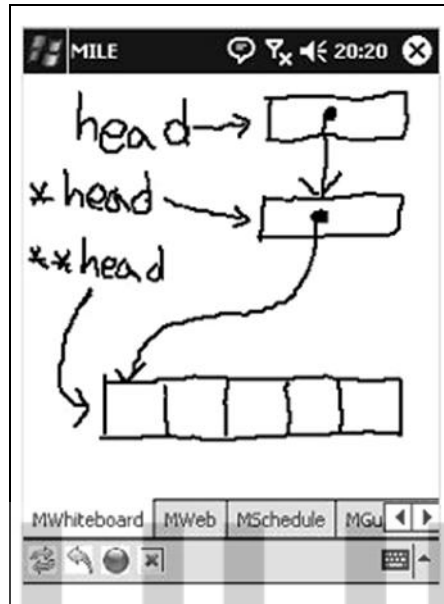
Figure 2.29. Screenshot of MWhiteboard of MILE
Source: (Boticki et al., 2009)

2.5.2.2 Mobile Butterfly-Watching Learning System (BWL)

Mobile Butterfly-Watching Learning System (BWL) is purposed to support independent learning (Chen et al., 2004). It consists of four steps of learning, which are, self-selection, self-determination, self-modification, and self-checking (refer to Figure 2.30). The steps are explained in the following:

a. Self-Selection

Learner is able to take different pictures of butterfly using his/her own colour Charge-Coupled Device (CCD) camera and transfer the images from the PDA to the local server using the wireless mobile ad-hoc network routing protocol. These images are processed in the content-based butterfly image retrieval system. After that, the system will transfer the closest matching butterfly-data files to the

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learner's mobile device. In this step, learner is able to learn different types of butterfly easily. Moreover, similar butterfly data files also will be helpful for those learners who want to learn related information to this data.

b. Self-Determination

After the image is processed in the database, the system will reply with three most similar butterfly-data files with the one which is processed. Learner is allowed to choose which butterfly that he/she considers as the best answer. If there is no similar butterfly, learner can look for information in the web-based wireless querying subsystem. Then, learner can write the results of search in nature journal subsystem. This becomes the notes of learning result from learners. The notes will be uploaded to the teacher's notebook and the teacher will give feedback about the notes.

c. Self-Modification

After the learners have submitted their answer to the system, the teacher will check which one has the correct answer by using the teacher-modification interface. Then, learner can see whether his/her answer is correct or not. At the same time they can revise their answers and adjust their knowledge of the butterfly. This step allows learner to learn, improve his/her knowledge quickly and practice independent learning.

d. Self-Checking

Teacher can check the answer through pre-test and post-test. Teacher can assign questions by adding questions in words or pictures and learners can answer the question in the specific time given. The level of difficulty is categorized into less than 40%, between 40% and 60%, and higher than 60%. If the average of score is

less than 40%, the system will provide the learner with more difficult questions. The number of selection items of butterfly to be chosen is three. If the average score is between 40% and 60%, the number of selection is four. And, if the average score is higher than 60%, the number of selection is five. If learner needs higher support level, a fewer selection items are provided since there is higher probability of selecting the correct item. Learner also can record the learning process into a journal, including picture of searching conditions, searching results, suggestions from image mapping and the decision they make.

BWL is considered as successful in creating an independent learning platform which enables fast knowledge acquisition through content-based image-retrieval technique. Its significant contribution is nature journal subsystem that connects independent learning method and brand-new wireless network technology. The implementation of BWL to conceptual model is the element of share information to social media that can be used to learn and reflect on the learning outcome.
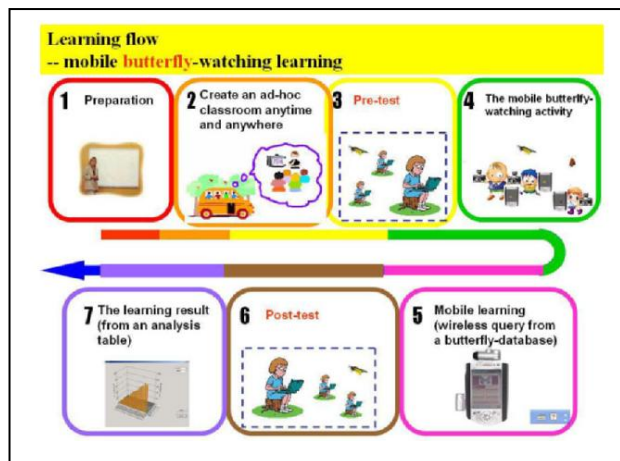
Figure 2.30. Learning Steps of BWL
Source: (Chen et al., 2004)

2.5.2.3 EULER (Environment of Ubiquitous Learning with Educational Resources)

EULER was proposed by Liu et al. (2009). It presents context-aware system that support outdoor learning, such as, historical sites. It consists of two subsystems, MOBILE server and mobile-tools (m-tools). MOBILE server is used by teachers and m-Tools is created for students. MOBILE server comprises three main modules: Mobile Content Database (MCDB), Mobile Learning Record Database (MLRDB), and Mobile Assessment Database (MADB). MCDB is used to upload teachers' learning materials and MADB is used to disseminate the assignment. Besides, MLRDB has other tasks which are to record teachers' marks, number of discussions, reading times, instances of data collection, and instances of information sharing.

Meanwhile, m-Tools provide functions such as m-sharer, m-capture, m-AR, m-RFID, m-Loader, m-Calendar, m-Notes, m-Player, m-Messenger and m-Test. The user interface coordinates each tool and saves it in mobile database (MDB). For example, student uses PDA to observe museum exhibition with a Radio-Frequency Identification (RFID) tag installed, then the RFID reader on PDA identifies the internal code of tag. Then, m-RFID sends the code to the server which downloads the context-aware content to PDA. The content is saved into the database and student can access the content via m-Player. Later, students can update the content as student accesses the material. Student also can get the teacher's guidance from m-Messenger, record videos of animals with m-Capture, and access additional materials from EULER server with m-Loader. Furthermore, student can collect all articles in m-Notes and send them using m-Sharer to their project leader via WLAN. Lastly, to

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organize schedule students can use m-calendar and to see virtual animals that appear

rarely in wetlands areas, students can use m-AR (refer to Figure 2.31).

The feature of m-AR is the unique feature in EULER. It allows students to see the

unseen in natural environment that help them to broaden their knowledge. This

feature is also enabled to be implemented to show the lost or broken parts of cultural

heritage site in 3D model and image in the conceptual model.
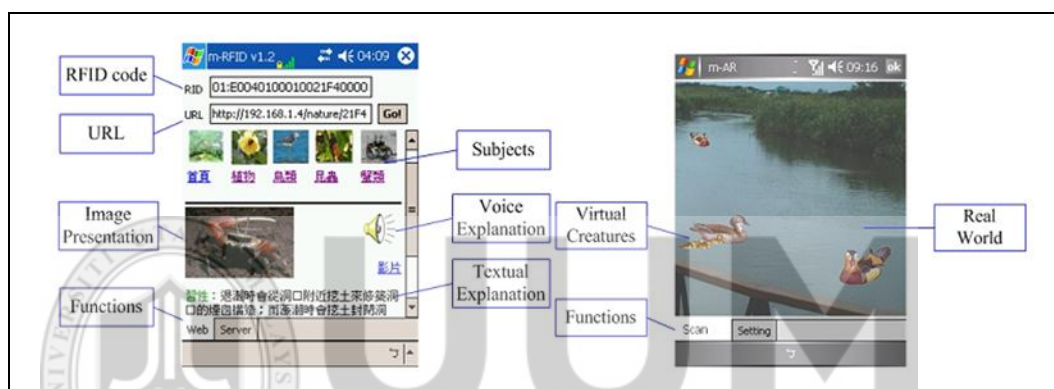
Figure 2.31. Screenshots of m-RFID and m-AR of EULER
Source: (Liu et al., 2009)

All mobile learning applications have been analysed in order to define the

characteristics and useful components for developing the proposed conceptual model

(refer to Table 2.10).

Table 2.10

Review of Mobile Learning

Project	Salient Features	Limitation
MILE (Boticki et al., 2009)	• It has unique feature named MCollaboration that supports collaboration and interaction between students, such as, meetings or virtual communication	• It has limited modules. • It has limited custom made system components. • It lacks of graphic.

Table 2.10 continued

Mobile Butterfly Watching Learning (BWL) (Chen et al., 2004)	• It has one unique feature named nature journal sub-system that connects independent learning method and brand-new wireless network technology	• It requires internet connection
EULER (Liu et al., 2009)	• It has one unique feature named m-AR that shows students the virtual animals which are rarely seen in wetland areas.	• It lacks of interaction.

The analysis shows that mobile learning has modules and features to support learners to learn, for instance, MCollaboration that can view location of friends which helps learners to set up face to face meeting which consequently eliminates the shortcoming of virtual communication (Boticki et al., 2005), nature journal sub-system that allows learners to perform independent learning by uploading and receiving feedback (Chen et al., 2004), and m-AR that enables students to see the virtual animal which are rarely seen in wetland areas (Liu et al., 2009). These two functions support significant contribution in developing the proposed conceptual model: MCollaboration that supports implementation of supporting element of show map of site and location of visitors within the site, nature journal sub system that contributes to element of share information to social media, and m-AR that relates to supporting element of overlay certain part that is lost.

The next subsection provides reviews of features and content of mobile guide projects.

2.5.3 Mobile Guide Application

This study had reviewed three mobile guides applications which are: Mobivisit (Damala & Lecoq, 2005), DANAE (Damala, 2009), and Hypermedia Tour Guide (Bellotti et al., 2002). These projects were chosen as they are related to the feature of

physical orientation and as a guideline to review the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. Details of these mobile guides are provided in the following subsections.

2.5.3.1 Mobivisit

Mobivisit is developed for indoor and outdoor museum (Damala & Lecoq, 2005). It presents text, audio, image and interactive map (refer to Figure 2.32). Mobivisit allows visitors to select the theme of exhibition and organize the visit based on their available time. In addition, it also allows visitors to zoom in and zoom out the image, go forward and go back, and tick the work that is linked with the map that updates the viewed work. Moreover, visitors are also able to do work searching based on criteria of type, period, and artist as well as knowing the exact location of work on the map. All these component and features in Mobivisit can be implemented in the proposed conceptual model.

Figure 2.32. Snapshot of Mobivisit
Source: (Damala, 2009)

2.5.3.2 DANAE

DANAE focuses on context-aware dynamic multimedia content adaptation (Brelot et al., 2005). The context is defined based on visitor's location, preference, terminal capability, and bandwidth. The media presented (text, audio, video, image, and 3D character) are selected based on these data (refer to Figure 2.33). This context operation is done by optimizer, the main component of DANAE. After the media has been selected, optimizer develops the media and sends it to the multimedia player, followed by organisation of exhibition based on themes and sub-themes. Besides the optimizer, content adaptivity that is enabled by transferring the PDA or tablet PC session to the museum display is also limited in other projects. This makes DANAE is unique. All components of DANAE can be considered in designing conceptual model.

Figure 2.33. Screenshots of DANAE
Source: (Brelot et al., 2005)

2.5.3.3 Hypermedia Tour Guide

Hypermedia tour guide is a tour guide developed for Genoa's Costa Aquarium, Italy (refer to Figure 2.34). It is developed to reinforce link between visitor and aquarium and to present useful information of aquarium that is not provided in the environment (Bellotti et al., 2002). In order to meet these goals, it provides visitors with photo or photo sequence along with comments and video about the birth of the aquarium mascot seal pup. In addition, this guide also provides a map to personalize the path and to estimate the length of visit.

Hypermedia Tour Guide has been tested to visitors. It has resulted the significant results. Firstly, visitors prefer image to video and audio. Image is preferred because it makes visitors understand easily and quickly. Visitor prefers audio and video for in-depth content rather than text as audio allows visitors to focus on the information. Whereas, video is appropriate for presenting special information that is not available. Secondly, recorded audio is preferred over synthesize speech. Thirdly, thematic path through exhibition is required to explore the environment. Fourthly, it requires other acoustic modality besides headphone for bending the visitors with the environment. Other than these evaluation results, the component were also derived from a preliminary study with users and experts, specifically for navigation and user interface, which provides information layer by layer and uses shaped buttons. Finally, the evaluation concludes that multimedia guide is an effective tool for learning as it supports better knowledge acquisition. In spite of that, components, contents, and features have been taken into account in developing the proposed conceptual model.

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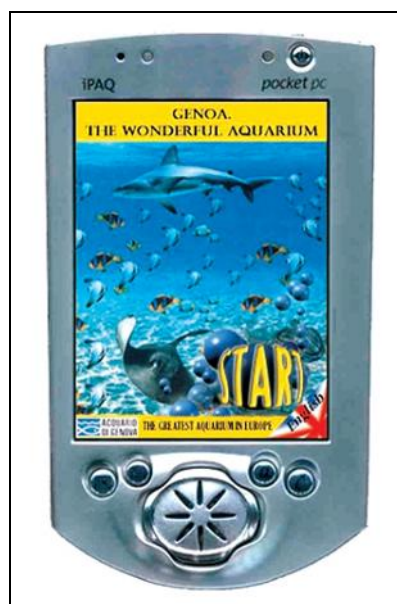
Figure 2.34. Hypermedia Tour Guide
Source: (Bellotti et al., 2002)

An analysis on content and features of projects of mobile guides has been carried out

and exhibited in Table 2.11.

Table 2.11

Review of Mobile Guide

Application	Salient Features	Limitation
Mobivisit (Damala & Lecoq, 2005)	• It enable visitor to choose theme of exhibition based on available time for visit. • It allows visitor to zoom picture. • It allows visitor to tick on exhibit that has been viewed. • It updates the map with the work has been viewed. • It allows visitor to search works based on type, period and artist. • It enables visitor to see where the exhibit is located exactly on the map.	• The interactive map is not fully functioned. • The disproportionate time amount of presentation of internal museum and total duration of museum project. • Lack of visitor's comfort, it will be better if the system uses personal mobile phone. • Lack of the link between museum and home for post-visit.

Table 2.11 continued

DANAE (Brelot et al., 2005)	• It focuses on context-aware dynamic multimedia content adaptation. • The context was defined as visitor's location, preferences, terminal capabilities (PDA, tablet PC, projection screen) and allocation of network bandwidth according to number of other sessions run by other visitors, equipped with other kind of terminals. • It organizes exhibition based on themes and sub-themes. • It enables visitor to transfer the PDA or tablet PC session to museum display and vice versa.	• It has limited storage.
Hypermedia Tour Guide (Bellotti et al., 2002)	• It provides map that allows visitor to create their visit of path, request desired information, and seek current position.	• It has limited memory. • It has complex interfaces. • It lacks of content and interaction modalities.

This section provides reason why 'Navigation and user interface design' is required in conceptual model. It is because it is related to enjoyability. Enjoyability is proven correlated with quality of content (image, audio, comments) and technology (controls and system response) (Bellotti et al., 2002). Therefore, component of navigation and user interface design should be applied to provide enjoyment of user.

Furthermore, the review provides useful contribution in reviewing conceptual model based on content, navigation and user interface design, and physical orientation.

The following section presents analysis of frameworks of mobile AR.

2.5.4 Mobile AR Framework

There are three frameworks of mobile AR which were analysed in order to define components of mobile technology: ARToolkit Architecture ("ARToolkit," n.d.),

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Metaio Framework (Majid, 2013), and Mobile AR Framework (Oui, Ng & Khan, 2011). The next discussion takes up the review of architecture of ARToolkit.

2.5.4.1 ARToolkit Architecture

ARToolkit is software for developing AR application. It consists of four main components; openGL, GLUT, standard API, and video library (refer to Figure 2.35). The OpenGL is used for rendering, GLUT is used for event handler, standard Application Programming Interface (API)is used to represent the platform dependent parts, and video library presents a hardware-dependent video library ("ARToolkit," n.d.).

ARToolkit reduces dependency to library without ceding efficiency. However, the components are specific only for ARToolkit which is not appropriate for the proposed conceptual model.
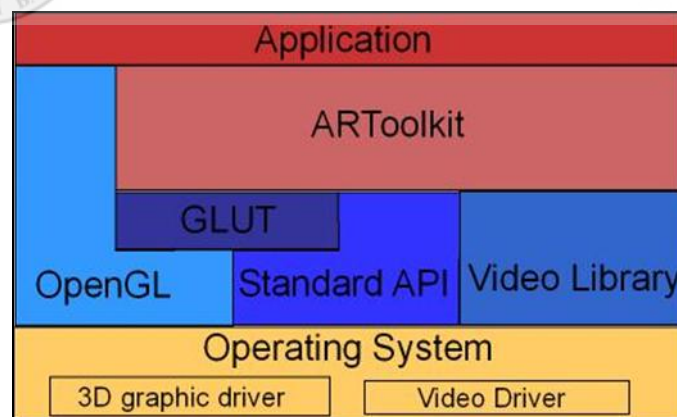
Figure 2.35. Architecture of ARToolkit
Source: http://www.hitl.washington.edu/artoolkit/documentation/devframework.htm

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2.5.4.2 Metaio Framework

Metaio framework comprises four layers, which are: application, API, Metaio software development kit (SDK) and operating system (OS) (refer to Figure 2.36).The first layer, which is application, is the application program in the mobile phone. The second layer, API is the application programming interface that contains instructions and standards for building the application (Beal, n.d.).The third layer, Metaio SDK is a set of programs to write application program specialized for Metaio (Blackwell, 2005). Lastly, the fourth layer, OS is a software program that allows mobile phone to communicate with the application ("Computer Hope," n.d.)

Similar to ARToolkit, Metaio also provides specific distinct components for AR based application. It addresses components for developing AR based application, such as, API, SDK, and OS. However, these components are still considered in developing the proposed conceptual model.
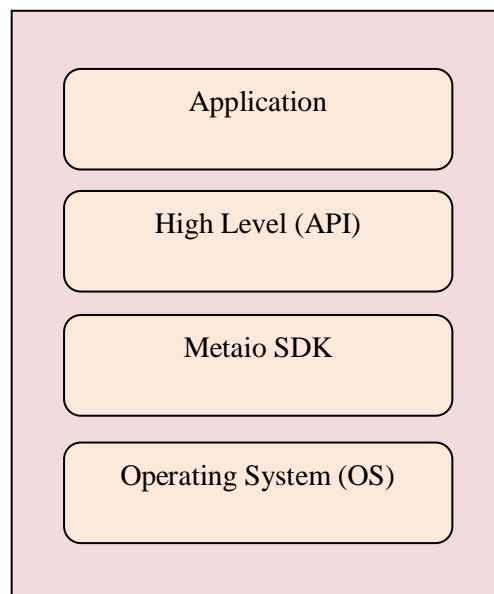
Figure 2.36. Framework of AR based Application by Metaio
Source: (Majid, 2013)

2.5.4.3 Mobile AR Framework

Oui et al. (2011) proposed an identical framework to Studierstube Tracker created by Wagner (2007).The difference between this framework and Studierstube Tracker relies on the usage of OpenGL ES that is used for rendering and Open CV that is applied for tracking (refer to Figure 2.37). Furthermore, mobile AR framework also comprises 3D, tracking, Graphical User Interface (GUI), multimedia, and interactive maker. Considering accustomed component that mobile AR framework has, it has highly been taken into account in development of the proposed conceptual model.
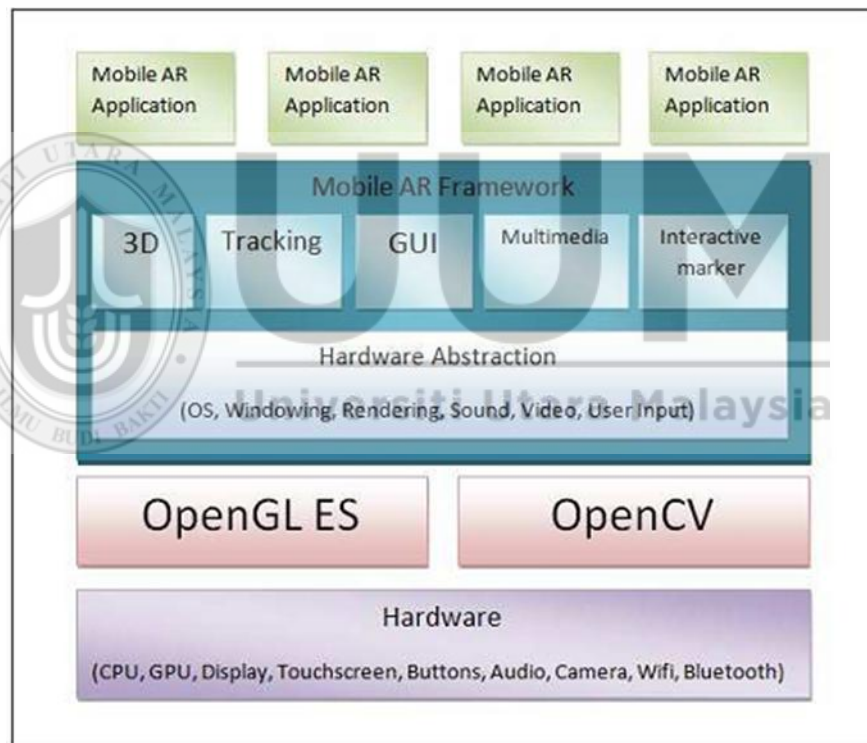
Figure 2.37. Mobile AR Framework
Source: (Oui et al., 2011)

All these frameworks have their strengths and weaknesses. Description and limitation about these aspects are exhibited in Table 2.12.

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Table 2.12

Review of Framework of Mobile AR

Framework	Description	Strength/Weaknesses
ARToolkit Architecture ("ARToolkit,"n.d.)	• It reduces dependency to library without ceding efficiency.	• It addresses specific component which is not appropriate for the study. • However, available components are considered in designing conceptual model.
Metaio Framework (Majid, 2013)	• It is purposed for AR based application.	• It provides specific component for developing AR based application which is not appropriate for this study. • Nevertheless, presented components are taken into account in developing the conceptual model.
Mobile AR Framework (Oui et al., 2011)	• It comprises six components. • It implements general component for developing mobile AR application.	• It applies general component for creating AR application that makes it is highly appropriate to be considered in designing the conceptual model.

Analysis shows that only one framework presents the general component while others provide specific ones. Mobile AR framework shares the component of hardware and process that contributes to development of conceptual model. These components are taken into account in producing the conceptual model.

The subsequent section discusses about informal learning aspects at cultural heritage site.

2.6 Informal Learning at Cultural Heritage Site

This section reviews two important topics related to informal learning at cultural heritage site, which are, interpretive media and theory of informal learning at cultural heritage site. The first subsection reviews about interpretive media.

2.6.1 Interpretive Media

There are two types of interpretative media: personal and non-personal media (Timothy & Boyd, 2003). Personal media is a media that utilizes human to assist the visitors in getting the information. However, non-personal media is any kind of media, printed media or electronic media that does not require human to assist visitors in delivering information.

2.6.1.1 Personal Media

Guided tours are examples of personal media. These tour guides give talk and lectures to the visitors to help visitors understand about the site (Timothy & Boyd, 2003). This talk opens up possibility of two-way communication. Other type of personal media is staff who acts as information provider when visitors ask questions regarding to cultural heritage site.

Personal media usually incorporates living character and cultural demonstrations as media representation. This can be done with interpreters' performance to simulate a specific situation in the current era by speaking in the traditional language, wearing traditional clothes, and telling traditional stories. Furthermore, visitors are also able to conduct self-exploration by participating in events, such as, baking a traditional cake and sewing traditional clothes.

2.6.1.2 Non-Personal Media

Non-personal media is a common media in heritage sites that is categorized into two types, visual and audio. The visual media is in the form of brochures, maps, leaflets

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and books that are provided at information centre. Audio guide is an audio device that provides information in audio about cultural heritage site.

Above all, non-personal media covers the media equipped at cultural heritage site, which include signs, self-guided audio tour and electronic media. Signs are used to show visitors objects or places at cultural heritage site. It can be in the form of cues on the way to sites or symbol of important station at sites. Besides, self-guided audio tour supports audio of multiple languages and historical information about the site. Moreover, electronic media uses technology to assist visitors, such as virtual reality (VR) and AR. The projects that implement AR are ARCHEOGUIDE (Vlahakis et al., 2001); iTACITUS ("iTACITUS," 2007); MART (Kim & Park, 2011); SkyLineDroid (Armanno et al., 2012); AR-based On-Site Tour Guide (Seo et al., 2011); SHMAR (Angelopoulou et al., 2012); Techcooltour ("Techcooltour," 2013) ; Smart Virtual Exhibition (Ciurea et al., 2014); LIFEPLUS (Papagiannakis et al., 2002); Immersive Tour Post (Park et al., 2006); PRISMA (Fritz et al., 2005); ARCO (White et al., 2004); and GEIST (Braun, 2003; Kretschmer et al., 2001).

2.6.2 Theory of Informal Learning at Cultural Heritage Site

There are six theories related to theory of informal learning at cultural heritage site, which are informal education at cultural heritage site (Light, 1995a), interpretation principles (Tilden, 1977), Mindfulness (Moscardo, 1996), communication theory (Ham, 1992), and museum experience model (Falk & Storksdieck, 2005). These theories are explained in the next subsections.

2.6.2.1 Interpretation Principles

Interpretation principles are proposed by Tilden (1977). It consists of six fundamental principles of interpretation that have been used as guidance for interpretive planning program since mid-twentieth century. The followings explain the principles:

a. Any interpretation that does not relate about what is being displayed or described to something within the personality or experience of the visitor will be sterile.

   This statement asserts that interpretation should relate the content information to the personal life of visitors.

b. Information, as such, is not interpretation. Interpretation is a revelation based upon information. However, all interpretation includes information.

   Interpretation is not information but it is the understanding of information. Information is the message evaluated by visitors. The meaning between these two should not be misunderstood.

c. Interpretation is an art, which combines many arts, whether scientific, historical or architectural.

   Interpretation should be a creative process that combines many arts into one media.

d. The chief aim of interpretation is not instruction, but provocation.

   The main objective of the interpretation is to provoke positive action from visitors. This can be done by creating relationship between visitors and cultural heritage.

e. Interpretation should aim to present a whole rather than a part, and must address itself to the whole man rather than any phase.

Cultural heritage is needed to be presented as a whole in integrity and unity (Malpas, 2007).

f. Interpretation addressed to children (for instance, age of twelve) should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best it will require a separate program.

Children and adult group should obtain different interpretation program (Timothy & Boyd, 2003).

This theory provides the basic principles of interpretation that relates to enjoyable informal learning as the main component of conceptual model.

2.6.2.2 Mindfulness

According to Walker (2007), mindful means care to the world around us. On the contrary, mindless is a situation when a person is not active to process new information. Mindfulness theory provides factors that are related to interpretive communication at heritage, which are, "Communication" and "Visitor" (Moscardo, 1996) (refer to Figure 2.38). Communication is a factor associated with interpretation and visitor is a factor representing the visitor's mind. These factors are not always the same and changeable at different times.

The process starts with each positive element in communication factor influencing visitor factor (high level of fatigue and interest in content), then goes to the cognitive state (mindful). This results in more learning outcome, high satisfaction and greater understanding. The result is different if there is lack of communication factor.

The following are details of communication factors for mindful character:

a. The Variety / Change

Multisensory, audio visual and dynamic interpretive techniques are required to enhance visitor attention and learning (Moscardo, 1996).

b. Use of questions

Questions are needed to increase visitor's learning. It is one of the cognitive orientation devices for mindful visitors to recall the knowledge they have got. Furthermore, guided tours, pre-visit instruction and organization of exhibit material are other types of cognitive orientation devices.

c. Visitor control / Interactive exhibits

Interactive material is useful to catch and keep visitors' attention as well as to improve their learning and interest (Moscardo, 2001). Moreover, by giving the chance for visitors to control the information, makes their level of interpretation is also increased.

d. Connection with the visitors

An effective interpretation is the one which can relate visitors' present experience to the prior experience. This is necessary as visitors' interest does not always remain constant throughout the visit.

e. Good physical orientation

Visitors who easily find their way inside the built heritage are more mindful than those who do not. Therefore, presence of maps and signs are highly needed for the visitors.

f. Repetition

Repetition of the exhibits is not effective for interpretation as it has potential to

induce mindfulness.

i. Novelty/conflict/surprise

Surprise, conflict or novelty factor is important to keep the interest of visitors and

wake them up from boredom and tiredness.

COMMUNICATION FACTORS VISITOR FACTORS COGNITIVE STATE CONSEQUENCES
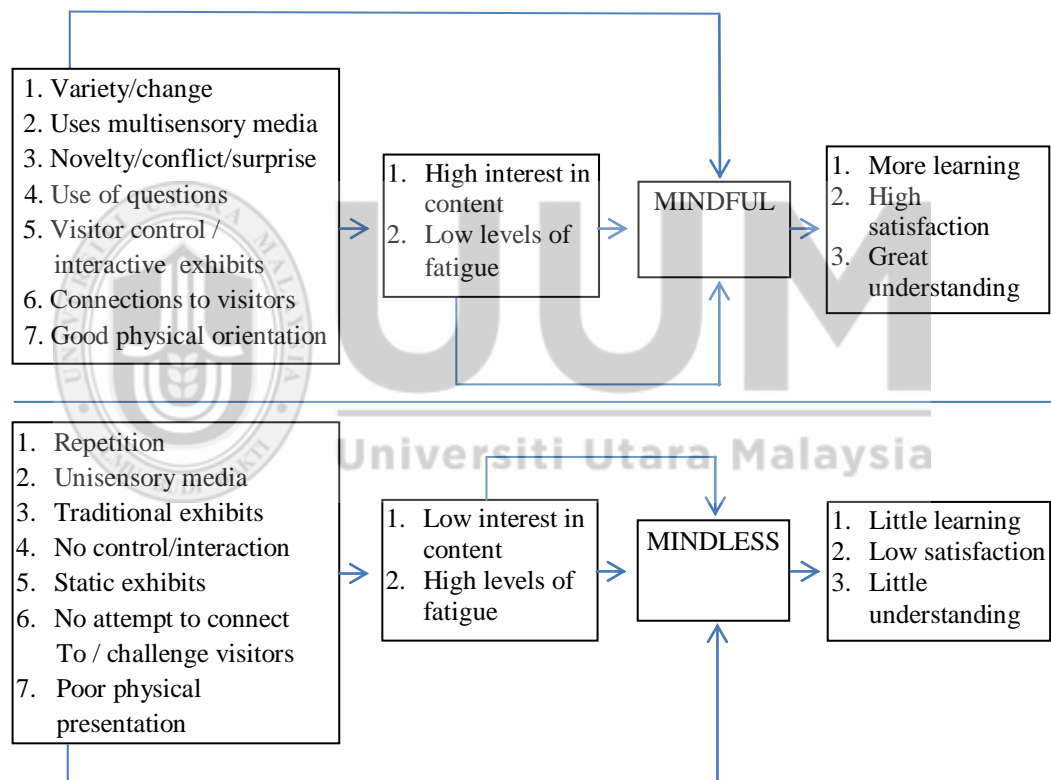
Figure 2.38. Mindfulness for Communication
Source: (Moscardo, 1996)

These factors contradict with factors in mindless characters. The model shows the

indicator of mindful visitors at heritage site. Furthermore, mindful and mindless also

have main features, conditions, and outcomes which are explained in Table 2.13.

Table 2.13

Characteristics of Mindfulness and Mindlessness

Visitor's Type	Main Features	Conditions	Outcomes
Mindfulness	Receptive to learning	New and different settings	Feelings of control
	Aware to the setting	Control and choice	Feelings of achievement
	Create new routines	Different and changing situations	Feelings of fulfilment
		Personal significance	Capability to deal with problems
			Learning and recall
Mindlessness	Use existing routines	Familiar setting	Feelings of helplessness
	Little attention to the setting	Little control, few choices	Feelings of incompetence
	Use existing routines	Recurring situations	Feelings of dissatisfaction
		No personal relevance	Limited capability to handle problems
			No learning, poor recall

Source: (Moscardo, 1999, as cited in Timothy & Boyd, 2003; Moscardo, 2001)

In summary, mindfulness theory demonstrates different characters of visitors at heritage site. There are two characters which are illustrated in the communication model, mindful and mindless. The characters are influenced by communication and visitor. The visitor is determined by interest, cognitive schemata, and fatigue level. All the visitor elements are defined by communication. The results of process produce higher learning outcome, high satisfaction and more understanding of heritage for mindful visitors, which are obtained the other way around by mindless visitors.

The mindfulness theory can be used as the concept for informal learning at cultural heritage site for this study. It deliberates extensive work for achieving mindfulness that relates to interpretation or informal learning at cultural heritage site.

2.6.2.3 Museum Experience Model

Museum experience model contains guideline of context which influences museum experience (Falk & Storksdieck, 2005). Museum experience model has three contexts, which are personal context, social context and physical context (refer to Figure 2.39). This model considers that visitors have different experience because visitors bring their own personal and social context. This study has also been applied to physical context by which visitors are influenced differently. Visitors choose what aspect they focus on for each context. The following are explanation of contexts in museum experience model:

a. Personal context

Personal context related to the inner value in visitors:

• Motivation and expectations

Intrinsic motivation is the fuel for having informal learning at cultural heritage site. It is considered as emotional experience. Emotional experience is a type of experience which will be remembered and marked by the brain.

• Prior knowledge and experience

Knowledge is constructed by the collection of existing knowledge and new knowledge. New knowledge is developed to confirm the existing knowledge. The existing knowledge is the source for further learning or to storing new knowledge.

• Prior interests and believes

Prior interests and believes influence visitors on accepting the new knowledge.

• Choices and control

Choices and control assist visitor to obtain the knowledge.

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b. Social context

Social context is related to visitors' surrounding, for instance, group members and museum staff.

- Within-group sociocultural mediation

  Learning is a social process where visitors' shares and build the knowledge with others.

- Facilitated mediation by others

  Social interaction with museum staff can enhance the museum experience.

c. Physical context

Physical context is related to physical things provided in the museum. The following are the physical context:

- Advance organizers, consisting of leaflets, websites, signs
- Orientation to the physical space, consisting of clear entrance gate, ticket locket, route, pace
- Architecture and large scale environment, consisting of large and small object, rest area, café, restroom, shop
- Design of exhibits and interpretation / content delivery, consisting of interpretation devices, interactive audio-visual, hands-on interactive space
- Reinforcing events and experiences outside the museum, consisting of post-visit online feedback.
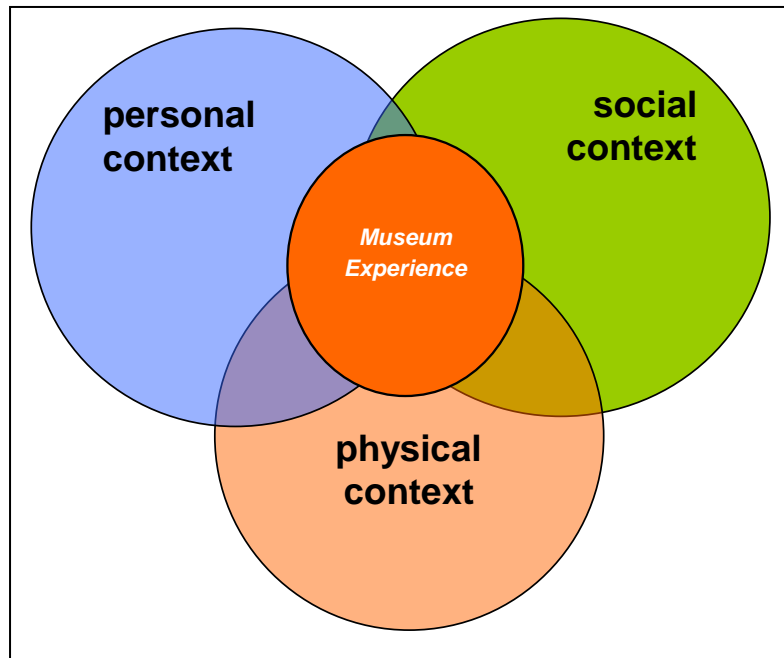
Figure 2.39. Museum Experience Model
Source: (Falk & Dierking in Smit, 2013)

Museum experience model provides context that influences visitors' experience at the museum. These contexts are similar to contexts at cultural heritage site. Therefore, this theory contributes highly on motivation, connection with visitors, choices and control, social interaction, and content delivery in designing the proposed conceptual model.

2.6.2.4 Communication Theory

According to Ham (1992), interpretive approach to communication consists of the following features: pleasurable (entertaining), relevant (meaningful and personal), organized (does not require much effort to be followed) and has a theme (has major point to communicate the message). This is because interpretation has different method to transfer the knowledge to visitors. Since, visitors at heritage sites are categorized as "non-captive" audiences whom are a volunteer and have no time

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commitment. Therefore, interpreters have to work hard to attract visitors to listen to their explanation. This communication technique is a good approach to conduct interpretation. Therefore, this theory can be implemented in developing conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

2.6.2.5 Implications of Theory of Informal Learning at Cultural Heritage Site to the Study

In general, theory of informal learning at cultural heritage site provides significant contribution for conducting informal learning at cultural heritage site. Interpretation theory demonstrates basic principle of interpretation. Meanwhile, mindfulness theory explains factors that influence visitors to be mindful at cultural heritage site. In addition, communication theory provides approach to communicate with visitors at cultural heritage site. Lastly, museum experience model provides guideline of context that influences museum experience that is similar to contexts at cultural heritage site. All these theories provide important points of informal learning at cultural heritage site that can be applied in designing conceptual model.

The next section demonstrates explanation of enjoyable informal learning.

2.7 Definition of Enjoyable Informal Learning

This section examines definition of enjoyment, design of enjoyable technology, and informal learning which results in the concept of enjoyable informal learning that is implemented in the study. The first subsection provides definition of enjoyment.

2.7.1 Definition of enjoyable

Enjoyment is a noun that comes from the verb "enjoy". Enjoyment means a feeling of pleasure caused by doing or experiencing something you like (Meriam-Webster Dictionary[1]). This is similar with the definition provided by The Free Dictionary by Farlex[2], Oxford Learner's Pocket Dictionary (2008), and Collins Cobuild Advanced Dictionary of American English (2007). Meanwhile, Webster New World Thesaurus defines enjoyment as the result of obtaining or fulfilling one's desire (Webster Thesaurus, 1985).

Besides, Lin et al., (2012), considered that enjoyment involves three dimensions: (i) engagement, a person should engage and focus in activity with high levels of attention, (ii) positive effect, a person feels good, a feeling that is aroused from satisfaction, happiness or similar emotions, (iii) fulfilment, a person feels to be fulfilled by doing some activities that make him/her achieve his/her needs. Davis, a psychologist, had come with a theory of enjoyment that X is enjoying Y if Y is causing X to have an additive amount of pleasure of what X is experiencing (Davis, 1982). Other definition proposed by Warner (1980)defines enjoyment as an activity that contains pleasure and fulfils desire in certain amount of time. Whereas (Beck, 1945) has other definition of enjoyment, as she stated that it is not a joyful feeling but it is the effect of satisfaction of needs or natural impulse that human experiences. Furthermore, a different point of view of enjoyment has also been conveyed by Dishman et al., (2005) stating that enjoyment is a feeling that occurs in a physical

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[1] http://www.merriam-webster.com/dictionary/enjoyment
[2] http://www.thefreedictionary.com/enjoyment

activity which is proximal and a tangible influence of behaviour that provides an immediate reward as being active in physical.

In relating to the study, the word "enjoyable" is the adjective of enjoyment. It is defined as not frustrating, enjoyable, and delighted as stated by Ariffin (2009). Furthermore, Oxford Thesaurus (Oxford Thesaurus, 2008), Roget's Super Thesaurus (Roget's Thesaurus, 2003), and Encarta Essential Thesaurus (Encarta Thesaurus, 2002), categorized enjoyable as word which has similar meaning with entertaining, amusing, delightful, pleasing, satisfying, and agreeable. This study classifies enjoyable as portrayed in Table 2.14.

Table 2.14

Definition of enjoyable

Expert	Definition	Word
Lin et al., (2012)	i) Engagement ii) Positive effect, e.g. : happy, satisfy iii) Fulfilment	Engaged, happy, satisfied, fulfilled
Davis (1982)	X is enjoying Y if Y is causing X to have an additive amount of pleasure of what X is experiencing	Pleased
Warner (1980)	An activity that contains pleasure and fulfils desire in certain amount of time	Pleased, fulfilled
Beck (1945)	it is not a joyful feeling but it is The effect of satisfaction of needs or natural impulse that human experiences	satisfied
Dishman (2005)	A feeling that occurs in a physical activity which is proximal and a tangible influence of behaviour, that provides an immediate reward as being active in physical.	Active, physical
Ariffin (2009)	Not frustrating, enjoyable, delighted	Not frustrating, enjoyable, delighted
Oxford Thesaurus(Oxford Thesaurus, 2008), Roget's Super Thesaurus (Roget's Thesaurus, 2003), and Encarta Essential Thesaurus (Encarta Thesaurus, 2002)	Entertaining, amusing, delightful, pleasing, satisfying, and agreeable	Entertained, amused, delighted, pleased, satisfied, agreed

This study calculates frequency of words for seven definitions. It resulted pleased (3), satisfied (3), fulfilled (2), delighted (2), and the rest, (engaged, happy, active, not frustrating, enjoyable, entertained, agreed (1)). Therefore, the study decides to define enjoyable with the feeling that is related to pleased and satisfied.

2.7.2 Design of Enjoyable Technology

This study reviews design of enjoyable technology as it is related to the implementation of mobile AR technology in conducting enjoyable activity. It is defined by Brandztæog et al. (2005) which is explained in the following points.

a. User control and participation

A set of challenges and activities should be embedded in the technology for users to feel the enjoyment. The activities should enable users to test their skills which should make users to have feel of control while doing activities. Then, they can see the effect of their actions as a sense of personal power. The key point of enjoyable experience is the active participation that is given to users.

b. Variation and multiple opportunities

The opportunities to change or customize the product should be given to users. The set of setting that enables users to personalize the product gives users the feeling of control. These changes are chosen under a series of options and variations.

c. Social opportunities and social cohesion

Technology should allow users to do things collectively in a group of people. It should bring users to cohesion of society where users can interact and feel as part of the group.

2.7.3 Informal Learning

Self-paced learning is also referred as self-directed learning (Mocker & Spear, 1982; Lowry, 2004; Smith, 1996; Bennet, 2010; Schugurensky, 2000). It is a type of learning where learner has the most control during process (Mocker & Spear, 1982). They can control the objective and means of learning, such as deciding who is in charge, what should be learned, who should learn, what methods and resources should be used and how success of effort should be measured (Lowry, 1989).These characteristics made learners aware and have intention to learn (Bennet, 2010) without force or pressure. Mostly, self-paced learning is undertaken without any assistance from teachers or mentors (Schugurensky, 2000) and conducted from any resources and any place (Lowry, 1989).

This study is scoped to cultural heritage site. Therefore, informal learning definition that is used in the one that refers to cultural heritage, which is, interpretation. Interpretation combines theory of education and tourism. Interpretation is related to mindfulness where visitor constructs the new knowledge. Mindfulness or mindful, is the characteristic of being aware and in control. It means the act of visitor to care to the world around him/her and processes new information actively (Walker, 2007).

Mindful is influenced by two components: communication and visitor (Moscardo, 1996). These two components determine the mindfulness based on level of fatigue and interest in content. If these factors transfer good factors, the visitor will be mindful. The visitor will learn, feel satisfied and understand greatly (Moscardo, 1996). Therefore, this study implements mindfulness theory to define the criteria of

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informal learning at cultural heritage site. A detailed explanation about mindfulness theory is provided in Section 2.6.2.

2.7.4 Enjoyable Informal Learning

As mentioned in page 108, enjoyable is defined based on enjoyable definition, which is pleased and satisfied. Enjoyable is also reflected in design of technology. Design of enjoyable technology should fulfil three criteria, user control and participation, variation and multiple opportunities, and social opportunities (Brandztæog et al., 2003). These three criteria should be provided to make user enjoy while using technology. Next, informal learning theory used in this study is mindfulness theory. This theory provides factors that affects visitor to acquire knowledge at cultural heritage site. It is appropriate for this study as it also discusses about learning at cultural heritage site.

The definition of enjoyable, requirement of design of enjoyable technology and mindfulness theory were gathered and united in order to form criteria of enjoyable informal learning. The criteria of enjoyable informal learning is portrayed in Figure 2.40.

a. Variety of media

Implement multisensory, audio visual, and dynamic interpretive techniques to help visitors learn at cultural heritage site.

b. Use of questions

Questions that recall visitors' learning after visit the cultural heritage site.
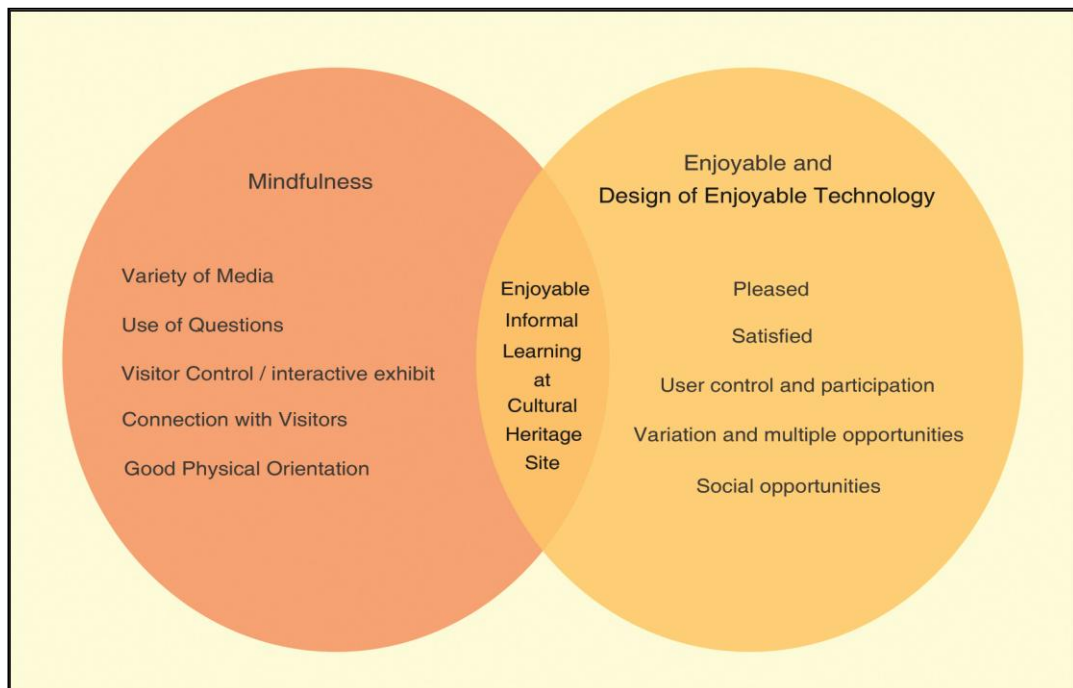
*Figure 2.40.*Enjoyable informal learning at cultural heritage site

c. Visitor control

Control from visitor, for example, giving option to view information, increases the level of interpretation.

d. Connection with visitor

The content of interpretation should connect with prior experience so visitors can always remain interested throughout the visit.

e. Good physical orientation

Knowing where they are will help visitors to always be mindful at cultural heritage site.

f. User control and participation

Provide options to control the flow of information and active participation to boost enjoyment of visitors.

g. Variation and multiple opportunities

Facilitate visitors with a variety of choices to personalize the application.

h. Social opportunities

Enable visitors to interact and discuss about content with group members while visit the cultural heritage site.

i. Pleased

Pleased is a feeling invoked when a person encounters to desirable but unexpected situation in using a product (Hassenzahl, 2003). There are fifteen experience characteristics that invoke pleasure in using mobile AR based on study done by Olsson (2012):

- Empowerment: feelings of strength and accomplishments to be facilitated by new tool. AR can make empower user by overlaying virtual object in the real world in the same time that stimulates insight of using tool that is not existed before (augmentation), provide new way to gain information about places, services, and products (information embedding), and remind user of services and features (proactivity).

- Meaningfulness: Feeling of having personal and meaningful activity. AR can makes user feeling meaningful by personalizing content based on needs and preferences (contextuality and personalization), user-generated content (community-created content), and information about services and products nearby user's location embedded to real world (information embedding).

- Awareness: feeling of being aware of current environment (unfamiliar environment), have better understanding of familiar location, and gain information about physical risk which caused by over immersion in AR. AR can

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make user feel aware by the characteristic of augmenting virtual object in the real world (augmentation), information embedding to real object and locations (information embedding), user-generated content that build collective participation (community-created content), and provision of information about current location that makes user is aware of the current location (proactivity).

- Amazement: feeling of being amazed to experience novel things. AR can amaze user by presenting augmented content in real environment in the first time use (augmentation) and novel interaction that derived from creating content and touch interaction (input and control), and proactive reminder about information and features (proactivity).

- Surprise: feeling of astonishment and pleased to have unexpected performance. AR can make user surprise by providing contextual information (contextuality), availability of diverse and quantity of information (community-created content) and receiving automatic information about current location (proactivity).

- Playfulness: feeling of playful and happy of content and interaction. AR can makes user feel playful through the novelty value of AR that overlays virtual object in the real world (augmentation), novel way of interaction that consists of creating content and touch interaction (input and control), information embedding to real world (information embedding), and user-generated content (community-created content).

- Liveliness: feeling of dynamic and alive with the continuous change in the mixed-reality environment. AR can make user feel alive through the control of interaction and amount of information that invokes feeling of vivacity (augmentation), user-generated content that create interaction between user

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(community-created content), and information embedding of virtual information to the real object that makes user always feel alive (information embedding).

- Captivation: feeling of being captivated, engaged, being present and being in the flow in the interaction with the mixed reality environment. AR can captivate user through augmentation of virtual object in the real environment (augmentation) and interaction with the virtual object (input and control).

- Tangibility: feeling of having tangible and physical interaction with augmented environment. AR can makes user feeling real and concrete through user's control of interaction and amount of information (augmentation), touch interaction (input and control), and interaction with the virtual content embedded in the real world (information embedding).

- Connectedness: feeling of pleasure for getting in touch with friends and knowing the shared information. AR can connect user through content sharing and product commenting that allows user to communicate indirectly (information embedding) and mobile characteristic that makes user always feel connected anytime (mobility).

- Collectivity: feeling of contributing to community by generating content for system. AR can create sense of community by enabling user to generate content by him / her (community-created content) and allow interaction with virtual information embedded in real world (information embedding).

- Privacy: feeling of having privacy about personal information that is revealed in system (contextuality and personalization) and also feeling of awkwardness that attained from interaction that used many gestures (input and control).

- Inspiration: Feeling of being inspired and stimulated to try new things. AR can inspire user through the novelty value of blending virtual and reality information (augmentation), user-generated content (community-created content), digital information embedded in the real environment (information embedding), and the limited additional AR service and contextualization of AR that is attached only to certain place (contextuality and personalization) .

- Motivation: feeling of being motivated to participate in community and perform task with AR's help. AR can motivate user by allowing user to generate the content by him/herself that makes user enjoy the content (community-created content), the ubiquitous characteristic of AR (augmentation), and the contextualization and limited additional AR service that is provided only for certain location (contextuality and personalization).

- Creativity: feeling of being creative to create things to express artistic feelings. AR can makes user feel creative through the novelty value of superimposing virtual object to the real environment (augmentation) and ability to use real environment as physical context to create artwork which later can be presented in the form of image, audio, and video (information embedding).

These experiences are triggered by certain features that are explained in the followings:

- Augmentation: This applies to characteristics of AR that overlays the virtual object in real environment which causes experience of captivation, intuitiveness, and awareness. This is also followed by control from user to the interaction and amount of information that is presented. The visual and ubiquitous of AR brings

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experience of empowerment, efficiency, liveliness, tangibility, and privacy. The novelty value of AR also creates the experience of amazement, playfulness, inspiration, and creativity.

- Input and control: This refers to provide input to the mobile device and enable visitors to interact with the augmented content. The interaction covers browsing as well as creating and managing content. The interaction can be in the form of interaction-related (creating, managing, editing content) and sensory experience (touch interaction) which creates experience of intuitiveness, captivation, and tangibility. For the novel interaction, it may create the experience of amazement and playfulness.

- Information embedding: embed virtual content to the real object and location. For example: provide information about public transportation and public places. Information embedding brings experience of efficiency, empowerment, meaningfulness, awareness, liveliness, playfulness, inspiration, creativity, tangibility, intuitiveness, connectedness, and collectivity.

- Community-created content: enable user to generate or edit the content to increase the amount, diversity, relevancy and reliability of information. This feature may contribute to experience of liveliness, surprise, collectivity, awareness, motivation, playfulness, meaningfulness and inspiration.

- Contextuality and personalization: adapt the content based on user's context and enable user to personalize the content. It invokes experience of meaningfulness, surprise, inspiration, motivation, and privacy.

- Proactivity: Provide recommendation of places based on user's interest and include it as the reminder location. It contributes to experience of surprise, awareness, amazement, and empowerment.

- Mobility: refers to technology that can be used in mobile context and accessed anytime and anywhere. It contributes to feeling of privacy and connectedness.

Detailed description about experience characteristic and feature is provided in Table 2.15.

Table 2.15

Experience Characteristic and Feature that invokes Pleasure

Experience Characteristic	Description	Feature
Empowerment	feelings of strength and accomplishments to be facilitated by new tool	Augmentation, Information embedding, Proactivity
Meaningfulness	Feeling of having personal and meaningful activity	Contextuality, Community-created content, embedding
Awareness	feeling of being aware of new surrounding and discover new aspect of the surrounding	Augmentation, Information embedding, Proactivity, Community-created Content
Amazement	feeling of experiencing new things that has not been felt before	Augmentation, Input and control, Proactivity
Surprise	feeling of astonishment and pleased to have unexpected performance	Community-created content, Contextuality and personalization, Proactivity
Playfulness	feeling of delight and happy of content and interaction	Augmentation, Community-Created content, Information embedding, Input and control
Liveliness	Feeling of vivid and dynamic for continuous change	Augmentation, Community-created content, Information embedding
Captivation	Feeling of being immersed and engaged	Augmentation, Input and control
Tangibility	feelings of real for interacting with the augmented content	Augmentation, Information embedding, Input and control
Connectedness	feelings of getting in touch with friends and having social interaction	Information embedding, Mobility
Collectivity	feeling of belonging and participating in community	Embedding, Community-created content
Privacy	feeling of private about personal information that is revealed in system such as location and status	Contextuality and personalization, Input, Mobility

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Table 2.15 continued

Inspiration	feelings of being inspired and stimulated about augmented content	Augmentation, Community.-created content, Contextuality and personalization, Information embedding
Motivation	feeling of being motivated to contribute to augment content and give back to society	Augmentation, Community-created content, Contextuality and personalization
Creativity	feeling of artistic for creating augmented content	Augmentation, Information embedding

Source: (Olsson, 2012)

j. Satisfied

Satisfied is a feeling which occurs when someone meets his/her expectation in using a product (Hassenzahl, 2003). There are eight experiences that make user feel satisfied in using mobile AR: awareness, immersion, fascination, and surprise (Olsson, 2012). The followings describe about the experiences:

- Awareness: feeling of being aware of new surrounding and discover new aspect of the surrounding. It is represented by location-based content and augmentation.

- Immersion: feeling immersed in virtual world, feeling real of virtual object that is augmented in the real environment. It is represented by novelty in interaction and merging virtual object in real world

- Fascination: feeling fascinated to see something new that creates wow effect and using tool that is magical. It is represented by novelties in interaction and functionality.

- Surprise: feeling of surprised to see the application performs beyond expectation and also discover useful content. It is represented by the functionality of application and type and amount of content.

2.8 AR Learning Theory

Learning theories that are related to this study are situated learning theory, constructivism theory, and multimedia learning theory. The next subsection explains situated learning theory.

2.8.1 Situated Learning

This theory deals with social contexts. Situated learning shows how to approach technology as a culture that influences the perception of informal learning in community. It also configures the role of teacher and experts in the community of learning (Sefton-Green, 2004). Situated learning through immersive interface, which is, AR, requires transfer as the most important role. Transfer is the implementation of knowledge from a learning context to solve the real world problem (Dede, 2009). Transfer consists of two types: sequestered problem solving and preparations of future learning (Mestre, 2002).

Sequestered problem solving measures the prior knowledge which has been attained to solve the current problem (Schwartz & Bransford, 2005) whereas preparation for future learning measures knowledge by solving problems in real world setting. This type of transfer gives opportunity to perform the solution based on similar context that has been learned before but implemented in different situation (Dunleavy & Dede, 2014). This is contradictory with sequestered problem solving where learning is measured through direct application, such as, standardized test.

Situated learning theory contributes useful idea in designing conceptual model by implementing interaction between visitor and the virtual character (such as noble

people) in the past also simulating important events that occurred at the cultural heritage site.

2.8.2 Constructivism

Constructivism concerns on the process of meaning creation by people. Learners use the prior knowledge to process new information which they obtained (Roussou, 2004). This knowledge is achieved through interaction with the environment and also other resources, namely, database, hypertext and export system (Kettanurak, Ramamurthy, & Haseman, 2001).

According to Driscoll (2004), there are five conditions that enhance learning process: (a) embed learning in complex, realistic, and relevant environments, (b) provide for social negotiations as an integral part of learning, (c) support multiple perspectives and the use of multiple modes of representation, (d) encourage ownership in learning, and (e) nurture self-awareness of the knowledge construction process.

AR is considered as fulfilling these conditions by the release of Sutton Hoo Mobile AR Games (Angelopoulou et al., 2011), SkyLineDroid (Armanno et al., 2012), iTACITUS ("iTACITUS," 2007), Techcooltour ("Techcooltour," 2013), MART (Kim & Park, 2011), and ARCHEOGUIDE (Vlahakis et al., 2001).

This theory suggests the component of constructed learning where visitors can create knowledge by themselves, such as, share and add comment about the information of cultural heritage site to social media.

2.8.3 Multimedia Learning Theory

Multimedia learning is a process where learner constructs the mental model from words and pictures (Mayer, 2005). Words are printed text or spoken text. Pictures are photos, illustration and videos. Activity to present words and pictures in the purpose of learning is called multimedia instruction.

According to Mayer (2005), there are three assumptions for multimedia learning theory:

a. Dual-channel: humans have two separate channels for processing information, auditory/verbal model, visual / pictorial model.

b. Limited capacity: humans have limited time to process information within one time in each channel.

c. Active processing assumption: make meaningful learning, involving selecting information, organizing information and integrating information with the prior knowledge.

These three assumptions lead to the three processes of cognitive theory. These processes consist of the total of five processes that occur in sensory memory, working memory and long-term memory. The processes are as follows:

a. Selecting relevant words

   The learners should choose which relevant message is important to them. The words could be narrated or spoken words that are presented. It also could be printed text or on-screen text. For spoken words, the auditory channel will process the words, and it will be processed in visual channel if it is a printed text. The

input has to be selected since the capacity of each channel is limited. The output of this process is sound that is obtained through the words that have been selected.

b. Selecting relevant images

It is not much different with selecting the words. Since this activity is related with images, learners must choose the most relevant images that is useful for them. They need to focus only to a part of animation or pictures in verbal channel. It could be in auditory channel too, if the animation is translated into narration version. The output for this process is images from the images that have been selected.

c. Organizing selected words

After the words have been selected, the learners will organize and build the structure representation based on those selected words. This structure of knowledge is called verbal model. Learners should build a simple structure due to the limited capacity for associating all possible connections.

d. Organizing Selected Images

The pictorial model is acquired through organizing selected images. Same with organizing the selected words, learners should build the knowledge structure based on the images that have been selected. This activity is held in the visual channel that has limited capacity. Therefore, learners have the chance to build simple knowledge structure for understanding the images.

e. Integrating words-based and image-based representations

After the words and images have been organized, it is the time to combine the words and images into one integrated representation. This is probably the most difficult step to be done since learners have to build the two single different

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forms. It also built by connecting the material in those forms and relating them to the prior knowledge. The result of this combines pictorial model, verbal model, visual channel, and auditory channel. The messages of these visual and verbal representations are required to be understood. The prior knowledge can be used to help learners to integrate the information.

Moreover, Mayer and his friends also proposed twelve principles in cognitive multimedia learning which are, modality, redundancy, spatial-continguity, multimedia, personalization, voice, segmenting, pre-training, signalling, temporal contiguity, coherence and image(Mayer & Moreno, 2003; Mayer, 2003; Mayer, 2005). All the principles are listed in Table 2.16.

Table 2.16

Principles of Cognitive Multimedia Learning

Principles	Representation	Description
Modality	Animation & narration	Learners learn better from animation and narration than animation and on-screen text.
Redundancy	One representation only	Learners learn better when the extraneous resources are discarded. However, it will be better when animation and narration are presented, compared to animation, narration and text at the same time.
Spatial-contiguity	Text and pictures	Learners learn better when text and pictures are near to each other.
Multimedia	Text and pictures combine together	Learners learn better from words and pictures than from words alone.
Personalization	Words	Learners learn better when the words are in conversational style than in formal style.
Voice	Words	Learners learn better when the narration is in spoken in a human voice rather than in machine voice.
Segmenting	Any representation	Learners learn better when message is presented into some segments than in one continuous message.
Pre-training	Any representation	Knows the basic concept, names and characteristic.
Signalling	Any representation	The cue is given as the highlight of information.
Temporal contiguity	Text & pictures	It is better to present the information simultaneously than successively.

Table 2.14 continued

Coherence	Without sound or auditory elements	Learners learn better without music or other auditory material. It is better to exclude the unsupported material.
Image	Pictures	The learning process does not necessarily get better when the speaker's image is on screen.

Source: (Mayer & Moreno, 2003; Mayer, 2003; Mayer, 2005)

All these principles are highly appropriate in designing the proposed conceptual model. It addresses relevant media representation for learning with multimedia which includes AR. The principles can be applied to construct the proposed conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

2.9 Summary

Mobile AR is AR that is experienced through smart-phones or handheld devices (Craig, 2013). It consists of five components, which are, computational platform, display, registration and tracking, wearable input and interaction technologies, and data storage and access (Höllerer & Feiner, 2004).

Conceptual model of mobile AR for cultural heritage site and conceptual model of AR for cultural heritage site have diverse aims which are improving situation of cultural heritage; enhancing visitor's experience; reproducing ancient life at cultural heritage which influence provision of content, features and technique of application. However, these components are not related to enjoyable informal learning content for learning at cultural heritage site which is necessary for cultural heritage site learning.

Enjoyable is defined as feelings that are related to pleased and satisfied. Enjoyable should be reflected to technology by three requirements, user control and participation, variation and multiple opportunities, and social opportunities (Brandztæog et al., 2003). Informal learning at cultural heritage site is usually called, interpretation. Interpretation combines theory of tourism and education. It deals with four theories: interpretation theory, mindfulness theory, communication theory, and museum experience model.

Mindfulness theory provides factors that affects visitor to obtain knowledge at cultural heritage site. Therefore this theory is used for the study. Informal learning theories that are related to AR are situated learning, constructivism, and multimedia learning theory. All theories provide useful ideas for developing proposed conceptual model.
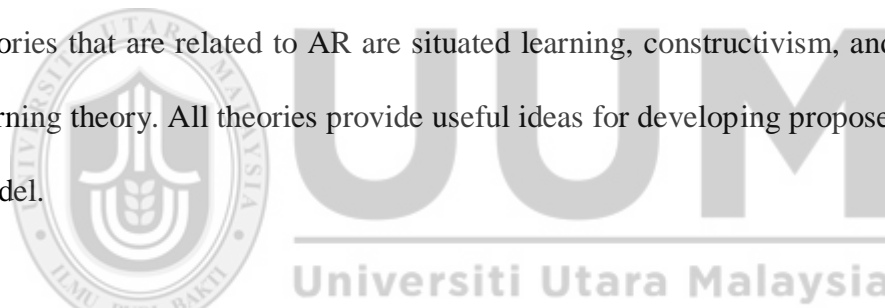
All these fields (mobile AR, enjoyable, and informal learning) were reviewed and analysed. In addition, existing guidelines of enjoyable informal learning, guidelines of designing mobile AR guide for cultural heritage site, mobile tourism application, mobile learning application, and mobile AR framework were also reviewed for determining shared functions for developing proposed conceptual model.

The summary of literature study is illustrated in Figure 2.41.
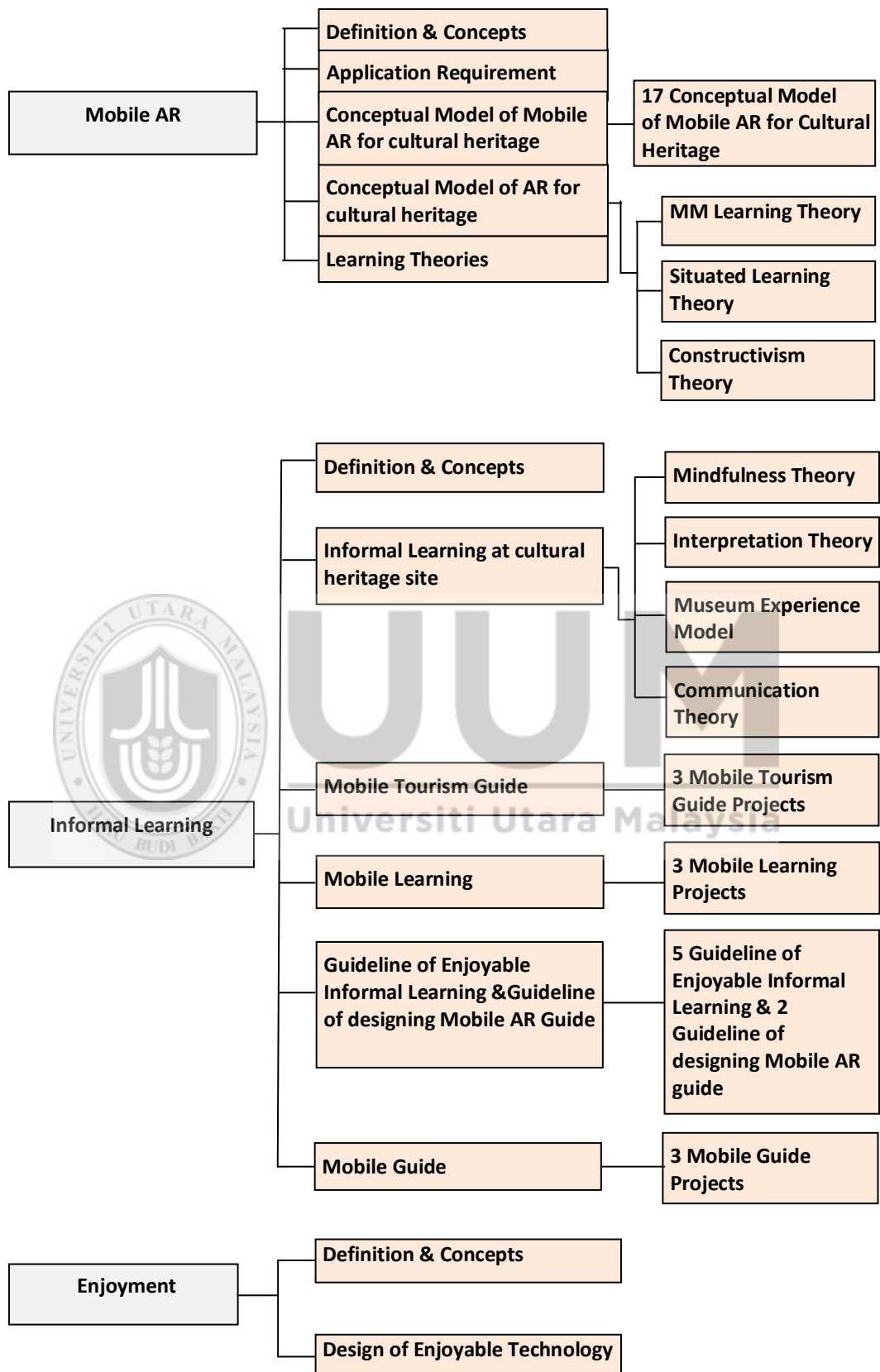
Figure 2.41. Summary of Literature Review

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CHAPTER THREE
RESEARCH METHODOLOGY

Introduction

This chapter explains the design research methodology that has been implemented in this study. This study uses design research methodology to conduct the research. Design research methodology is a methodology that focuses on producing artefact as outcome of study. This methodology is appropriate with the study because it develops a conceptual model as an artefact. The conceptual model has been developed through many phases and activities. These phases and activities on developing and evaluating the model are elaborated in the following sections.

3.1 Design Research

Design research is implemented in many disciplines, such as education, psychology, engineering, and fine arts (Cross, 2001). Design research focuses on creation of artefact that improves situation of environment, institution, and society (Shiratuddin & Hassan, 2013). The artefact can be in the form of constructs, model, method or instantiation (March & Smith, 1995). More importantly, it should fulfil two main characteristics: able to solve relevant important problem and address unsolved problem in innovative way or solve problem in effective way (Geerts, 2011; Hevner & Chatterjee, 2010). The detailed characteristics of design research are provided in Table 3.1.

Table 3.1

Guideline of Design Research

No	Guideline	Description
1	Design as an artefact	It produces construct, model, method, instantiation or better theories.
2	Problem relevance	It aims to develop artefact-based technology to solve relevant and important business problems.
3	Design evaluation	It prioritizes utility, quality, and efficacy of artefact gained from effective evaluation.
4	Research contributions	It provides verifiable contribution in three fields: design artefact, design foundations and/or design methodologies.
5	Research rigor	It depends on the rigorous method of construction and evaluation of design artefact.
6	Design as a search process	It uses existing means and abides rules in the journey of searching the artefact.
7	Communication of research	It disseminates result of research both to people of technology-oriented and management-oriented.

Source: (Hevner & Chatterjee, 2010)

3.2 Rationale of using Design Research

The following are the reasons why this study has chosen design research:

a. Design research concerns with producing the artefact as the end product. This study also produces a conceptual model that is considered as an artefact.

b. Design research aims to develop artefact-based technology that solves relevant problem. The existence of proposed conceptual model is the artefact that is able to solve the problem of the lack of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

c. Design research prioritizes quality of end product based on effective evaluation. The conceptual model was validated through expert review, focus group discussions and prototyping for producing a high quality conceptual model.

d. The context and domain of this study matches the design research since it is under the field of multimedia as well as educational technology. The conceptual model

uses mobile AR that is under multimedia field and caters enjoyable informal learning for cultural heritage which is considered in educational technology field.

The design research methodology is proposed by Vaishnavi and Kuechler (2008). It consists of five phases, (i) awareness of problem, (ii) proposed solutions (iii) development, (iv) evaluation and (v) conclusion. The overall phases is illustrated in Figure 3.1, while, the remainder of the phases are provided in Section 3.3 (phase 1), Section 3.4 (phase 2), Section 3.5 (phase 3), Section 3.6 (phase 4), and Section 3.9 (phase 5).

Phases	Activities	Outcomes

Awareness of Problem

Preliminary Studies: Perception of Users and Media Availability

Research Problems and Scopes

Literature Study and Content Analysis

Components, content and features of mobile AR for cultural heritage site

Review of Conceptual Model of Mobile AR for Cultural Heritage and Conceptual Model of AR for Cultural Heritage

Objective 1

Proposed Solutions

Literature Review on AR Learning theory, Concept of Enjoyable Informal Learning, and Theory of Informal Learning at Cultural Heritage Site

Concepts of learning theories, concept of enjoyable informal learning and mobile tourism guide and mobile learning project

Review of Guideline of Enjoyable Informal Learning for Cultural Heritage and Review of Guideline of Designing Mobile AR Guide for Cultural Heritage

Components and elements of conceptual model of MARCHSTEIL also first version of conceptual model of MARCHSTEIL

Development

Extraction of Enjoyable Informal Learning Concept and Comparative Analysis on mobile AR for cultural heritage, mobile tourism guide, mobile learning, and mobile AR framework

Objective 2

Evaluation

Expert Review for validating Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

Field Study of Enjoyable Informal Learning at Cultural Heritage Site for Gathering User Requirement

Final version of proposed conceptual model of MARCHSTEIL

Focus Group Discussion for re-validating conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning

Objective 3

Review of Related Mobile AR for Cultural Heritage and Mobile Guide for adding novel components of Conceptual Model of Mobile AR for Cultural Heritage towards Enjoyable Informal Learning

Prototyping

MARCHSTEIL prototypes

Evaluation of Enjoyable Informal Learning

Evaluation results

Conclusion

Analyse the Result from Evaluation

Analysis of results

Report Writing and Publication

Publication

Figure 3.1. Research Phase

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The following section elaborates phase of awareness of problem.

3.3 Phase 1: Awareness of Problem

The problem statement of this study is extracted from literature review and content analysis. Next, review of conceptual model of mobile AR for cultural heritage and conceptual model of AR for cultural heritage were done to discover characteristics and limitation of the existing conceptual model. In addition, preliminary studies were also conducted to determine the key issues of AR for cultural heritage. All these steps were integrated to build awareness of the problem as illustrated in detail in Figure 3.4.

3.3.1 Preliminary Study of Perception of Potential Visitor on the Usage of AR at Cultural Heritage Site

The preliminary study was conducted to identify potential visitor's perception on the usage of AR at cultural heritage site. Since AR is considered new, it is important to know potential visitor's perception towards it. This study had obtained the data related to perception of AR implementation, demographic information, and awareness level to visit historical building. Generally, this preliminary study which was conducted from 25th to 29th of June 2012 was joined by thirty respondents concluding the key issues and concepts for this study. Detailed explanation about preliminary study is discussed in Chapter 1 Section 1.3.

3.3.2 Preliminary Study of Availability of Interpretive Media at Melaka Heritage Site

Besides study of perception, study of availability of interpretive media was also embarked. There are three cultural heritage sites that were observed based on the data owned by Melaka Museum Corporations, which are, Porta de Santiago (A Famosa), Saint Paul's Hill and The Middlesburg Bastion Melaka (Melaka Museum Corporations, 2013). These sites were chosen based on definition of cultural heritage site that is provided in operational definition and terminologies in Chapter 1. The preliminary study result shows that signs and interpretive boards were the only two interpretive media provided (100%) (refer to Table 3.2 and Figure 3.2) and text and image were the only types of media (100% and 66.67%) (refer to Figure 3.3).

Table 3.2

Result of Preliminary Study of Availability of Interpretive Media at Melaka

No	List of Cultural Heritage at Melaka City	Interpretive Media	Type of Media
1	Porta de Santiago (A Famosa)	Signs & Interpretive Board	Text
2	Saint Paul's Hill	Signs & Interpretive Board	Text, Image
3	Middlesburg Bastion	Signs & Interpretive Board	Text, Image

Source: (Melaka Museum Corporations, 2013)
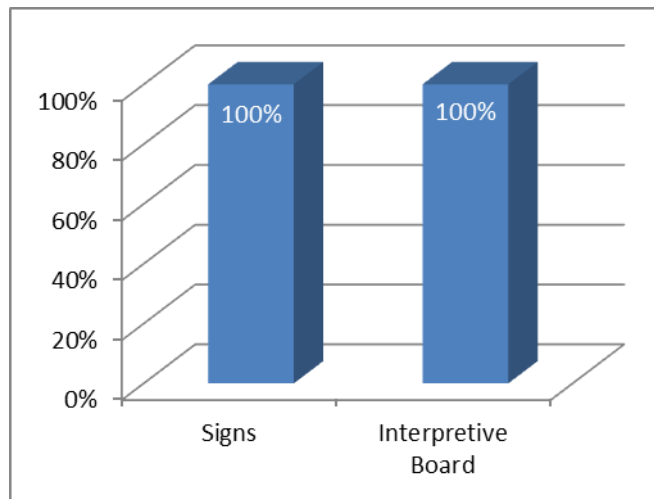
Figure 3.2. Percentage of Interpretive Media at Melaka Heritage Site
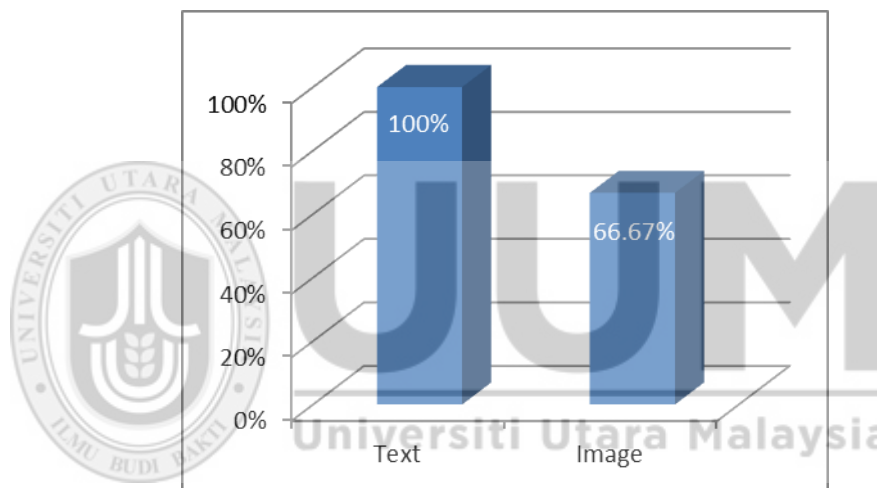
Figure 3.3. Percentage of Type of Media at Melaka Heritage Site

These findings revealed that mobile AR has not been applied at Melaka heritage site yet. Therefore, the implementation of mobile AR at Melaka Heritage Site is highly necessary because AR can support learning at cultural heritage site. It helps visitors to learn more and increase their knowledge while visiting the cultural heritage site.

3.3.3 Literature Review and Content Analysis

This study had reviewed existing literatures about enjoyable informal learning, mobile AR, and also the surrounding topics of these main topics. The review is

provided in Chapter 2. The literatures include books, journals, dissertations, conference proceedings, video, text, and image.

3.3.4 Review of Conceptual Model of Mobile AR for Cultural Heritage and Conceptual Model of AR for Cultural Heritage Site

Review of existing conceptual model of mobile AR for cultural heritage site and existing conceptual model of AR for cultural heritage site were done to identify their characteristics and limitations. The review has produced the gap of study. Detailed explanations about the review of these conceptual models are provided in Chapter 2 Section 2.3.1 and Chapter 2 Section 2.3.2.

Figure 3.4 shows the awareness of problem phase.

Phases	Activities	Outcome

Phases

Activities

Outcome

Preliminary study of Potential Visitor's Perception of Usage of AR at Cultural Heritage Site

Preliminary study of Availability of Interpretive Media at Melaka Heritage Site

Research Gap and Research Scopes

Awareness of Problem

Literature Study and Content Analysis:

(a) AR Concepts and Theories
(b) Informal Learning at Cultural Heritage Site
(c) Enjoyable Informal Learning Concepts and Theories

Concepts and Theories about AR, Enjoyable Informal Learning and Informal Learning at Cultural Heritage

Review of Conceptual Model of Mobile AR for Cultural Heritage

(a) Personalized System Architecture of ARCHEOGUIDE
(b) iTACITUS
(c) MART
(d) Content Management of SkyLineDroid
(e) Framework and Data Flow of AR-based on-site Tour Guide
(f) Architecture System of SHMAR
(g) Techcooltour
(h) Design Guideline for Mobile AR Systems for Heritage Interpretation & Visitor Guiding
(i) Mobile AR Museum Guide
(j) History Unwired
(k) Theoretical Framework for AR-guidance system
(l) Smart Exhibition

Components, Content and Features of Mobile AR for Cultural Heritage and AR for Cultural Heritage

Review of Conceptual Model of AR for Cultural Heritage

(a) GEIST
(b) Mobile System Architecture and Content Database LIFEPLUS
(c) System of ARCO
(d) System of PRISMA
(e) System Configuration of Immersive Tour Post

Figure 3.4. Awareness of Problem Phase

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3.4 Phase 2: Proposed Solution and Development

The proposed solution consists of two main steps, which are, literature review and review of related conceptual model (refer to Figure 3.5). Literature review covered learning theory, concept of enjoyable informal learning, theory of informal learning at cultural heritage site, and mobile projects (mobile tourism guide and mobile learning). Then it was continued by reviewing guidelines of enjoyable informal learning and guidelines of designing mobile AR guides. This review is followed by comparative analysis of mobile AR for cultural heritage sites, mobile tourism guides, mobile learning, and mobile AR frameworks. These activities suggest components in the proposed conceptual model. Details of these activities are provided in the subsequent sections.

3.4.1 Literature Review on AR Learning Theories, Concept of Enjoyable Informal Learning, and Theory of Informal Learning at Cultural Heritage Site

Appropriate AR learning theories, concept of enjoyable informal learning and theory of informal learning at cultural heritage site were reviewed to discover concept of enjoyable informal learning and concept of informal learning at cultural heritage site. These reviews are provided in Chapter 2 Section 2.8 (AR learning theory), Chapter 2 Section 2.7 (concept of enjoyable informal learning), and Chapter 2 Section 2.6.2 (theory of informal learning at cultural heritage site).

Phases	Activities	Outcome

Phases

Proposed Solutions

Development

Activities

Literature Review

(a) AR Learning theory
(b) Concept of Enjoyable Informal Learning
(c) Theory of Informal Learning at Cultural Heritage Site

Review of Guideline of Enjoyable Informal Learning at Cultural Heritage

(a) Conceptual Design Model of RLM
(b) Learning for Fun for Educational Leisure Experience
(c) Design Principles for AR Learning
(d) Design Guideline for Online Enjoyable Informal Learning

Review of Guideline of Designing Mobile AR Guide

(a) User Requirement of Designing MobileAR Guide at Cultural Heritage
(b) Categories of Functions for Mobile AR Guide

Extraction of Concept of Enjoyable Informal Learning

Comparative Analysis Mobile AR for Cultural Heritage, Mobile Tourism Guide and Mobile Learning

Review of Architecture and Framework of Mobile AR

Develop Conceptual Model of MARCHSTEIL

Outcome

Theory of Learning, Concept of Enjoyable Informal Learning, and Theory of Informal Learning at Cultural Heritage Site

Component and Element of Conceptual Model of MARCHSTEIL

Objective 1

Conceptual Model of MARCHSTEIL (Objective 2)

Objective 2

Figure 3.5. Proposed Solutions and Development Phase

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3.4.2 Review of Guideline of Enjoyable Informal Learning for Cultural Heritage Site and Review of Guideline of Designing Mobile AR Guide for Cultural Heritage Site

After reviewing on theory and criteria, review of guidelines was conducted in order to discover component of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. The review analysed guidelines of enjoyable informal learning for cultural heritage and guidelines of designing mobile AR guide for cultural heritage site, which are: Conceptual Design Model of RLM (Ariffin, 2009), Design Guideline for Online Enjoyable Informal Learning (Lin et al., 2012), Design Principles for AR Learning (Dunleavy, 2014), User Requirement of Mobile AR Guide at Cultural Heritage (Toh et al., 2010), and Categories of Functions for Mobile AR Guide (Damala et al., 2007).

Review of these guidelines is provided in Chapter 2 Section 2.4.

3.4.3 Extraction of Concept of Enjoyable Informal Learning

After reviewing and criticizing five guidelines of enjoyable informal learning and two guidelines of mobile AR guide, the process was continued by extracting the concept of enjoyable informal learning into component of conceptual model. This process obtained the components of conceptual model which is explained in detail in Chapter 4 Section 4.2.1.

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3.4.4 Comparative Analysis of Mobile AR for Cultural Heritage Site, Mobile Tourism Guide, Mobile Learning and Mobile AR Framework

After components of conceptual model have been determined, the process was continued by selecting elements of conceptual model. It was done by analysing the element of mobile AR for cultural heritage Site, mobile tourism guide, mobile learning, and mobile AR framework. The analysis produced elements of conceptual model which are provided in Chapter 4 Section 4.2.2, such as 'Media elements', 'Navigation', 'Activity', 'Social interaction', 'Games', 'Presentation style', and 'Mobile technology'.

3.5 Phase 3: Development of Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

Previous activities resulted in the components and elements of conceptual model. All these components were collected and arranged to construct the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. The development process of conceptual model is discussed in Chapter 4.

3.6 Phase 4: Evaluation

The proposed conceptual model was validated through two steps: expert review and focus group discussion. Expert review involved seven experts to validate model based on review form through email communication (See Section 3.6.1). Before continuing with the focus group discussion, the researcher embarked on a field study of enjoyable informal learning content at cultural heritage site in order to respond to review of expert on the novelty of component of conceptual model (see Section

3.6.2). Then, after the component of conceptual model was reviewed based on user requirement of enjoyable informal learning content from field study's result, it was sent to focus group discussion. The focus group discussion validated the model by joining seven experts (see Section 3.6.3). Then, after that, an activity called review of the conceptual model of mobile AR for cultural heritage site and review of mobile guide was completed to act in answering focus group discussion's feedback about the component of conceptual model (see Section 3.6.4). The result from the review was applied in revising the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. At the end, the final version of the conceptual model was produced.

After the conceptual model was ready, it became the guideline for developing the prototype. The prototyping phase was conducted for six months, then, the prototype was evaluated by visitors at Melaka Heritage Site in order to investigate the degree of enjoyable informal learning experience (see Section 3.6.5). Details about each phase are provided in the subsequent section and also portrayed in Figure 3.6.

3.6.1 Expert Review

The main objective of expert review is to validate the conceptual model. It involved seven experts who teach AR/HCI/Multimedia with a minimum of 5 years of experience (Appendix G). The experts came from various countries: Malaysia, France, Korea, Taiwan, Spain, and United States of America. They evaluated the conceptual model based on review form that was attached in email. The review process took about one and a half month from 15th of April until 25th of May 2014.

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The review instrument can be seen in Appendix C and the review result is provided in Chapter 4 Section 4.3.1.

3.6.2 Field Study of Enjoyable Informal Learning Content at Cultural Heritage Site

A field study was conducted to discover the novel component of enjoyable informal learning content at cultural heritage site (refer to Chapter 4 Section 4.3.2).
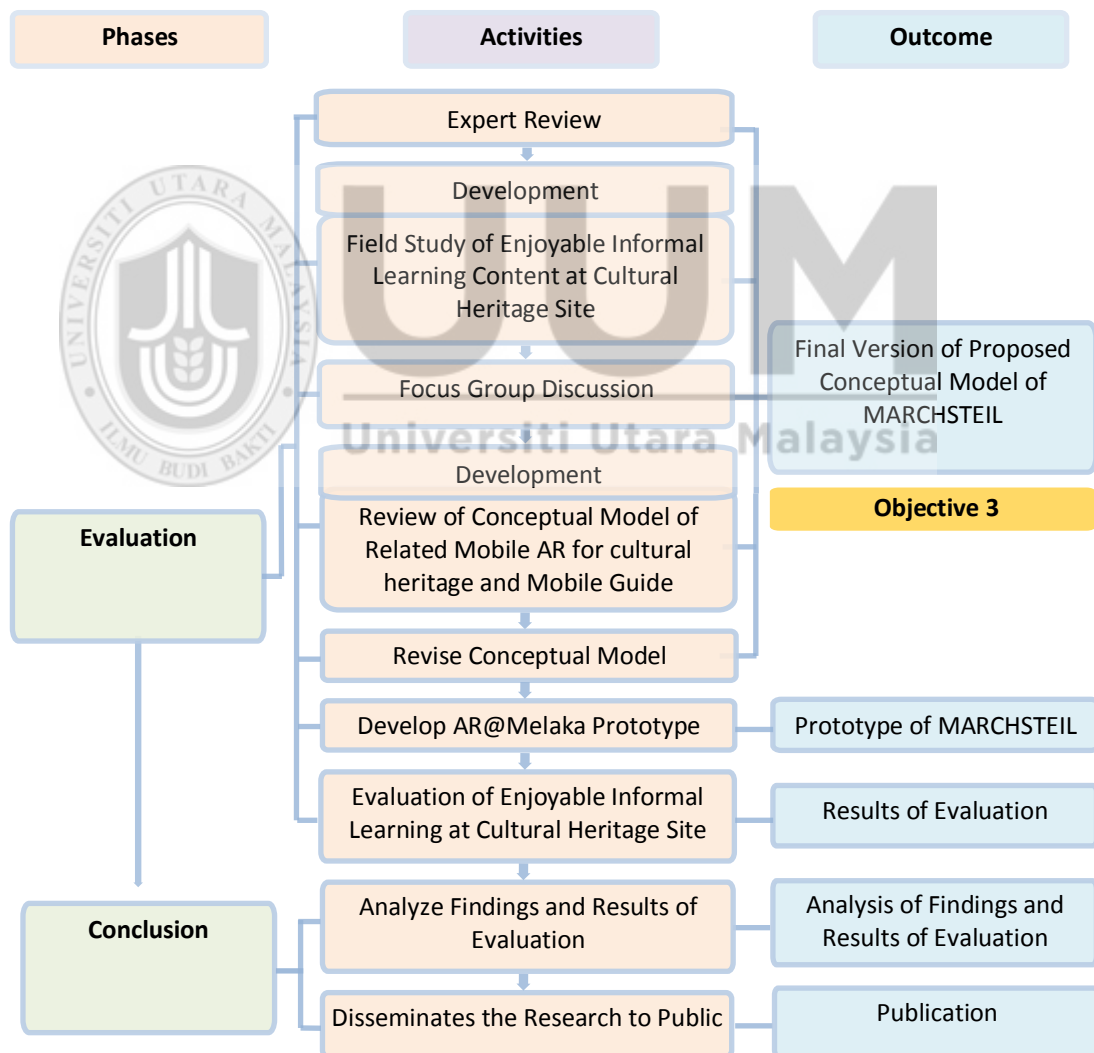
Figure 3.6. Evaluation and Conclusion Phase

It was done by interviewing participants on enjoyable content for learning at cultural heritage site (3D model, 3D character, text, audio, sound, animation, video, and etcetera) to 5 participants in Lembah Bujang Archaeological Site on 31st of May, 2014.

3.6.3 Focus Group Discussion

Focus group discussion was aimed to evaluate conceptual model in the form of discussion. The discussion involved seven experts in the field of AR, Human Computer Interaction (HCI), multimedia, and media studies in order to conduct brainstorming also generate consensus about conceptual model (Wong, 2008). The experts evaluated the conceptual model based on the questions provided in the review form (refer to Appendix E). The discussion also provided a question and answer session to enrich the session. The discussion obtained results that are provided in Section 4.3.3.

3.6.4 Review of Related Conceptual Model of Mobile AR for Cultural Heritage Site and Review of Mobile Guide

Review of conceptual model of related mobile AR for cultural heritage and review of mobile guide were completed to discover related articles as suggested in focus group discussion. The review examined three related conceptual models (Design Guideline for Mobile AR Systems for Heritage Interpretation and Visitor Guiding at Historic Sites, Mobile AR Museum Guide, and History Unwired) and three mobile guide (Mobivisit, DANAE, and Hypermedia Tour Guide). Results of the review are provided in Section 4.3.4.

3.6.5 Prototyping

A prototype was developed based on the conceptual model. The prototype acts as a validation tool for the conceptual model. It was chosen because it is listed as one of validation methods in design research (Shiratuddin & Hassan, 2013). Further deliberation about development process of the prototype is described in Chapter 5.

3.6.6 Evaluation of Enjoyable Informal Learning at Cultural Heritage Site

The evaluation was conducted in order to measure enjoyable informal learning experience. Evaluation was done at Melaka heritage site on June 12th 2014. The total number of respondent was 200 with the respondents' range of age 15-50 years old. This range of age selection is same with a previous study of "Study of perceptions of domestic tourist towards historical building in Ipoh" (Ismail, Harun, & Zin, 2006). The evaluation was done by asking respondents to use the prototype and answered the questionnaire (refer to Appendix F). The results of evaluation were analysed using descriptive analysis. The evaluation processes and results are presented in detail in Chapter 5. Further, the instrument used is described in Chapter 3 Section 3.8.1.

3.7 Samples and Unit of Analysis

The followings are the unit of analysis which were studied at individual level:

a. Participants in preliminary study

   30 participants participated in preliminary study of perception (Chapter 1 Section 1.3) with age ranging from 19 to 47 years old.

b. Experts who reviewed the conceptual model (Chapter 4 Section 4.3.1)

Experts are specialized in the field of AR, learning and cultural heritage and come

namely, Malaysia, Korea, Taiwan, Spain, France and United States of America.

The list of experts is provided in Appendix G.

c. Participants involved in the field study of enjoyable informal learning content at

cultural heritage site (Chapter 4 Section 4.3.2)

They were targeted eight participants as suggested by (Worthen & McNeill, 1996;

Jones & McEwen, 2000). However, five participants joined as volunteers in the

field study. They were visitors at Lembah Bujang Archaeological Site.

d. Experts who evaluated the conceptual model in the focus group discussion

(Chapter 4 Section 4.3.3)

Seven experts joined the discussion. Detailed list of experts is provided in

Appendix H.

e. 200 respondents who participated in the evaluation of enjoyable informal learning

experience are in the range of age of 15 to 50 years old (Chapter 5 Section 5.3).

They represented the visitors of Melaka heritage site.

The following section describes the instruments developed and used for this study.

3.8 Instruments Developed and Used for This study

Instruments developed for the study comprises four instruments: instrument for

expert review, instrument for field study of enjoyable informal learning content at

cultural heritage site, instrument for focus group discussion, and instrument for

evaluation of measuring enjoyable informal learning at cultural heritage site.

Detailed explanations of instruments are explained in the next subsections.

3.8.1 Instrument for Expert Review

The purpose of expert review is to validate the conceptual model. The instrument of expert review consists of questions on demographic profile, terminology of component, description of theory, terminology of content element, terminology of mobile AR technology, and review questions (refer to Appendix C).

The instrument was adopted from the instrument of expert review focus group for study of Conceptual Design Model of ComPDA (Sarif, 2011).

3.8.2 Instrument for Field Study of Enjoyable Informal Learning Content at Cultural Heritage Site

Field study was done to discover the novel components of the proposed conceptual model. It consists of seventeen questions which were taken from the conceptual model and expert review's comments. It asks about factors that support enjoyable informal learning at cultural heritage site, such as media, navigation, games, activity and interaction (refer to Appendix D). The instrument has been validated by experts.

3.8.3 Instrument for Focus Group Discussion

Focus group discussion was the second phase to evaluate the conceptual model. This instrument was adopted based on the instrument of expert review of questionnaire measuring entertaining and fun (Ariffin, 2009). It consisted of seven questions that are similar with questions in the instrument of expert review (refer to Appendix C), provided in the form of open-ended question (refer to Appendix E).

3.8.4 Instrument for Evaluation of Measuring Enjoyable Informal Learning at Cultural Heritage Site

Evaluation of measuring enjoyable informal learning at cultural heritage site was designed to measure enjoyable informal learning experience while using the prototype. It was produced through two cycles of steps: content validity and face validity (first cycle) and content validity and reliability test (second cycle) (Zikmund, 2003) (refer to Figure 3.7).

The process of constructing the instrument was started by selecting the related dimension and statements. According to the concept of enjoyable informal learning (refer to Chapter 2 Section 2.7), the researcher has selected dimensions and items for the instrument. The dimensions are informal learning and enjoyable. The items are statements that are related to the dimensions which were obtained through the analysis of component of first version of conceptual model. Detailed list of dimension and items were constructed in the first version of the instrument (refer to Figure 3.8).
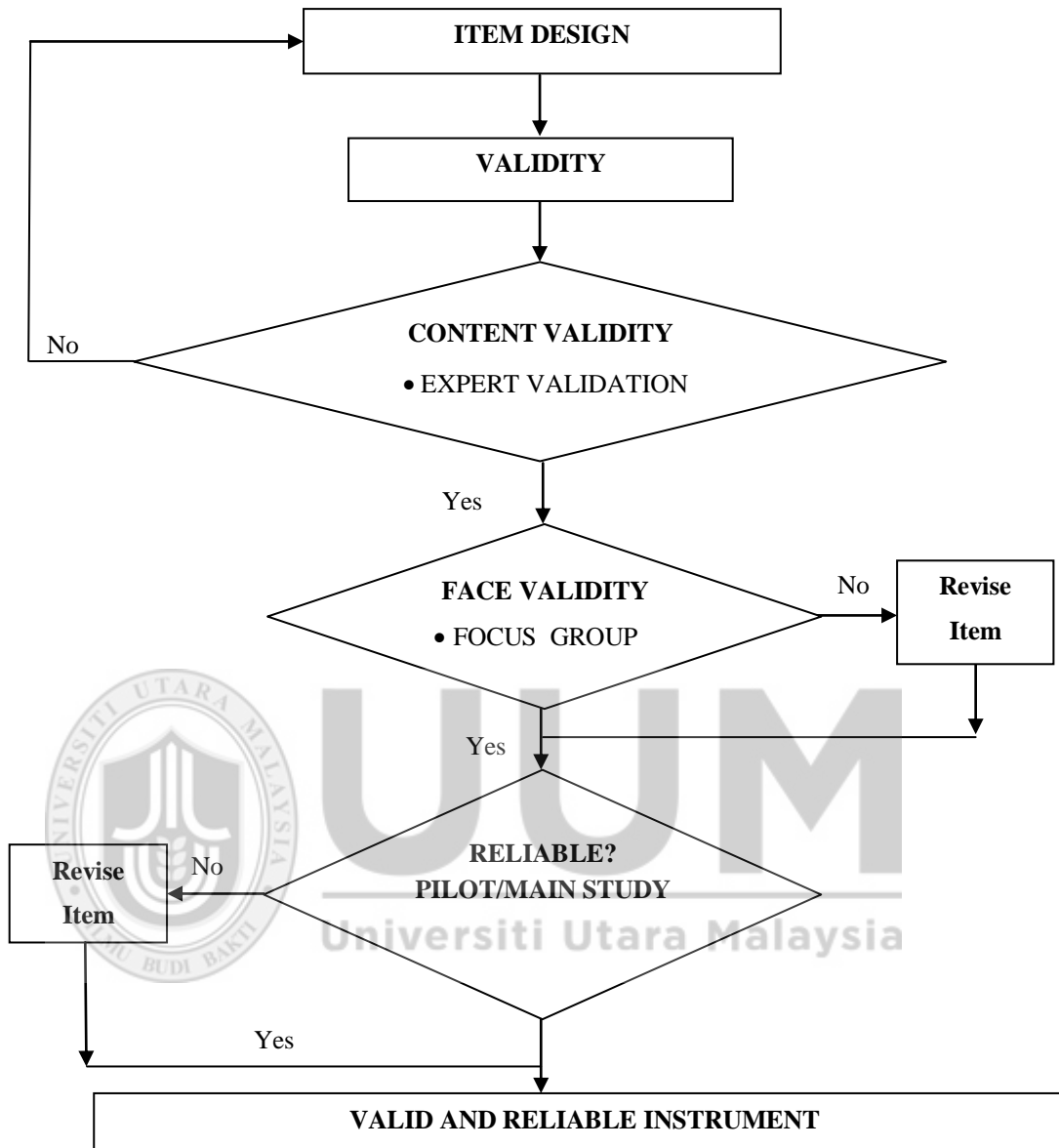
Figure 3.7. Design of Experiment
Source: (Zikmund, 2003)

Then, the instrument was validated through content and face validity. The content validity involved three experts as the minimum requirement for content validity (Scheneiderman, 1992). They must have qualification in AR, Human Computer Interaction (HCI) or cultural Heritage and/or have been studying or researching on AR or HCI or cultural heritage for at least three years.

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	Strongly Disagree								Strongly Agree	
	Sangat Tidak Setuju	1	2	3	4	5	6	7	*Sangat Setuju*	

A Variety of Media

1	A variety of media (3D model, text, image, animation, audio and video) can help me to learn about cultural heritage site.	1	2	3	4	5	6	7
2	I enjoy with the variety of media embedded in the application.	1	2	3	4	5	6	7
3	A variety of media increases my attention about cultural heritage site.	1	2	3	4	5	6	7
4	A variety of media makes the application interactive.	1	2	3	4	5	6	7

B Activity

1	Having notes about my visit help me to recall the learning.	1	2	3	4	5	6	7
2	Saving the information (image, audio, video and etc) that I get during the visit help me to recall the learning.	1	2	3	4	5	6	7
3	I want to be able to access my notes via mobile phone.	1	2	3	4	5	6	7
4	I want to be able to access my notes via computer.	1	2	3	4	5	6	7
5	I want to be able to access my notes via tablet.	1	2	3	4	5	6	7
6	Giving comment about certaat cultural heritage site makes me feel actively participated.	1	2	3	4	5	6	7

C Physical Orientation

1	I can easily find the Point of Interest (POIs) (cultural heritage site).	1	2	3	4	5	6	7
2	I can easily find my current position.	1	2	3	4	5	6	7

D Games

1	I like to answer multiple choice quiz about the cultural heritage site to recall the learning.	1	2	3	4	5	6	7
2	Multiple choice quiz helps me to understand the heritage story better.	1	2	3	4	5	6	7
3	Multiple choice quiz helps me to summarize the important points of things I have learnt.	1	2	3	4	5	6	7
4	Treasure hunt games help me to learn enjoyably about cultural heritage site.	1	2	3	4	5	6	7
5	Treasure hunt encourages me to collaborate with friends on solving the problem.	1	2	3	4	5	6	7

E Enjoyable

1	I enjoy using the application.	1	2	3	4	5	6	7
2	I like the short and simple learning content provided by application.	1	2	3	4	5	6	7
3	I feel fulfilled after using the application for learning at cultural heritage site.	1	2	3	4	5	6	7
4	I have the feeling of pleasure while using the application.	1	2	3	4	5	6	7
5	I like storytelling presentation to learn at the cultural heritage site.	1	2	3	4	5	6	7
6	Storytelling makes me enjoy learning at cultural heritage site.	1	2	3	4	5	6	7
7	I am happy that I can share my activity to social media.	1	2	3	4	5	6	7
8	I am happy to share the information I get to social media.	1	2	3	4	5	6	7

F Informal Learning

1	I obtain new knowledge at cultural heritage site.	1	2	3	4	5	6	7
2	I enjoy learning at cultural heritage site.	1	2	3	4	5	6	7
3	I am getting new knowledge at the cultural heritage site.	1	2	3	4	5	6	7
4	I learn something from the content of the application.	1	2	3	4	5	6	7

Figure 3.8. First Version of Instrument to Measure Enjoyable Informal Learning at cultural heritage site

The experts reviewed instrument through email communication. Then, experts sent the results back to the researcher. After that, the step continued with face validity. Face validity was purposed to evaluate the language structure of the instrument. It involved seven students of UUM from 15 to 50 years old who represented visitors of cultural heritage site. They were local students and international students who had good skill in English language. The results from content validity revealed that the instrument contains some inappropriate items and incorrect formatting. However, feedback from face validity shows that the instrument has a good language structure that makes participant easy to answer and understand question as what it is intended.

After content validity and face validity were completed, the process continued by reconstructing the items through eliciting the works which are related to informal learning and enjoyable. Informal learning items were adapted from Learning in Museum questionnaire (Packer, 2004). There are some questions added by linking the expected outcome of visitors after using the application and mapping the function of application and informal learning. The name of application is AR@Melaka. The questions are, AR@Melaka helps me to understand about history of my country, AR@Melaka helps me to recall what I have learnt about cultural heritage site, AR@Melaka encourages me to collaborate with friends on solving the problem, AR@Melaka allows me to save the information that I get during the visit, and AR@Melaka allows me to share the information that I get during the visit.

Meanwhile, items of enjoyable dimension have been adopted from the study of measuring the enjoyment of web experiences developed by Lin et al., (2008). This

instrument was chosen because it was scoped to enjoyment and conducted in museum that is categorized as cultural heritage and has similar characteristic with cultural heritage site. Furthermore, it has been proven reliable as it has been validated using content validity, factorial validity, reliability, convergent validity, discriminant validity and nomological validity (Lin et al., 2008). In addition, it also matches with the concept of enjoyable informal learning (refer to Chapter 2 Section 2.7.4).

Reconstruction of items for this instrument has also been completed. The process was continued by determining the scale of instrument. The seven scale measurements with the range of interval 0.86 from strongly disagree to strongly agree was used as the scale (refer to Figure 3.9). This number was achieved by dividing the range of scale and the scale as suggested by Zikmund, Babin, Carr, and Griffin (2010).

$$Interval: \frac{Range\ of\ scale}{Scale}$$

$$: \frac{6}{7}$$

$$: 0.86$$

Range of scale: $1 + 0.86 = 1.86$

Figure 3.9. Formula of interval and range of scale

The following is the list of scale:

a. 1 – 1.86   : Strongly disagree

b. 1.87 – 2.73   : Disagree

c. 2.74 – 3.59   : Somewhat disagree

d. 4.00 – 4.45   : Neither disagree nor agree

e. 4.46 – 5.31   : Somewhat Agree

f. 5.32 – 6.17   : Agree

g. 6.18 – 7.00   : Strongly Agree

This process resulted in the second version of instrument (refer to Figure 3.10).

	Strongly Disagree *Sangat Tidak Setuju*	1 2 3 4 5 6 7		**Strongly Agree** *Sangat Setuju*				
A	**Informal Learning**							
1	AR@Melaka helps me to gain new knowledge about cultural heritage site.	1	2	3	4	5	6	7
2	AR@Melaka helps me to understand about the history of my country.	1	2	3	4	5	6	7
3	I enjoy learning at the cultural heritage site using AR@Melaka.	1	2	3	4	5	6	7
4	AR@Melaka helps me to recall what I have learnt about the cultural heritage site.	1	2	3	4	5	6	7
5	AR@Melaka encourages me to collaborate with friends on solving the problem.	1	2	3	4	5	6	7
6	AR@Melaka allows me to save the information that I get during the visit.	1	2	3	4	5	6	7
7	AR@Melaka allows me to share the information that I get during the visit.	1	2	3	4	5	6	7
B	**Enjoyable**							
1	While using the AR@Melaka,							
	a. I was deeply engrossed.	1	2	3	4	5	6	7
	b. I was absorbed intently.	1	2	3	4	5	6	7
	c. My attention was focused.	1	2	3	4	5	6	7
	d. I concentrate fully.	1	2	3	4	5	6	7
2	While using the AR@Melaka, I felt							
	a. Happy	1	2	3	4	5	6	7
	b. Pleased	1	2	3	4	5	6	7
	c. Satisfied	1	2	3	4	5	6	7
	d. Contented	1	2	3	4	5	6	7
3	Learning about Melaka heritage site using AR@Melaka was							
	a. Fulfilling.	1	2	3	4	5	6	7
	b. Rewarding	1	2	3	4	5	6	7
	c. Useful	1	2	3	4	5	6	7
	d. Worthwhile	1	2	3	4	5	6	7

Figure 3.10. Second Version of Instrument to Measure Enjoyable Informal Learning at cultural heritage site

Then, the instrument was continued to be reviewed for the second cycle. The content

validity was executed by the same experts in the first cycle but the numbers of

experts were added by one expert from the field of VR/3D Animation. The review obtained good result where the revised instrument produced better version than the first version, however, it still needed to be improved in terms of content, formatting and Malay translation.

Then, the instrument was revised by taking the feedback from experts. This time, the review aimed to construct the instrument in order to meet the purpose of evaluation, which is to measure enjoyable informal learning. It followed some steps to achieve this goal. Firstly, it reconstructed the informal learning dimension. The items were taken from the concept of enjoyable informal learning (refer to chapter 2 section 2.7).

The concept was analysed and matched with the purpose. The process produced the third version of instrument (refer to Figure 3.11).

After the instrument has been reviewed completely, then it was tested in the pilot study. The pilot study was purposed to test the instrument in order to recognize any limitation in advance (Teijlingen & Hundley, 2014).

The pilot study was tested with 92 respondents. The number of respondents was determined based on principal factor analysis sample size which is between 50 to 100 (Sapnas & Zeller, 2004, as cited in Teijlingen & Hundley, 2014).

	Strongly Disagree								Strongly Agree					
	Sangat Tidak Setuju		1	2	3	4	5	6	7	*Sangat Setuju*					

1	The Mobile AR application allows me to keep attention to the content of application.	1	2	3	4	5	6	7
2	The Mobile AR application allows me to find my way during the visit.	1	2	3	4	5	6	7
3	The Mobile AR application allows me to learn in enjoyable way via different type of media at cultural heritage site.	1	2	3	4	5	6	7
4	The Mobile AR application keeps me to be awake during the visit at cultural heritage site.	1	2	3	4	5	6	7
5	The Mobile AR application allows me to control the information I get during the visit.	1	2	3	4	5	6	7
6	The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.	1	2	3	4	5	6	7
7	The Mobile AR application allows me to learn through story.	1	2	3	4	5	6	7
8	The Mobile AR application helps me to gain new knowledge about cultural heritage site.	1	2	3	4	5	6	7
9	The Mobile AR application helps me to recall what I have learnt about the cultural heritage site.	1	2	3	4	5	6	7
10	The Mobile AR application allows me to learn anytime and anywhere.	1	2	3	4	5	6	7
11	While using the Mobile AR application:							
	a. I was deeply engrossed.	1	2	3	4	5	6	7
	b. I was absorbed intently.	1	2	3	4	5	6	7
	c. My attention was focused.	1	2	3	4	5	6	7
	d. I fully concentrated.	1	2	3	4	5	6	7
12	While using the Mobile AR application, I felt:							
	a. Happy	1	2	3	4	5	6	7
	b. Pleased	1	2	3	4	5	6	7
	c. Satisfied	1	2	3	4	5	6	7
	d. Contented	1	2	3	4	5	6	7
13	Learning about cultural heritage site using mobile AR application was:							
	a. Fulfilling	1	2	3	4	5	6	7
	b. Rewarding	1	2	3	4	5	6	7
	c. Useful	1	2	3	4	5	6	7
	d. Worthwhile	1	2	3	4	5	6	7

Figure 3.11. Third Version of Instrument to Measure Enjoyable Informal Learning at cultural heritage site

The results of pilot study were analysed using factor analysis and Cronbach alpha.

These three steps are required to measure the reliability of instrument.

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Firstly, the data was analysed using factor analysis by calculating the value of Kaiser-Meyer-Olkin (KMO)and Bartlett's test of spherecity (refer to Figure 3.12).

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.903
Bartlett's Test of Sphericity	Approx. Chi-Square	1822.127
	Df	231
	Sig.	.000

Figure 3.12. KMO and Bartlett's Test

According to Behrens (1997), the condition of factor analysis are:

a. KMO value must be greater than 0.50

b. Bartlett's test of spherecity must have significant value of p less than 0.05

The results show that the numbers of KMO and Bartlett's test have fulfilled the conditions. Therefore, factor analysis was confirmed to be executed. After the analysis was completed, the result as shown in Table 3.3 was obtained.

Table 3.3

Factor Loadings

No	Items	Loadings
1	The Mobile AR application allows me to keep attention to the content of application.	.623
2	TheMobile AR application allows me to find my way during the visit.	.572
3	The Mobile AR application allows me to learn in enjoyable way via different type of media at cultural heritage site.	.748
4	The Mobile AR application keeps me to be awake during the visit at cultural heritage site.	.703
5	The Mobile AR application allows me to control the information I get during the visit.	.626

Table 3.3 continued

6	The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.	.743
7	The Mobile AR application allows me to learn through story.	.594
8	The Mobile AR application helps me to gain new knowledge about cultural heritage site.	.754
9	The Mobile AR application helps me to recall what I have learnt about the cultural heritage site.	.586
10	The Mobile AR application allows me to learn anytime and anywhere.	.492
11	While using the Mobile AR application:	
	a. I was deeply engrossed.	.800
	b. I was absorbed intently.	.729
	c. My attention was focused.	.733
	d. I fully concentrated.	.751
12	While using the Mobile AR application, I felt:	
	a. Happy	.802
	b. Pleased	.856
	c. Satisfied	.731
	d. Contented	.739
13	Learning about cultural heritage site using mobile AR application was:	
	a. Fulfilling	.730
	b. Rewarding	.625
	c. Useful	.822
	d. Worthwhile	.812

The rule requires that the factor loading should be greater than 0.5 (Hair, Black, Babin, & Anderson, 2010), which have been achieved by all items. Next, the process was continued by rotating the data using varimax method (refer to Figure 3.13).

The result of rotation shows the items are classified into three factors. These factors were grouped based on characteristics (refer to Figure 3.13). In addition, the blank space was loaded because of the output suppression for factor that is less than 0.1 (Field, 2005).

However, A5, A2 and A10 got the three lowest values. The indication of low score of A5 is because of inadequate experience which was obtained by the respondents during the field study. During the pilot study, the mobile phone was kept by the

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evaluator for most of the time. In addition, the low score of A2 was indicated because of the limitation of device that could not display the route to go to the cultural heritage site. However, there is no indication of reason of the low score of A10 that makes the researcher decided to retain A10 since it represents the informal learning characteristic.

Rotated Component Matrix^a

	Component		
	1	2	3
A15	.846	.255	.148
A16	.816	.172	.400
A11	.747	.418	.259
A14	.700	.459	.223
A18	.698	.373	.336
A13	.690	.319	.393
A17	.648	.302	.469
A12	.633	.537	.199
A3	.242	.789	.259
A6	.434	.727	.162
A7	.324	.692	
A9	.247	.684	.241
A8	.174	.663	.533
A4	.212	.619	.523
A1	.471	.617	.141
A22	.171	.158	.870
A21	.314		.846
A19	.541	.202	.629
A20	.270	.435	.603
A5	.258	.454	.595
A2	.324	.440	.523
A10	.379	.412	.422

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 7 iterations.

Figure 3.13. Rotation of Factor Loadings

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The result shows that all items in factor one is related to enjoyable so it is labelled as a factor of enjoyable. Items in factor two are related with informal learning, which makes this factor a labelled factor of informal learning. Furthermore, items in factor three are related with informal learning at cultural heritage, so it is a labelled factor of learning at cultural heritage site. The rotated components are shown in Table 3.4 until Table 3.6.

Table 3.4

Factor of Enjoyable

No	Enjoyable
A15	While using the Mobile AR application, I felt: Happy
A16	While using the Mobile AR application, I felt: Pleased
A11	While using the Mobile AR application: I was deeply engrossed.
A14	While using the Mobile AR application: I fully concentrated
A18	While using the Mobile AR application, I felt: Content
A13	While using the Mobile AR application: I was absorbed intently
A17	While using the Mobile AR application, I felt: Satisfied

Table 3.5

Factor of Informal Learning

No	Informal Learning
A3	The Mobile AR application allows me to learn in enjoyable way via different type of media at cultural heritage site.
A6	The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.
A7	The Mobile AR application allows me to learn through story.
A9	The Mobile AR application helps me to recall what I have learnt about the cultural heritage site.
A8	The Mobile AR application helps me to gain new knowledge about cultural heritage site.
A4	The Mobile AR application keeps me to be awake during the visit at cultural heritage site.
A1	The Mobile AR application allows me to keep attention to the content of application.

Table 3.6

Factor of Informal Learning at Cultural Heritage Site

No	Informal Learning at Cultural Heritage Site
Learning about cultural heritage site using mobile AR application was:	
A22	Worthwhile
A21	Useful
A19	Fulfilling

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Table 3.6 continued

A20	Rewarding
A5	TheMobile AR application allows me to control the information I get during the visit
A2	TheMobile AR application allows me to find my way during the visit.
A10	The Mobile AR application allows me to learn anytime and anywhere.

To make sure about the categorization and items, a reliability test was executed. The value of Cronbach's Alpha was 0.964 that shows that the value met the minimum condition, which is 0.7 (Sekaran, 2003). Furthermore, in order to know the items to be deleted, the analysis was continued to test the Cronbach's Alpha value if the item is deleted (refer to Table 3.7). The results show that the values of Cronbach's Alpha for each item when deleted do not have a significant difference.

Table 3.7

Result of Frequency and Cronbach's Alpha if item deleted

No	Items	Cronbach's Alpha if item deleted
1	The Mobile AR application allows me to keep attention to the content of application.	.963
2	TheMobile AR application allows me to find my way during the visit.	.963
3	The Mobile AR application allows me to learn in enjoyable way via different type of media at cultural heritage site.	.963
4	The Mobile AR application keeps me to be awake during the visit at cultural heritage site.	.963
5	The Mobile AR application allows me to control the information I get during the visit.	.963
6	The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.	.963
7	The Mobile AR application allows me to learn through story.	.964
8	The Mobile AR application helps me to gain new knowledge about cultural heritage site.	.963
9	The Mobile AR application helps me to recall what I have learnt about the cultural heritage site.	.964
10	The Mobile AR application allows me to learn anytime and anywhere.	.964
11	While using the Mobile AR application:	
	a. I was deeply engrossed.	.962
	b. I was deeply engrossed.	.962
	c. Absorbed intently.	.962
	d. My attention was focused.	.962
	e. I fully concentrated.	.963
12	While using the Mobile AR application, I felt:	
	a. Happy	.802

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Table 3.7 continued

	b. Pleased	.856
	c. Satisfied	.731
	d. Content	.739
13	Learning about cultural heritage site using mobile AR application was:	
	Fulfilling	.730
	b. Rewarding	.625
	c. Useful	.822
	d. Worthwhile	.812

By looking at the result, it had been decided that all items of instrument were retained. However, the statement of A2, A5, and A10 were rephrased in order to deliver clearer meaning to the respondents.

The final version of instrument is provided in Figure 3.14 and Appendix F.

3.9 Phase 4: Conclusion

In the final phase, the results of evaluation went through the analysis process (refer to Figure 3.6). The result was analysed by descriptive analysis. The analysis had obtained positive results which concluded that visitors agree that they had enjoyable informal learning experience. Besides analysing the findings, this phase concluded that all findings are related to the outcome of the study, such as, final version of conceptual model and result of validation of conceptual model. All the conclusions were documented into publications (journals and proceedings). The list of publication is provided in Appendix B. Moreover, conclusion of study is elaborated in Chapter 6.

	Strongly Disagree								Strongly Agree	
	Sangat Tidak Setuju		1 2 3 4 5 6 7						*Sangat Setuju*	

A	**Informal Learning**	
1	The Mobile AR application allows me to keep attention to the content of application.	1 2 3 4 5 6 7
2	The Mobile AR application allows me to find the location in the cultural heritage site.	1 2 3 4 5 6 7
3	The Mobile AR application keeps me to be awake during the visit at cultural heritage Site.	1 2 3 4 5 6 7
4	The Mobile AR application allows me to choose the content	1 2 3 4 5 6 7
5	The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.	1 2 3 4 5 6 7
6	The Mobile AR application allows me to learn through story.	1 2 3 4 5 6 7
7	The Mobile AR application helps me to gain new knowledge about cultural heritage Site.	1 2 3 4 5 6 7
8	The Mobile AR application helps me to recall what I have learnt about the cultural heritage Site.	1 2 3 4 5 6 7
9	The Mobile AR application allows me to learn about cultural heritage Site anytime and anywhere.	1 2 3 4 5 6 7
10	Learning about cultural heritage Site using mobile AR application was:	1 2 3 4 5 6 7
	a. Fulfilling	1 2 3 4 5 6 7
	b. Rewarding	
	c. Useful	1 2 3 4 5 6 7
	d. Worthwhile	1 2 3 4 5 6 7
B	**Enjoyable**	
1	While using the Mobile AR application:	1 2 3 4 5 6 7
	a. I was deeply engrossed.	1 2 3 4 5 6 7
	b. I was absorbed intently.	1 2 3 4 5 6 7
	c. My attention was focused.	1 2 3 4 5 6 7
	d. I fully concentrated.	1 2 3 4 5 6 7
2	While using the Mobile AR application, I felt:	1 2 3 4 5 6 7
	a. Happy	1 2 3 4 5 6 7
	b. Pleased	1 2 3 4 5 6 7
	c. Satisfied	1 2 3 4 5 6 7
	d. Content	

Figure 3.14. Final Version of Instrument for Measuring Enjoyable Informal Learning

3.10 Summary

This chapter explains the process of research based on design research methodology.

The research process comprises five steps: awareness of problem, proposed

solutions, development, evaluation and conclusion. The awareness of problem consists of literature review and content analysis, comparative study and preliminary study. Then, the proposed solution phase and development phase were conducted. These phases achieved the first objective by reviewing literature and analysing the mobile projects and also the second objective by delivering the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. Then, the conceptual model was brought to the validation phase includes expert review and focus group discussion (objective 3). These results were generated by conducting field study of enjoyable informal learning content (after expert review) and review of related conceptual model of mobile AR for cultural heritage and review of mobile guide (after focus group discussion). All the processes produced a revised version of the conceptual model.

Next, the model was sent to a prototyping phase where a prototype was developed based on it. The prototype was developed for six months. Once it had finished, it was evaluated by users in evaluation of enjoyable informal learning experience. Then, these results were analysed and discussed. Finally, all findings associated to the study were concluded and documented in publication and presented in the conclusion phase. In overall, design science research methodology has guided the research process in order to accomplish the research objectives provided in Chapter 1.

CHAPTER FOUR
CONCEPTUAL MODEL OF MOBILE AUGMENTED REALITY FOR CULTURAL HERITAGE SITE TOWARDS ENJOYABLE INFORMAL LEARNING

Introduction

This chapter mainly discusses about the proposed conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. It explains development and validation phase of the conceptual model, which include selection of component, comparative analysis, expert review, field study of enjoyable informal learning content at cultural heritage site, focus group discussion, review of related conceptual model and review of related mobile guide.

4.1 The Overall Development Process of the Proposed Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The conceptual model was developed through extraction of enjoyable informal learning concept, comparative analysis, and literature review. The extraction of enjoyable informal learning concept was done to determine the component of the conceptual model. After the component was obtained, the comparative analysis was executed to define the element of conceptual model. Afterwards, related literature had been reviewed to add components of conceptual model. Then, these components, elements and results of literature review were incorporated together to form the conceptual model. This formulation produced the first version of the conceptual model.

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Phases		**Outcomes**

Extraction of Enjoyable Informal Learning Concept	··▶	Component of conceptual Model: Media elements, navigation, activity, social interaction, games, opening, and presentation style. (Section 4.2.1)
Comparative analysis of mobile AR for cultural heritage, mobile tourism, mobile learning, and mobile AR framework	··▶	Element of conceptual Model: Media elements, navigation, activity, social interaction, games, opening, and presentation style. (Section 4.2.2)
Literature review	··▶	Element of conceptual Model: media elements, navigation, activity, social interaction, games, and presentation style. (Section 4.2.2 and Section 4.2.2)

Develop First Version of Conceptual Model

Expert review	··▶	Revision of mobile technology, content structure, and theory. Also revision of terminologies and link between theory and content structure. (Section 4.3.1)
Field study of enjoyable informal Learning Content at Cultural Heritage Site	··▶	Criteria of supporting elements of media elements, navigation, activity, games & interaction. (Section 4.3.2)
Focus group discussion	··▶	Revision of content structure, interaction and enjoyable informal learning element. General structure of model was also developed. (Section 4.3.3)
Review of related mobile AR for cultural Heritage and mobile guide	··▶	Revision of elements/components of content, activity, interaction, and physical orientation.Addition of navigation and user interface design and personalization. (Section

Develop Final Version of Conceptual Model

Prototyping	··▶	A prototype based on conceptual model of MARCHSTEIL, called AR@Melaka. (Chapter 5 Section 5.2)

Note:
⬙⬙⬙ : Development
⬚⬚⬚ : Validation

Figure 4.1. Summary of Development and Validation of Conceptual Model

After the conceptual model was ready, it was sent to validation phase. This phase consists of two phases, expert review and focus group discussion. In between these phases, field study of enjoyable informal learning content at cultural heritage site and review of conceptual model were completed to respond to the feedback from expert review and focus group discussion. Then, all results from these activities were integrated to revise the conceptual model. Summary of development and validation of conceptual model is portrayed in Figure 4.1.

The next sections elaborate the process of developing the conceptual model (Section 4.2) and process of validating the conceptual model (Section 4.3).

4.2 Development Activities of Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

This section describes development process of conceptual model which comprises selection of component, selection of element, and selection of mobile AR element. The next subsection discusses the selection of component.

4.2.1 Selection of Component of Conceptual Model

The main components of the conceptual model were determined by extracting the enjoyable informal learning concept (Chapter 2 Section 2.7). It executed keyword of factors and transformed it into a name, for example, variety/change of media and variation and multiple opportunities into 'Media elements', use of questions into 'Games' and visitors control and user control and participation into 'Activity' (refer to Table 4.1).

Table 4.1

Extraction of Enjoyable Informal Learning Concept into Components of Conceptual Model

No	Factors	Component
a.	Variety/change of media and variation and multiple opportunities Various media and opportunities can help visitors to learn while visiting cultural heritage site	Media elements
b.	Use of questions Questions are necessary to recall learning of visitor	Games
c.	Visitor control/interactive exhibits and user control and participation Visitor is allowed to choose, control and interact with the content	Activity
d.	Social opportunities Visitor can interact with other members via social media during the visit	Social interaction
e.	Connections with visitor Build a content in the form of story to build connection with visitor	Content in the form of story
f.	Good physical orientation The presence of map is highly needed to help visitors find their way	Navigation
g.	Pleased Feature of augmentation, input and control, community-created content, contextuality and personalization, proactivity, mobility which can stimulates pleasure of user during the visit	Media elements, activity, social interaction
h.	Satisfied Feature of interaction, location-based content, augmentation, type and amount of content, and functionality	Media elements

This list was added by review result of design guideline of online enjoyable informal learning of cultural heritage (Chapter 2 Section 2.4.1) and review of user requirement of designing mobile AR guide at cultural heritage (Chapter 2 Section 2.4.2). Further, 'Presentation style' is added because it is required to determine correct type of presentation that is enjoyable for visitors (Lin et al., 2012). In addition, 'Social interaction' was considered to be provided as it is necessary for connecting visitors at large cultural heritage site (Toh et al., 2010). Overall, this study decided seven components to form the conceptual model: media elements, navigation, activity, games, mobile technology, presentation style, and social interaction.

After the components have been defined, the process was continued by selecting the elements. This step is explained in the following section.

4.2.2 Selection of Element of Conceptual Model

The elements of conceptual model were obtained from a comparative analysis of mobile AR for cultural heritage, mobile tourism guide and mobile learning. There are 34 elements identified at the end of this phase including those suggested during pilot study.

The next section explains about selection of 'Media elements'.

4.2.2.1 Media Elements

Elements of 'Media elements' were obtained from comparison of elements provided in mobile AR for cultural heritage site (refer to Table 4.3), mobile tourism guide (refer to Table 4.4), and mobile learning (refer to Table 4.6). The consideration for taking the element consists of three factors: discarded (1-3), recommended (4-6), and compulsory (7-9). The list of names of projects which were compared is provided in the Table 4.2.

Table 4.2

List of Projects

Code	Name
MAR1	ARCHEOGUIDE
MAR2	iTACITUS
MAR3	MART
MAR4	SkyLineDroid

Table 4.3 continued

MAR5	AR-based on-Site Tour Guide
MAR6	SHMAR
MAR7	Techcooltour
MTG1	Lol@
MTG2	Cyberguide
MTG3	Context-aware Smart Tourist Guide
ML1	MILE
ML2	BWL
ML3	EULER

Table 4.3

Media Elements of Mobile AR for Cultural Heritage Site

Media Element	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6	MAR7	Total
3D Object	✓	✓	✓	✓	✓	✓	✓	7
Text	✓	✓	✓	✓	✓	✓	✓	7
Image	✓	✓	✓	✓	✓	✓	✓	7
Video	✓	✓	✓	✓	✗	✓	✓	6
Audio	✓	✓	✓	✓	✗	✓	✓	6
3D virtual character/ Animation	✓	✓	✓	✓	✗	✗	✓	5

Table 4.4

Media Elements of Mobile Tourism Guide

Media Element	MT1	MTG2	MTG3	Total
3D Object	✗	✓	✓	2
Text	✓	✗	✓	2
Image	✓	✗	✓	2
Video	✓	✗	✗	1
Audio	✓	✗	✗	1
3D virtual character / Animation	✗	✗	✗	0

Table 4.5

Media Elements of Mobile Learning

Media Element	ML1	ML2	ML3	Total
3D Object	✓	✓	✗	2
Text	✓	✗	✗	1
Image	✓	✓	✗	2

Table 4.5 continued

Video	✓	✗	✗	1
Audio	✓	✗	✗	1
3D virtual character /Animation	✓	✓	✗	2

By looking at the result, it is noted that 'Text', 'Audio', 'Image', and 'Video' are compulsory as the media element, whereas, '3D model' and '3D virtual character/animation' are the recommended ones. The proposed element is illustrated in Figure 4.2.The other elements that are needed are pull content and push content which are existing in User Requirement of Designing Mobile AR Guide for Cultural Heritage (Toh et al., 2010).

'Push content' is a type of content that automatically appears when visitors enter the site whereas 'Pull content' requires visitors to request the information.
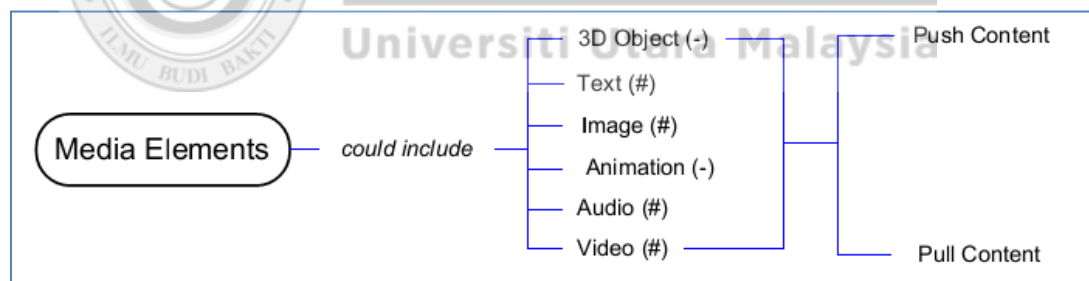
Note: (-) choose only one

(#) choose only one or combined

Figure 4.2. Element of Media

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4.2.2.2 Navigation

Element of 'Navigation' was determined based on the comparison provided in Table 4.6, Table 4.7, and Table 4.8. It obtained 'Point of interest' as the compulsory element analysis of mobile AR for cultural heritage and mobile tourism guide.

Table 4.6

Navigation of Mobile AR for Cultural Heritage Site

Navigation	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6	MAR7	Total
Point of interest	✓	✓	✓	✓	✓	✓	✓	7
Visitor Position	✓	✗	✗	✗	✗	✓	✗	2
Visited places	✓	✗	✗	✗	✗	✗	✗	1

Table 4.7

Navigation of Mobile Tourism Guide

Navigation	MT1	MTG2	MTG3	Total
Point of interest	✓	✓	✓	3
Visitor Position	✗	✓	✓	2
Visited places	✗	✗	✓	1

Table 4.8

Navigation of Mobile Learning

Navigation	ML1	ML2	ML3	Total
Map	✓	✗	✗	1

However, there are other elements for mobile AR for cultural heritage which are recommended to be applied: 'Allow visitor to insert destination queries and show the guide through virtual arrows that overlay the real environment' and 'Display the visited route' that is equipped by the request option if visitors want to go back to the visited place. These amendments were added based on User Requirement of Designing Mobile AR Guide for Cultural Heritage (Toh et al., 2010). The 'Navigation' element is illustrated in Figure 4.3.

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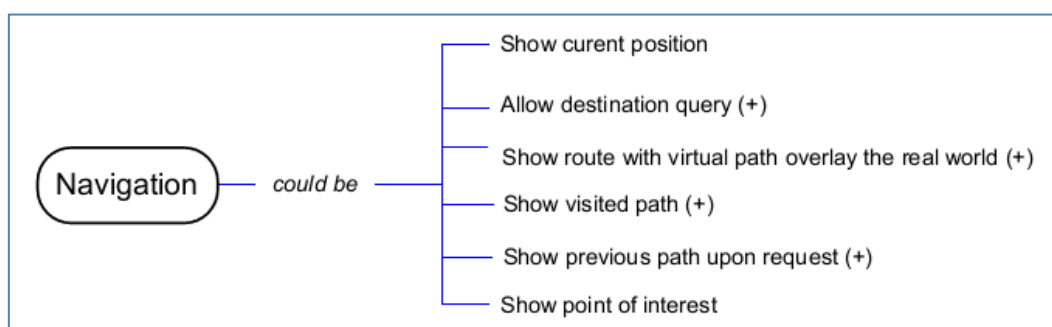
Note: (+) not compulsory but recommended to be applied

Figure 4.3. Element of Navigation

4.2.2.3 Activity

The element of 'Activity' was obtained from the comparison table in mobile AR for cultural heritage (refer to Table 4.9). The elements were taken based on these three conditions: discarded (1-2), recommended (3), and compulsory (4-5). 'Add comment' was deduced as the compulsory element because it is only provided by one mobile AR. However, mobile tourism guide did not obtain any element and mobile learning produced many elements of activity (refer to Table 4.10).

Table 4.9

Activity of Mobile AR for Cultural Heritage Site

Media Element	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6	MAR7	Total
Add comment	✗	✓	✗	✗	✗	✗	✗	1
Take picture of place	✗	✗	✗	✗	✗	✗	✗	0
Add description	✗	✗	✗	✗	✗	✗	✗	0
Upload picture	✗	✗	✗	✗	✗	✗	✗	0

Table 4.10

Activity of Mobile Tourism Guide

Media Element	MT1	MTG2	MTG3	Total
Add Comment	✗	✗	✗	0

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Table 4.11

Activity of Mobile Learning

Activity	ML1	ML2	ML3	Total
Take picture	✓	✓	✓	3
Create note	✓	✓	✓	3
Share presentation & notes	✓	✓	✓	3
Save notes	✓	✓	✓	3
Access notes	✓	✗	✓	2
Conduct survey	✓	✗	✓	2
Upload data via internet	✗	✗	✓	1
Add comment	✗	✓	✗	1
Evaluate sheet	✗	✗	✗	0
Talk with others via mobile	✗	✗	✗	0
Map of friends' location	✓	✗	✓	2
File sharing	✓	✗	✓	2
Chat	✓	✗	✓	2

By looking at the result, it has been determined that 'Create notes', 'Share notes' and 'Save notes' are compulsory components. Meanwhile, 'Take picture' is considered as recommended supporting element. In addition, 'Journal' was added as it acts as a souvenir to bring home. It stores information about what has been done in the site and helps visitors to continue the learning process (Demiris, Vlahakis, & Ioannidis, 2006). The element of 'Activity' is provided in Figure 4.4.
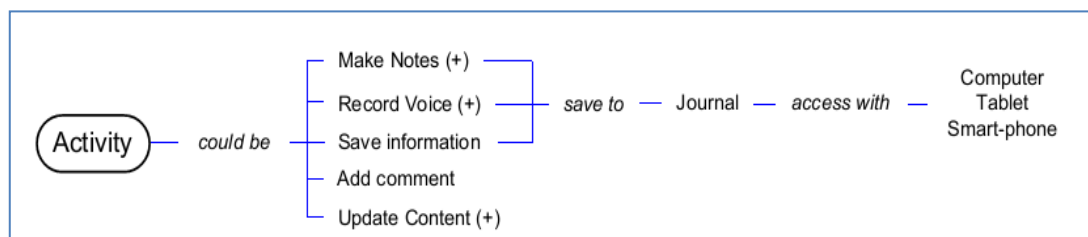
Figure 4.4. Element of Activity

4.2.2.4 Social Interaction

Visitors prefer to communicate with their friends by chatting and sending broadcast message at cultural heritage site (Toh et al., 2010). In addition, based on the result of pilot study, visitors needed to interact with social media, such as, Facebook, Twitter,

and Line. Therefore, these three elements have been integrated in the component of 'Social interaction' (refer to Figure 4.5).
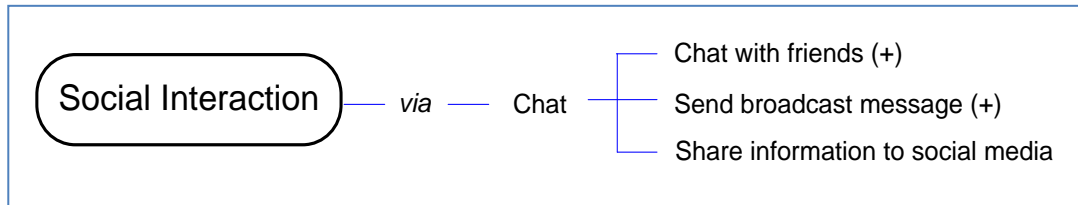
Figure 4.5. Element of Social Interaction

4.2.2.5 Games

Learning at cultural heritage site should include participatory program that engages visitor's physical and mind (Hein, 1995). Hence, games are necessary to make this purpose achieved. The game that was chosen is 'Treasure hunt' as a game at the cultural heritage site. It is a game that requires players to discover objects in specific area or unlimited space (Angelopoulou et al., 2012). The SHMAR also implemented this game. Beside games that are engaging, questions to recall learning are also important as mentioned in the theory of mindfulness (Moscardo, 1996). Therefore, this study implements the multiple choice quiz.

The model for 'Games' element is illustrated in Figure 4.6.
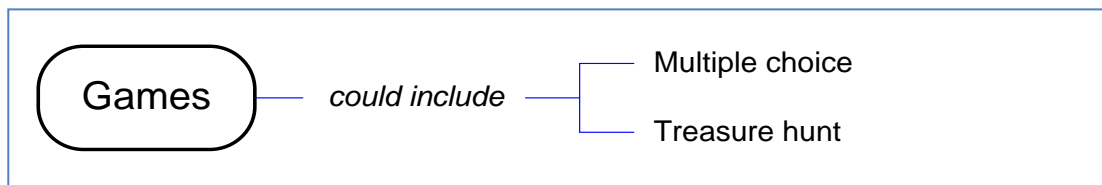
Figure 4.6. Element of Games

4.2.2.6 Presentation Style

Based on the design guideline for online enjoyable learning developed by Lin et al. (2012), creation of storyline for the content is a good approach to make visitors enjoy

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learning at cultural heritage. Therefore, this study decided to include 'Narrative storytelling' as one of the presentation style in addition to 'Separate augmented views' that have been commonly used in mobile AR application. The 'Presentation style' element is displayed in Figure 4.7.
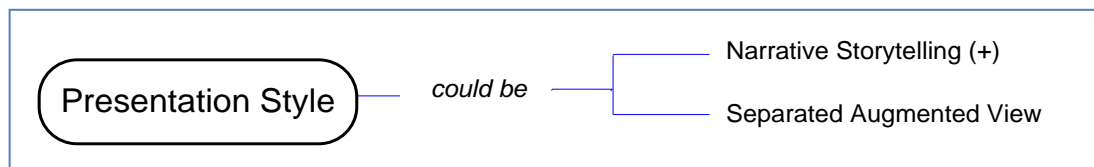
Figure 4.7. Element of Presentation Style

4.2.2.7 Mobile Technology

The elements of mobile technology were obtained from comparative analysis of ARToolkit Framework (MARF1) ("ARToolkit,"n.d.), Metaio Framework (MARF2) (Majid, 2013), and Mobile AR Framework (MARF3) (Oui et al., 2011). The consideration of taking the element is discarded (0), recommended (1-2), and compulsory (3).

The comparison resulted that 'Application' is the only compulsory element. This is followed by API, OS, and OpenGL as recommended elements (refer to Table 4.12). API is a set of standards and instructions for building software application (Roos, 2007; Beal, n.d.). Meanwhile, OS is a software program that manages computer hardware to communicate with the computer software ("Computer Hope," n.d.). Furthermore, Open GL is an API standard for determining 2D and 3D graphic images (Gumbel & Yasko, 2011).

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Table 4.12

Element of Mobile AR Framework

Criteria	MARF1	MARF2	MARF3	Total
Application	✓	✓	✓	3
API	✓	✓	✗	2
SDK	✗	✓	✗	1
OS	✓	✗	✓	2
OpenGL	✗	✗	✓	2
OpenCV	✗	✗	✓	1
Video Library	✓	✗	✗	1
Tracking	✗	✗	✓	1
GUI	✗	✗	✓	1
3D	✗	✗	✓	1
Multimedia	✗	✗	✓	1
Interactive Marker	✗	✗	✓	1
Hardware	✗	✗	✓	1

However, these elements are not appropriate with the requirement of mobile AR system (Wagner, 2007; Azuma, 1997; Marimon et al., 2010). Therefore, this study decided to add the element of 'Registration', 'Compass', 'Sensor' and 'GPS'.

Registration was included to align the virtual object to real environment (Azuma, 1997). In addition, 'Compass', 'Sensor', and 'GPS' are necessary tools in a mobile phone to deliver the augmented presentation (Marimon et al., 2010). These elements were incorporated and gathered to form the component of mobile technology (refer to Figure 4.8).
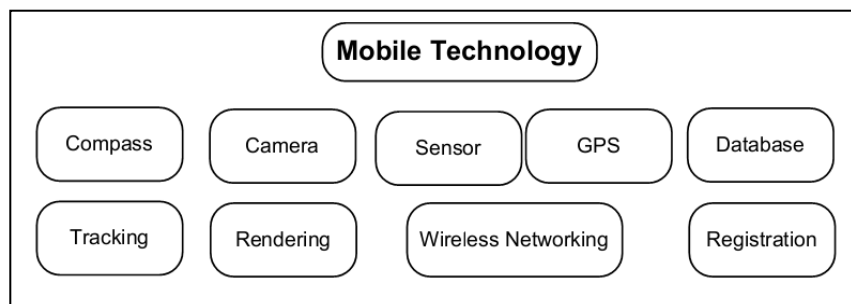
Figure 4.8. Element of Mobile Technology

4.2.3 The Proposed Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning (First Version)

After series of comparative analyses and review of related literature, the elements of conceptual model have finally been formulated. There are three components in conceptual model: 'Theory', 'Content structure' and 'Mobile technology'. These components are supported by elements and supporting elements which later formed the first version of the conceptual model (refer to Figure 4.9).

Then, the conceptual model was sent to validation phases, which include expert review and focus group discussion. Along the validation steps, one step as feedback response from the validation step were conducted, which are, field study of enjoyable informal learning content at cultural heritage site and review of related conceptual model of mobile AR for cultural heritage and review of mobile guide. However, these steps are explained in detail in the following section.
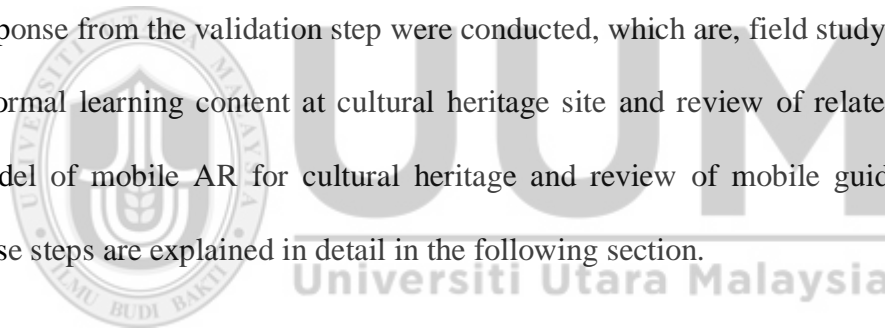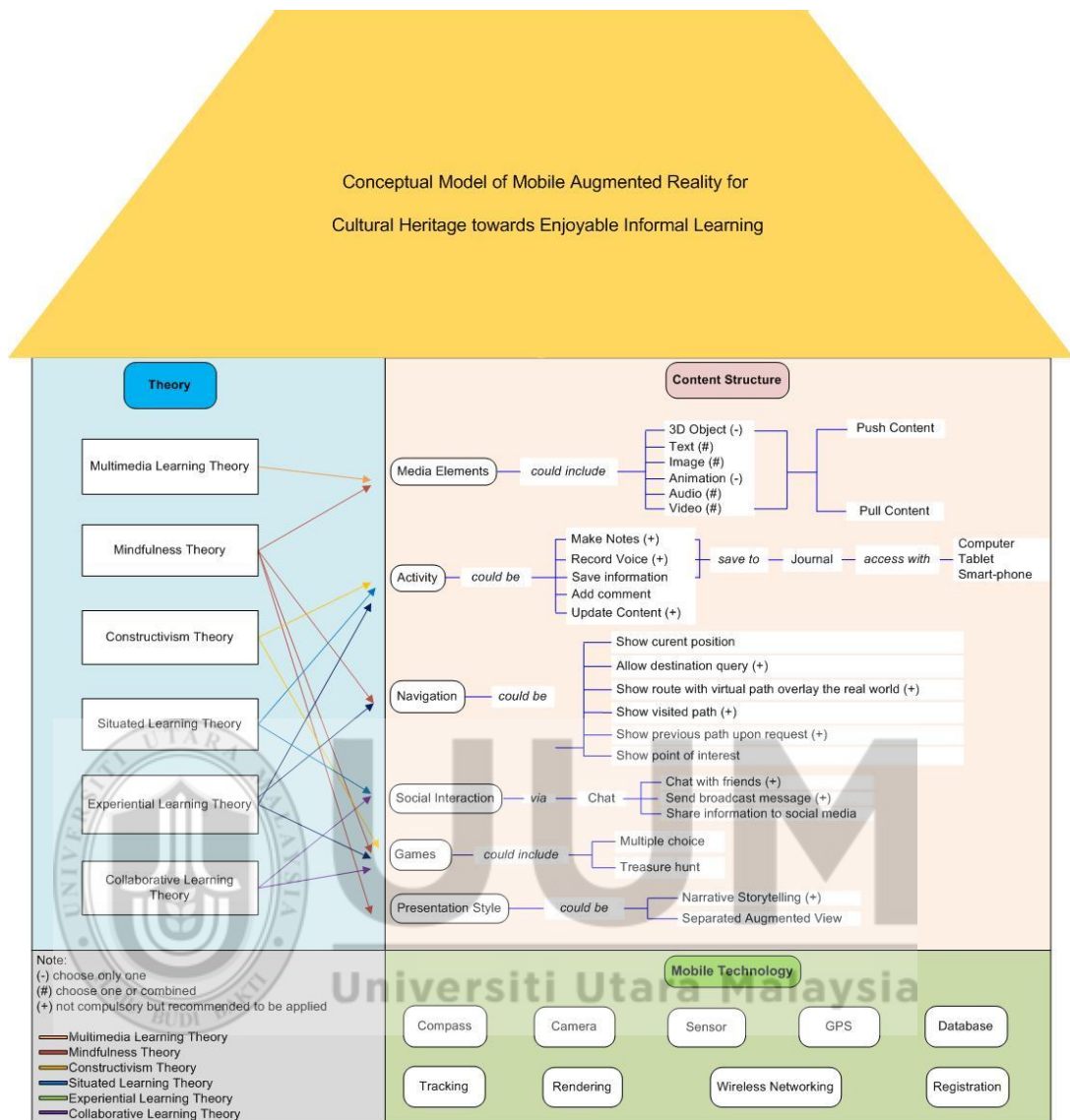
Figure 4.9. The First Conceptual Model of Mobile Augmented Reality for Cultural Heritage Site towards Enjoyable Informal Learning

4.3 Validation Phases of Conceptual Model

Conceptual model was validated by means of expert review and focus group discussion. Before and after focus group discussion, field study of enjoyable informal learning content at cultural heritage site was conducted to gather user requirement and to add novel components as suggested in expert review and review of related conceptual model of mobile AR for cultural heritage and review of mobile guide

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were executed to add the novel components as suggested in focus group discussion (see Figure 4.1). Detailed explanations on these phases are provided in the next subsections.

4.3.1 Expert Review

In validating the conceptual model, expert review was conducted. There were seven experts who had reviewed the conceptual model with criteria of teaching AR/Human Computer Interaction/Multimedia with minimum 5 years of experience (refer to Appendix G). The expert review took one and half month process from 15[th] of April until 25[th] of May 2014.

The form was collected back by seven experts. Table 4.13 shows the frequency of responses of expert which was collected from seven experts. Experts thought that the conceptual model had terminology that was easy to understand. This also applies to the proposed components which are relevant. However, experts thought that some of social interaction and mobile technology components may not be relevant. Meanwhile for the theories, most of the theories are relevant and the connections of all theories and components are logical. Overall, experts concluded the conceptual model is usable in the development of mobile AR for cultural heritage site towards enjoyable informal learning.

Table 4.13

Frequency of Responses of Expert Review

Items	Needs very detail explanation	Needs some explanation	Is easy to understand	Didn't respond	Total
1. Clarity of terminology					
a) Content Structure	0	2	3	2	7
b) Theory	0	2	3	2	7
c) Mobile Technology	1	1	3	2	7
	Some are definitely not relevant	**Some may be not relevant**	**All are relevant**		
2. Relevancy of proposed components					
a) Media Elements	0	0	5	2	7
b) Activity	0	0	5	2	7
c) Navigation	0	0	5	2	7
d) Social Interaction	0	2	3	2	7
e) Games	0	1	4	2	7
f) Presentation Style	0	0	5	2	7
g) Mobile Technology	0	1	3	3	7
	Not relevant	**Relevant**			
3. Relevancy of proposed theories	0	5		2	7
a) Multimedia Learning Theory	1	4		2	7
b) Mindfulness Theory	0	5		2	7
c) Constructivism Theory	0	5		2	7
d) Situated Learning Theory	0	5		2	7
e) Experiential Learning Theory	0	5		2	7
f) Collaborative Learning Theory	0	5		2	7
	Yes	**No**			
4. The connections of all the theories and components are logical	3	1		3	7
5. The conceptual model is usable for the development of mobile AR for cultural heritage towards enjoyable informal learning.	4	0		3	7
6. In overall, the conceptual model is readable.	4	0		3	7

The next result displayed written comments which were sent by two experts who did not fill up the form and other five experts who filled up the form. Three experts addressed the mobile technology component. They suggested mobile technology should be provided by category to divide different functions of each element. Furthermore, they also added some elements in the content structure component and changed the terminologies. Moreover, 'Theory' and link between 'Theory' and 'Content structure' element were suggested to be revised. However, the most important comment was about the lack of novel component that makes the conceptual model too generic and too brief for a conceptual model of mobile AR for cultural heritage that emphasizes enjoyable informal learning as what was conveyed by expert 6 and 7. The comments are provided in Table 4.14. Some comments were changed in terms of diction but the meaning of comment was maintained.

Table 4.14

Feedback from Experts

Experts	Comments
(a)	The media elements can be divided into two types: passive and active content. Active content is the content that includes user interaction, such as: activity, social interaction and games.
(b)	More details on the theory are needed to understand about their relevancy on supporting the content structure.
(c)	The elements in mobile technology should be put into categories, such as core technologies for AR and necessary devices for AR. The terms 'sensor' and 'mobile technology' are also not proper.
(d)	Should add taking picture and interacting with content in the activity component.
(e)	The term 'chat' in social interaction is not proper.
(f)	It is possible to add virtual views in the presentation style.
(g)	Strength: the conceptual model is feasible and worthwhile to improve the informal learning experience at cultural heritage site. Weakness: Most of components have been presented in previous works and novel components in informal learning are not sufficient.
(h)	Provide details for each component in hierarchy or layers than list the individual elements.
(i)	Validate the conceptual model through user evaluation.

Table 4.14 continued

Expert 2 (France)	(a)	Provide more detailed explanation on content structure and theory.
	(b)	The relationship between the components in mobile technology is not understandable.
	(c)	Provide category for different function of component and add display component.
	(d)	Activities, navigation and manipulation can be added as well as activity related with media elements, such as see and hear in activity component.
	(e)	Provide navigation for museum and indoor cultural heritage environment.
	(f)	Add shared view with single display in social interaction.
	(g)	Provide other type of games, such as 3D puzzle.
	(h)	Provide more explanations in the presentation style.
	(i)	MLT theory and collaborative learning theory should be linked to other elements in the content structure.
	(j)	Mindfulness theory should consider personal cognitive style and traits of visitor that may influence the social interaction.
	(k)	Constructivism theory, situated learning theory and experiential learning theory should be linked to media elements.
Expert 3 (Spain)	(a)	Consider HCI theory as AR system should be interactive in real time (Azuma, 1997).
	(b)	Differentiate between audio and sound in media elements. Also distinguish different types of object, such as static and dynamic. The elements also can respond to user interaction.
	(c)	Consider providing a complete map of the site and recommended route for the visit in navigation.
	(d)	Clarify the term 'chat'. Differentiate between virtual and real (face to face) interaction in social interaction.
	(e)	Clarify the term 'separated augmented view' in presentation style.
	(f)	Provide category for different function of each mobile technology component, such, hardware, software and process.
	(g)	Conceptual model is well presented and logical. However, it misses the term 'interaction' as it is a fundamental part of AR system. The mobile technology component also needs to be better presented.
	(h)	Consider to add validation/evaluation component in content structure on evaluating the learning process.
Expert 4 (Taiwan)		The proposed model is thorough and detail. I expect the outcomes of this model would be good if the learning activities can be well-arranged.
Expert 5 (United States of America)	(a)	A useful conceptual framework to inform the design. The mindfulness theory is not familiar but others are well aligned with the teaching and learning methods possible through AR.
	(b)	The missing major element is the outcome of the variable that will be measured.
Expert 6 (Malaysia)	(a)	The proposed elements in content structure are too generic and are applicable to any kind of applications.
	(b)	The connections of all theories ad components are somewhat logical
	(c)	The conceptual model is partly usable to the development of AR for cultural heritage towards enjoyable informal learning.
	(d)	The conceptual model is too brief.
	(e)	Expand and detail out specifically about AR and cultural heritage.

Table 4.14 continued

Expert 7 (Malaysia)	The conceptual model is good but the scope is too wide that it should focus more on enjoyable learning.

The review was taken into consideration in revising the conceptual model. In addition, one particular comment which mentioned about lack of conceptual model of novel component of enjoyable informal learning was responded by conducting a field study of enjoyable informal learning content that is elaborated in the following section.

4.3.2 Field Study of Enjoyable Informal Learning Content at Cultural Heritage Site

In response to the feedback from expert, a field study was conducted on 31st of May, 2014 at Lembah Bujang Archaeological Site, Kedah. The purpose is to gather user requirements about content of enjoyable informal learning at cultural heritage site and to define novel components of proposed conceptual model. The questions were taken from the component of conceptual model, the literature, and expert's feedback. In total, there were five participants from targeted 10 participants from 17 to 49 years old who participated in the study. The numbers of participants are relatively enough as the researcher has attained similar answer from all participants (Creswell, 2011).The questions are in Malay and English language. They are related to the content that is appropriate for learning in enjoyable way at cultural heritage site, including: types of media, navigation, games, activity and interaction. In total, there were nineteen questions in total (refer to Appendix D page 257) with fifteen multiple

choice questions and two open-ended questions. The responses from participants are provided as follow:

a) Preferences of media

From total of five participants, image, animation and video obtained the highest frequency (4 participants), while the rest, 3D model (3 participants), 3D character (2 participants), audio (2 participants), and text (1 participants).Video was chosen because it provides picture and voice as visitors can listen and watch the information directly. "Video..because it has voice and picture. It is easier for us so we can watch and listen," said participant number four.

b) Text

Five participants considered that the text should be in point by point and have a big size of font. "It's too bored to read," said participant number one. He said that cultural heritage site is a place for leisure and relax, so if there are many texts, he will be bored. Therefore it is better if the text is short and straight to the point. In addition, the size of font should be bigger in order to make it easier for visitors to read the information. These results are also supported by the theory of properties that highlight the readability of text as aspect that influence visitors' attention to interpretive medium (Light, 1995b).

c) 3D Model

All participants agreed to have the 3D model overlaying certain parts that are lost at cultural heritage site. The feature is also applied in iTACITUS ("iTACITUS," 2007), ARCHEOGUIDE (Vlahakis et al., 2001), Techcooltour ("Techcooltour,"2013), AR-based on-site tour guide, and SkyLineDroid (Armanno et al., 2012). Further, with the 3D model, participants would like to

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have interaction with it, such as rotating the 3D model as said by participant number one, "It also would be better if we can rotate the 3D model." This is considered as tangible AR interaction where visitors can use their own hands to interact with the virtual object (Billinghurst, Kato, & Poupyrev, 2008).

d) 3D Character

Represent the noble people in the past is the criteria of 3D character that is agreed by all participants. This criteria is also implemented in the AR-based on-site tour guide (Seo et al., 2011), ARCHEOGUIDE (Vlahakis et al., 2001), MART (Kim & Park, 2011), and Techcooltour ("Techcooltour," 2013) .

e) Image

All participants agreed to have image which overlays certain part that is lost at cultural heritage site and have the old image with year in chronological order. This is also applied in iTACITUS ("iTACITUS," 2007) where the old pictures in are overlaid in the lost part of cultural heritage site and SkyLineDroid (Armanno et al., 2012) where the old pictures are organized in chronological order.

f) Audio

Two of five participants agreed to have criteria of audio that presents the history of cultural heritage site in storytelling, another two preferred to have audio which presents the history of cultural heritage site in storytelling with the age of narrator is same with the participant, and one agreed to have audio that presents the history of cultural heritage site. The storytelling is also supported by Lin et al., (2012) where storytelling creates sense of ownership and involvement in the study of online enjoyable informal learning.

Next, about narrator of audio which should have the same age with visitors to make visitors fully understand the content is supported by design principles of AR learning (Dunleavy, 2014). This is to make a clear understanding about history as said by participant number three, "It is clearer. I don't understand if old people tell the story. They have different articulation."

Meanwhile, the length of audio should be within three to five minutes. It is purposed to make the visitors grasp the meaning of audio within the time as said by participant number four, "It is in the middle, not too short and not too long. So we can gain information from the audio."

g) Sound

All participants agreed that sound has a criteria to provide the ambience of cultural heritage site. It can be in many forms: people chattering and talking in long corridor ("iTACITUS," 2007), sound of bomb, and explosions during the war (Park et al., 2006). The sound has to address specific events occurred at cultural heritage site.

h) Animation

Four participants agreed to have criteria of animation that presents history of cultural heritage site with the noble person as the character who narrates the story in narrative storytelling, whereas, one participant agreed for having animation that presents the history of cultural heritage in narrative storytelling.

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The length of animation should be within five to ten minutes which had been

agreed by three participants also one to five minutes which have been agreed by

two participants.

i) Video

Two of five participants agreed to have criteria of video that presents the history

of cultural heritage site with noble people as character in narrative storytelling

and narrator has the same age with visitor, another two preferred to have video

which presents the history of cultural heritage site with noble people as the

character in narrative storytelling, and one agreed to have video of cultural

heritage site with noble people as the character.

j) Preferences to learn based on interest

Two of five participants do not bother whether they learn based on interest or

not. They came to see and look around at the site, so they do not care about the

preferences to learn, as said by participant number three "I don't care. I just

come to see and refresh the mind."

However, three participants prefer to have option of interest as stated by

participant number 1, "It is better that we can select which area to be visited so,

we can know which site we would like to visit from the beginning. It will save

our time." This strengthens the use of function of personalization that is

important for learning at cultural heritage site (Damala et al., 2008).

k) Navigation

Four of five participants agreed to have a feature of map that shows interesting

places around the cultural heritage site. It would be more helpful if mobile AR

could show the route of visitors that they have visited. Also, the site should be shown based on history in a chronological order. These features are also provided in ARCHEOGUIDE (Vlahakis et al., 2001) and context aware tourist guide application (Park et al., 2007).

l) Activity

All participants would like to take picture during the visit. They also would like to have a feature to add or edit information of the activity. "Take picture is easy" and "I like to take picture and then add the description based on the picture" (Participant number 4 and 1). Moreover, creating notes is also preferred as activity.

m) Games

Four of five participants agreed to have adventure games, such as, treasure hunt games at cultural heritage site. This kind of games is preferred by visitors as they could play around and create interest to do something. "Games to refresh, to create interest to do something and to stimulate the memory so we can understand about the history that had happened at the site," said participant number 4.

n) Interaction

Three of five participants preferred blowing as the interaction feature, followed by shaking that is agreed by two participants, and rotating that is agreed by one participants. Shaking and blowing are suggested for interaction by Toh et al. (2010) for mobile AR guide for cultural heritage site.

o) Preferences of AR features

All participants would like to take picture wearing augmented traditional costume and take picture with the important events augmented in the real environment of cultural heritage site.

p) Things that make visitors enjoy at cultural heritage site

Feeling relaxed is the feeling most sought after, which makes visitors pleased and satisfied with their visit at cultural heritage site. This is followed by feeling fresh that adds up to the enjoyment of visiting cultural heritage site.

q) Other Features

Other feature that is needed for visitors to learn at cultural heritage site is music. The traditional music that relates to the site as stated by participant number 4, "I think it is music. Music that relates to the cultural heritage." However, other participants did not have the answer for this question.

The findings of the field study provided the novel components as well as user requirement of enjoyable informal learning content at cultural heritage site. The numbers of participants are enough as similar studies have been conducted by few researchers (Worthen & McNeill, 1996; Jones, & McEwen, 2000) with number of 8 and 10 participants. These requirements contribute positive change for improving the conceptual model (refer to Table 4.15). All media elements (text, image, audio, sound, video, animation) have their criteria. Image, animation and video were three types of media that visitors would like to have the most while learning at cultural heritage site. Navigation, activity and games element are the new criteria which were discovered. In addition, interaction and entertainment were two new components that

have been figured out in the field study. Each of them had features which were preferred by visitors. Additional feature that was recommended to be added in the conceptual model is music that is associated to the cultural heritage. All results were gathered and collected to revise the conceptual model.

Table 4.15

Findings of Field Study of Enjoyable Informal Learning Content at Cultural Heritage Site

No	Category	Responses
1	Preferences of Media	Image, animation and video.
2	Text	a. Show point by point. b. Provide big size of font.
3	3D Model	Overlay certain part that is lost.
4	3D Character	Represent the noble people in the past.
5	Image	a. Overlay certain part that is lost. b. Old pictures with year in chronological order.
6	Audio	a. Provide history of cultural heritage site. b. Provide history of cultural heritage site in storyline. c. Provide history of cultural heritage site in storyline and the narrator has the same age with visitors. d. The length of audio should be in 3 to 5 minutes.
7	Sound	Provide ambience of heritage site.
8	Animation	a. Provide history of cultural heritage site with the noble people as the character in storyline. b. Length of 3D animation is 5 to 10 minutes.
9	Video	a. Provide video of cultural heritage site with noble people as the character. b. Provide video of cultural heritage site with noble people as character in narrative storyline. c. Provide video of cultural heritage site with the noble people as the character in the storyline and the narrator should be of same age with visitors. d. Length of video is 5 to 10 minutes.
10	Preferences to learn based on interest	No, it is not preferable to learn based on interest.
11	Navigation	a. Show other interesting places around the cultural heritage site. b. Show the route visitor had visited. c. Show the site based on history in chronological order.
12	Activity	a. Add / edit information. b. Take picture. c. Create notes.
13	Games	a. Brain games. b. Adventure games.
14	Interaction	a. Shaking. b. Blowing. c. Rotating.
15	Preferences of AR	a. Take picture wearing the costume of noble people using AR

Table 4.15 continued

	features	technology.
		a. Take picture with the events of the past using AR technology.
16	Things make visitors enjoy at cultural heritage site	b. Relax. c. Fresh.
17	Other features	Music.

4.3.3 Focus Group Discussion

Focus group discussion was conducted to evaluate the conceptual model. There were seven experts who had participated in the focus group. The experts should be those have been teaching AR/HCI/Multimedia/Media Studies with a minimum of 5 years of experience (refer to Appendix H).

The focus group was started by presentation about the conceptual model. Then experts were asked to review the conceptual model based on the criteria in the review form (refer to Figure 4.10).

During the discussion, experts were also allowed to ask questions. The process of discussion lasted for one and half hour. It was a beneficial discussion. The result is provided in Table 4.16.

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Figure 4.10. Focus Group Discussion

Table 4.16

Comments from Focus Group Experts

No	Comments
Expert 1	a. Include informal learning theory. b. Emphasized on interactivity and enjoyable informal learning for content element component c. The connection in conceptual model couldn't be seen. d. Focus more on enjoyable informal learning and the main contribution of conceptual model.
Expert 2	a. The theories are relevant but have to be presented more clearly. b. Add informal learning theory. c. Consider 'tangible AR' for terms. d. Add interaction component.
Expert 3	a. Connect the mobile AR technology and content element component. b. It is should be possible to add more elements in content element. c. Create general model to be used for other field related with mobile AR or enjoyable informal learning or cultural heritage site.
Expert 4	a. Connection between all components should be improved. b. Focus more on enjoyable informal learning.
Expert 5	a. Mobile AR technology component should be improved. b. The terms should be improved. c. The connection between mobile AR, theories and content element is not clear. d. The conceptual model is not clear enough.

Table 4.16 continued

Expert 6	a. The theory should be reconstructed in order to be understood. b. Consider to combine content element with mobile AR technology. c. Some terms are not clear, such as, 'provided for each site'. d. Combine all components with mobile AR technology. e. Differentiate the uniqueness of mobile AR technology component from the existing one.
Expert 7	a. Add one element special for cultural heritage site in content element. b. Connection between theory and content element seems logical. c. The term 'registration' is not clear.
Expert 8	Create general model consists of three main topics: mobile AR, enjoyable informal learning and cultural heritage site.

Most of the experts considered that 'Mobile AR technology' should be connected with the 'Content element' in order to create the interrelated connection with all components in the conceptual model. Furthermore, the 'Interaction' should be added to highlight the enjoyable informal learning concept that becomes the main contribution of this conceptual model. Furthermore, experts also suggested creating a general conceptual model that only consists of three main domains, mobile AR, enjoyable informal learning and cultural heritage site. Conceptual model can be flexible model and used by developers from different domain. Overall, the focus group discussion was helpful for validating the conceptual model and the results from discussion have been taken into consideration.

4.3.4 Review of Related Conceptual Model of Mobile AR for Cultural Heritage Site and Review of Mobile Guide

Review of related conceptual model of mobile AR for cultural heritage and review of mobile guide were done to discover related articles suggested by experts in the focus group discussion. There were three related conceptual model of mobile AR for cultural heritage and three mobile guides were obtained to review the conceptual

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model, which are, Design Guideline for Mobile AR Systems for Heritage Interpretation and Visitor Guiding at Historic Sites (Mohammed-Amin et al., 2012), Mobile AR Museum Guide (Damala et al., 2008), and History Unwired (Epstein & Vergani, 2006). Meanwhile, the projects of mobile guide consist of Mobivisit (Damala & Lecoq, 2005), DANAE (Brelot et al., 2005), and Hypermedia tour guide (Bellotti et al., 2002). These conceptual models were examined based on components, structure, concept, and result of evaluation (refer to Table 4.17).

Table 4.17

Result of Review of Related Mobile AR for Cultural heritage Site and Mobile Guide

Related Conceptual Model	Part	Description
Design Guideline for Mobile AR Systems for Heritage Interpretation and Visitor Guiding at Historic Sites (Mohammed-Amin et al., 2012)	Structure	It comprises five requirements, which are technology, content, user interface design, interactivity and features.
	Navigation	a. It provides information in layer by layer. b. It sets appropriate size between content and display. c. It presents text that is clear and easy to read. d. It provides enough contrast between text and background e. It supports quick access to main menu. f. It provides one tap away access to frequent features.
	Features	a. It enables visitor to geo tag the photo during the visit. b. It provides internet search engine to find information at the site. c. It supports multiple languages for text and audio. d. It provides link to database of cultural heritage to upload their image or story about their visit.
Mobile AR Museum Guide (Damala et al., 2008)	Content	a. It provides thematic themes through exhibition. b. It should present appropriate content for visitor.
	Feature	Personalization is highly needed to present the content to different profiles of visitor.
	Criteria	a. The AR guide should be presented in more playful way in discovery for detection. b. The AR guides should be: playful, accessible for larger public, original, motivating, interactive, intriguing, surprising but also subjective, and sensitive.

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Table 4.17 continued
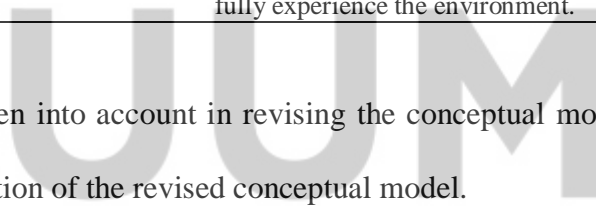
History Unwired (Epstein & Vergani, 2006)	Content	a. It uses 3D character as guide. b. It provides treasure hunt games. c. It presents tour in narrative structure. d. The narrative structure consists of: linearity, coherence, sensitivity.
	Navigation and User Interface Design	a. It provides navigation access that is not more than three tap away. b. It provides buttons that are operable with adult finger.
Mobivisit (Damala & Lecoq, 2005)	Features	a. It enables visitor to choose theme based on available time for visit. b. It enables visitor to organize visit based on the provided plans on the system and exhibits. c. It allows visitor to tick on exhibit that has been viewed. d. It updates map with the work that has been viewed. e. It allows visitor to search for works based on type, period and artist. f. It allows visitor to ask for help. g. It enables visitor to close the application. h. It enables visitor to see where the exhibit is located exactly on the map. i. It allows visitor to search for works based on type, period and artist. j. It allows visitor to ask for help. k. It enables visitor to close the application. l. It enables visitor to see where the exhibit is located exactly on the map. m. It allows visitor to search for works based on type, period, and artist. n. It allows visitor to ask for help. o. It enables visitor to close the application. p. It enables visitor to see where the exhibit is located exactly on the map.
DANAE (Brelot et al., 2005)	Navigation and User Interface Design	a. It provides 3D avatar as guide. b. Content is adapted to visitor's context, which are, location, preferences, terminal capabilities (PDA, tablet PC, projection screen) and allocation of network bandwidth according to number of other sessions run by other visitors, equipped with other kind of terminals. c. It organizes exhibition based on themes and sub-themes. It enables visitor to transfer the PDA or tablet PC session to museum display and vice versa.

Table 4.17 continued

Hypermedia Tour Guide (Bellotti et al., 2002)	Guideline for user interface	a. It should use shaped button. b. It synchronises the physical space with program virtual space. c. The content should be presented in layer by layer based on visitor's preferences and needs.
	Content	a. Image is preferred to video-audio. b. For in-depth content, audio-video is preferred to text. c. Video is preferred for special information. d. Maps are better than alternative text index. e. Build thematic path through exhibition. f. Provide other modalities for acoustic information because headphones make visitor isolated from real world.
	Enjoyable	a. Enjoyable is related with quality of content and technology (controls and system response). b. Visitor tends to use guide less if it interferes with their focus on the exhibit. c. Visitors enjoy their visit most when they can fully experience the environment.

The review has been taken into account in revising the conceptual model. The next section provides justification of the revised conceptual model.
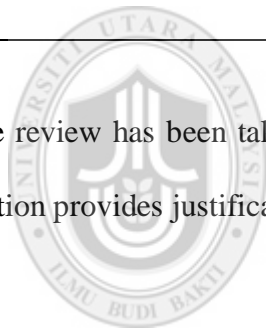
4.3.5 Revised Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The conceptual model has been changed based on the expert review, field study, focus group discussion and review of related conceptual model of mobile AR for cultural heritage site, and review of mobile guide. This section details out the changes that occurred in the conceptual model.

4.3.5.1 Terms

Some terms have been changed to avoid misunderstanding with other terms, such as, 'Navigation' to 'Physical Orientation', 'Provide profile of site in point by point' to

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'Provide description of site in point by point', and 'Narrative storytelling' to 'Storyline' .

4.3.5.2 Name of component

The name 'Media' component was changed to 'Content' component to represent the appropriate name of component as the conceptual model focuses on enjoyable informal learning content.

4.3.5.3 Structure of Conceptual Model

The structure of conceptual model has achieved a major revision. The 'Content structure' was omitted and has the elements to be taken up as components which consist of 'Content', 'Navigation and user interface design', 'Interactivity', and 'Features'. Further, 'Mobile technology' component had two components, 'Process and 'Hardware'. However, the theory was omitted because it is not the main focus of study. The revision of structure of conceptual model is provided in Table 4.18.

4.3.5.4 Supporting Elements of Content

The supporting elements of content have achieved significant changes based on theory and result of evaluation. These include the editing of words, omission, addition, and movement.

Table 4.18

List of Revision of Structure of Conceptual Model

Component	Previous Version	Changes
Content structure	Consists of seven elements: 'Opening', 'Media elements, 'Activity', 'Navigation', 'Social interaction', 'Games', 'Presentation style'.	Omit 'Content structure' and put up the element to main components which consist of: 'Content', 'Navigation and User Interface Design', 'Interactivity', and 'Features'.
Mobile AR Technology	Comprises 'Compass', 'Camera', 'Sensor', 'GPS', 'Database', 'Tracking', 'Rendering', 'Wireless networking', and 'Registration'.	Categorize the component based on category of 'Process' and 'Hardware'. 'Process' includes 'Reconstruction', 'Registration', 'Tracking', 'Rendering', and 'Interaction'. While, 'Hardware' includes 'Smart-phones' and 'Tablet'.
Theory	Consists of 'Multimedia learning theory', 'Mindfulness theory', 'Constructivism theory', 'Situated learning theory', 'Experiential learning theory', and 'Collaborative learning theory'	Omit the theory

For 3D model, supporting element 'Can be rotated' was omitted because the element 'Rotating' is included in element of interaction already. For 3D character, the supporting element 'Act as virtual guide' was added because it can be an alternative to audio guide and increase the connection between visitor and the site (Brelot et al., 2005; Epstein & Vergani, 2006). Next, 'Text' had changes for three supporting elements, which are, (i) 'Provide profile of site in point by point' was changed to 'Provide description in point by point' because the term 'description' is more appropriate than 'profile', (ii) 'Provide big size of font' was moved to component of 'Navigation and User Interface Design' because size of font is categorized in 'Navigation and User Interface Design', and omitted 'Provide general information'

because the focus of conceptual model is for learning which does not cover general information.

Then, for 'Image', also had two changes for supporting elements, namely, (i) had omission of 'Provide picture of site' and 'Provide old picture with year in chronological order' because 'Historical period' has been provided in 'Personalization' already and (ii) had changed 'Provide picture of traditional clothes and important events' to 'Provide old picture about building, noble people and events' for presenting general terms and good sentence structure along with fulfilling respondent's feedback during evaluation regarding showing traditional of cultural heritage site.

For audio, 'Provide historical information in storyline' was changed to 'Provide in-depth information in storyline' based on evaluation of Hypermedia Tour Guide and survey of online enjoyable informal learning (Bellotti et al., 2002; Lin et al., 2012). Besides, new supporting element 'Provide recorded audio presented by narrator who has the same age with visitor' was also added because of the need of visitors who prefer recorded speech than synthesized one (Bellotti et al., 2002; Mayer, 2005) and to make visitors fully understand about the content delivered by narrator as suggested by the result of field study and design principles for learning with AR (Dunleavy, 2013, as cited in Dunleavy, 2014).

Furthermore, animation and video had achieved the same changes, which are, (a) 'Provide historical information in storyline' had been changed to 'Provide in-depth

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and specific information in storyline' because the evaluation result of Hypermedia Tour Guide found that respondents prefer in-depth and specific information in video, (b) 'Provide historical information with noble people as character in storyline' had been changed to 'Use noble people as character' because the use of noble character has been proven effective for helping visitor to learn at cultural heritage site as implemented in History Unwired (Bellotti et al., 2002; Epstein & Vergani, 2006). Details of amendment are provided in Table 4.19.

Table 4.19

List of Revision of Supporting Element of Content

Element	Previous Version	Changes
3D Model	'Can be rotated'	Omitted
3D Character		Add 'Act as virtual guide' in '3D Character'.
Text	'Provide profile of site in point by point'	'Provide description in point by point'
	'Provide big size of font'	Moved to 'Navigation and User Interface design'
	'Provide general information in different section'	Omitted
Image	'Provide picture of site and provide od picture with year in chronological order'	Omitted
	'Provide picture of traditional clothes and important events'	'Provide old picture of building, people and events' in 'Image'
Audio	'Provide historical information in storyline'	'Provide in-depth information in storyline'
		Add 'Provide recorded audio'.
		Add 'Presented by narrator who has the same age with visitor'.
Animation & Video	'Provide historical information in storyline'	'Provide in-depth and specific information in storyline'
	'Provide information with noble people as character in storyline'	'Use noble people as character'
Element	Previous Version	Changes
3D Model	'Can be rotated'	Omitted
3D Character		Add 'Act as virtual guide' in '3D Character'.
Text	'Provide profile of site in point by point'	'Provide description in point by point'

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4.3.5.5 Supporting Element of Physical Orientation

The physical orientation element was added with the feature of 'Recommended route to cultural heritage site' and 'Shows the map of cultural heritage site and location of visitors within it' based on expert's review and to support collaboration among visitors for discussion because social interaction is important for learning at cultural heritage (Falk & Storksdieck, 2005; Hein, 1995). Also 'Show site based on chronological order' was omitted because personalization has the element 'historical period' already.

4.3.5.6 Supporting element of Activity

Supporting element of activity had some changes, which are, (i) 'Make notes' had been changed to 'Create notes', (ii) 'Update content' had been changed to 'Edit/add information', and (iii) 'Record voice' and 'Add comment' were deleted. 'Journal' was changed to 'Social media' as it can also be referred as online diary where people post about their current activity (Pempek, Yermolayeva, & Calvert, 2009)**.** Furthermore, 'Take picture' was added as new supporting element.

4.3.5.7 Component of Process

The main process in developing the content for mobile AR for cultural heritage site consists of reconstruction, tracking, registration, rendering, and interaction. These five processes are the main production for developing AR content of cultural heritage application (Höllerer & Feiner, 2004; Noh, Sunar, & Pan, 2009). However, the pre-production and post-production are the same with general software development (International Organization for Standardization [ISO], 1999).

4.3.5.8 Component of Interaction

The major goal of AR is to enable user to interact naturally with the virtual object (Seo et al., 2011). In addition, it also encourages user to explore and understand the digital and physical space and to create feedback from virtual world in order to make user aware of limitation and possibilities of the design (Vallino, 1998). However, from all the mobile AR for cultural heritage projects, iTACITUS is the only project which implements visitor interaction in the system. It has five types of user interaction: touch interaction, rubbing and shaking, drag and drop interaction, touching and interacting and motion determination (Ortman & Swedlund, 2012). Furthermore, it also provides direct interaction based on visitor gestures, namely, shaking, nodding, leaning, and rotating.

Result of the field study shows that blowing element got the highest score followed by 'Shaking' and 'Rotating'. Shaking and blowing are two elements of interaction for mobile AR guide at cultural heritage suggested by Toh et al. (2010) and rotating, leaning and nodding are the interaction feature implemented in iTACITUS (Zoellner, Stricker, Bleser, & Pastarmov, 2007). Therefore, This study decided to implement 'Shaking', 'Blowing', 'Rotating', 'Leaning' and 'Nodding' as supporting elements of 'Interaction'.

4.3.5.9 Component of Personalization

The element of personalization was obtained based on the review of conceptual model of mobile AR museum guide. Personalization is a function that enables visitors to modify, construct, and adjust the system based on their needs (Damala et

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al., 2007). It is necessary as it allows visitor to learn at their own pace (Damala et al., 2008).

The supporting elements of personalization were obtained from comparative analysis of mobile AR for cultural heritage (refer to Table 4.20; Chapter 2 Section 2.3.1) and mobile tourism guide (refer to Table 4.21; Chapter 2 Section 2.5.1). However, mobile learning, related mobile AR for cultural heritage and mobile guide were not included in comparative analysis because they do not have personalization feature.

Table 4.20

Personalization of Mobile AR for Cultural Heritage

Criteria	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6	MAR7	Total
Historical Period	✓	✓	✗	✗	✗	✗	✗	2
Interest	✗	✗	✗	✓	✗	✗	✗	1
Location	✗	✗	✗	✗	✗	✗	✗	0
History	✗	✗	✗	✓	✗	✗	✗	1
Preference	✗	✗	✗	✗	✓	✗	✗	1
Position	✗	✗	✗	✗	✓	✗	✗	1
Orientation	✗	✗	✗	✗	✓	✗	✗	1
Language	✗	✗	✗	✗	✗	✓	✗	1
Age	✗	✗	✗	✗	✗	✓	✗	1

Table 4.21

Personalization of Mobile Tourism Guide

Criteria	MTG1	MTG2	MTG3	Total
Location	✗	✗	✓	1
Age	✗	✗	✓	1
Language	✗	✗	✓	1
Interest	✓	✓	✗	2
Distance	✗	✓	✗	1
Media	✗	✓	✗	1

The considerations for taking the elements are discarded (0-1) and compulsory (3). Therefore, the chosen criteria are historical period and interest. Furthermore, the pilot

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study and expert review mentioned that the range of distance and language are the other two necessary elements. Range of distance enables user to set the range of distance in order to avoid the overlap of point of interest. Besides, language feature enables visitor to set his/her preferred language. Finally, this study decided to select 'Historical period', 'Interest', 'Range of distance', and 'Language as supporting elements of 'Personalization'.

4.3.5.10 Component of Navigation and User Interface Design

Navigation and user interface design was added based on review of Guideline of Mobile AR Systems for Interpretation and Guidance at Historic Sites (Mohammed-Amin et al., 2012). This component was considered necessary as enjoyable relates to controls and system response (Bellotti et al., 2002). Therefore, comparative analysis from related mobile AR for cultural heritage (refer to Table 4.22) and mobile guide (refer to Table 4.23) were completed in order to define supporting element of navigation and user interface design.

Table 4.22

Navigation and User Interface Design of Related Mobile AR for Cultural Heritage

Feature	Arbella Layers Unit	Mobile AR Guide	History Unwired	Total
Provide thematic path	✓	✓	✓	3
Provide layered information	✓	✓	✓	3
Provide one tap access to frequent menu	✓	✓	✓	3
Provide one-handed control	✗	✗	✗	0
Provide clue for scene with augmented content	✓	✓	✓	3
Provide shaped button	✓	✓	✓	3
Provide quick button to go to main menu	✓	✓	✓	3

Feature				Total
Provide big touch screen button	✗	✓	✓	2
Provide pause button to capture the last frame as background	✗	✓	✗	1
Provide navigation track on the top	✓	✓	✗	2
Provide big size of font	✓	✓	✓	3
Provide enough contrast between text and background			✓	3
Provide appropriate size of content	✓	✓	✓	3

Table 4.23

Navigation and User Interface Design of Mobile Guide

Feature	Mobivisit	DANAE	Hypermedia Tour Guide	Total
Provide thematic path	✗	✓	✗	1
Provide layered information	✓	✓	✓	3
Provide one tap access to frequent menu	✓	✓	✓	3
Provide one-handed control	✗	✗	✗	0
Provide clue for scene with augmented content	✗	✗	✗	0
Provide shaped button	✓	✓	✓	3
Provide quick button to go to main menu	✓	✓	✓	3
Provide big touch screen button	✓	✓	✓	3
Provide pause button to capture the last frame as background	✗	✗	✗	0
Provide navigation track on the top	✓	✓	✓	3
Provide big size of font	✓	✓	✓	3
Provide enough contrast between text and background	✓	✓	✓	3
Provide appropriate size of content	✓	✓	✓	3

The considerations for element of navigation and user interface design are discarded (0-2) and compulsory (3). The analysis resulted 'Provide thematic path', 'Provide layered information', 'Provide one tap access', 'Provide one-handed control', 'Provide clue for scene with augmented content', 'Provide shaped button', 'Provide quick button to go to main menu', 'Provide big size of font', 'Provide enough contrast between text and background', and 'Provide appropriate size of content' as supporting element. In addition, 'Provide thematic path' was also included based on theory of communication (Ham, 1992).

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4.4 The Proposed Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The final version of the proposed conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning consists of six components and twenty nine elements (refer to Figure 4.12).

The conceptual model is proposed to help developer in developing mobile AR project for cultural heritage site towards enjoyable informal learning by using any platform whether online or offline. The next subsection explains the component of conceptual model.

4.4.1 Hardware

Physical components needed for developing mobile AR for cultural heritage towards enjoyable informal learning. Hardware comprises one element, which is, handheld devices such as smart-phones and tablet.

4.4.2 Process

Steps or actions needed to develop mobile AR for cultural heritage site towards enjoyable informal learning. The followings are elements of the process:

- Reconstruction

  Reconstruct parts of cultural heritage site into 3D model. Reconstruct wall of A Famosa into 3D model by using 3DsMax.

- Registration

  Align virtual object of wall of A Famosa in the real world by tracking user's

position and orientation of user's view.

- Tracking

  Find location of user by using sensor-based tracking, vision-based tracking, and hybrid-based tracking in A Famosa.

- Rendering

  Generate virtual object/scene and present it to the real environment of

  A Famosa.

- Interaction

  Create interaction that occurs between system and user by shaking, blowing, rotating, leaning, and nodding the mobile phone and user's head to retrieve information about A Famosa.

4.4.3 Navigation and User Interface design

Navigation and user interface design is easy and helps visitor to learn in enjoyable way at cultural heritage site. Navigation and user interface design comprises provide thematic path, provide layered information, provide one-tap access for frequent menu, provide clue for scene with augmented content, provide shaped button, provide quick button to go to main menu, provide big size of font, provide appropriate size of content, and provide enough contrast between text and background. For example: provide theme of cultural heritage site based on colonialism era (Portuguese colonialism, Dutch colonialism, British colonialism), provide description about the structure and construction about A Famosa and continued by history of formation of A Famosa, provide "home" button for accessing the menu, provide clue in balloon to tell there is augmented scene in the area, provide

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play button in its shape in order to make visitor easy to access, provide 'home' button to the information menu to go to homepage quickly, provide three-fourth content size for the page, and provide white background for black text.

4.4.4 Interactivity

Interactivity consists of two elements, which are, activity and interaction.

4.4.4.1 Activity

Activity is included in component of interactivity. It is a set of activities that can trigger the whole learning process at cultural heritage site by integrating the visitors, learning material, and learning environment. Activity includes take picture, edit/add information, create notes, save information and share information to social media. For example: provide option to take picture of A Famosa, provide option to edit or add description of A Famosa, provide option to create notes about experience of visiting A Famosa, provide option to save the information of A Famosa to personal device, and provide option to share information of A Famosa to social media (Facebook and Twitter).

4.4.4.2 Interactivity: Interaction

Interaction is included in component of interactivity. It is a set of activities that enable visitor to interact naturally with the virtual object**.** Interaction includes shaking, blowing, rotating, leaning and nodding. For examples: enable visitor to shake their phone in order to retrieve the information about A Famosa, enable visitor to blow the wall of A Famosa to retrieve the information, enable visitor to rotate their

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phone to left or right in order to turn the 3D object to the preferred direction, enable visitor to lean or move the 3D object to left or right, and enable visitor to move the 3D object to up and down by nodding his/her head.

4.4.5 Feature

Feature consists of three elements, which are, personalization, games, and physical orientation.

4.4.5.1 Personalization

Personalization is included in the component of feature. It is a set of options that can be chosen by visitors in order to display the right content to fulfil their needs. Personalization comprises historical period, interest, range of distance and language. For example: enable visitor to select the cultural heritage site in the range of 1819-1900 or 1901-present, enable visitor to choose the cultural heritage site to be visited based on personal interest, enable visitor to select the cultural heritage site within the range (0-5 km, 6-10 km, and 11-15 km), and enable visitor to choose the language based on their preferences.

4.4.5.2 Games

Games is included in component of feature. It is the type of games that help visitor to refresh, stimulate and make them understand the history. Games consists of adventure games (treasure hunt) and multiple choice quiz.

4.4.5.3 Physical Orientation

Physical orientation is included in component of feature. It is a set of functions to guide visitor while learning at cultural heritage site. Physical orientation comprises showing the surrounding interested places, showing recommended route to the site, allowing direction inquiry, showing direction with virtual arrows overlay on real path, showing map of the site and location of visitors within the site, showing provided content, showing visited route, and showing the current position. For example: show other cultural heritage site near A Famosa, show the route from airport to A Famosa, enable the visitor to search location of A Famosa, show direction to A Famosa with virtual arrows overlay on real path from Saint Paul, show the map of A Famosa and location of visitor within A Famosa, show the provided content in A Famosa, show the visited route at Melaka Heritage Site, and show the current position of visitor.
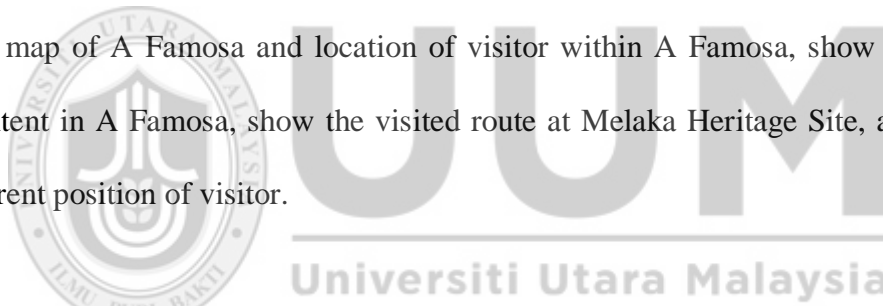
4.4.6 Content

Content is a set of media representation which consists of criteria that can be a guideline to provide enjoyable informal learning content at cultural heritage site. Content consists of eight elements:

4.4.6.1 3D Model

3D model has one criterion, which is, overlay certain part that is lost. The lost part of cultural heritage is reconstructed into 3D model. The lost or broken part of cultural heritage is created into 3D model. For example: the wall of A Famosa has been lost so it can be reconstructed into 3D model.

4.4.6.2 3D Character

3D character has two criteria, which are, represent noble people in the past and act as virtual guide. The noble people are made into 3D character. Also, these 3D characters can be the guide for visit. For example, Alfonso d'Alburqueque, Captain of Portuguese, as 3D virtual guide at A Famosa.

4.4.6.3 Text

Text has one criterion: provide description in point by point. All description about cultural heritage site is presented in point by point, such as, profile of cultural heritage site that contains information about history and background information of cultural heritage site.

4.4.6.4 Image

Image has two criteria: overlay certain part that is lost and provide old picture about the site, noble people, and events. For example: old picture of the wall of A Famosa, old picture of A Famosa, overlay picture of Alfonso d'Alburqueque, and old picture of war between Portuguese and Dutch at A Famosa.

4.4.6.5 Audio

Audio has three criteria: provide recorded audio presented by narrator who has the same age with visitor, provide in-depth information in storyline and provide audio with maximum duration in five minutes. Audio should present information about history of cultural heritage site in deep and detail. The information is conveyed through storyline and narrated by narrator who has the same age with visitor.

However, it should be not more than five minutes. For example: story that tells how A Famosa was built by Portuguese.

4.4.6.6 Sound

Sound has one criterion, which is, provide ambience of the site in the past. The ambience that can help visitor imagine how the site was. For instance, sound of bomb during the war, conversation between inhabitants, and sound of captain's car.

4.4.6.7 Animation

Animation has three criteria, which are, provide in-depth and special information in storyline, use noble people as character, and provide animation with maximum duration in ten minutes. Animation should present history about cultural heritage site that is deep and special which is not presented at cultural heritage site. It is conveyed through storyline and played by the noble people. It is should be not more than ten minutes. For example: story about how the war between Portuguese and Dutch long time ago happened in A Famosa.

4.4.6.8 Video

Video has three criteria: provide in-depth and special information in storyline, use noble people as character, and provide video with maximum duration in ten minutes. The information should contain history of cultural heritage site that is deep and special which is not provided at cultural heritage site. It is presented in storyline and played by noble people. The video should be not more than ten minutes. For

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example: story about how the war between Portuguese and Dutch happened in A Famosa long time ago.

Content is divided into two types, push content and pull content. Push content is the type of content that appears automatically when visitor reaches certain area and pull content is the type of content that should be retrieved. Elements with (#) symbol can be used as single element or combined with other elements.

The conceptual model focuses on enjoyable informal learning. However, it integrates existing three main fields; mobile AR, enjoyable informal learning, and cultural heritage site (refer to Figure 4.11). This becomes the uniqueness of conceptual model that is not implemented in the existing conceptual model. The proposed conceptual model is displayed in Figure 4.12.
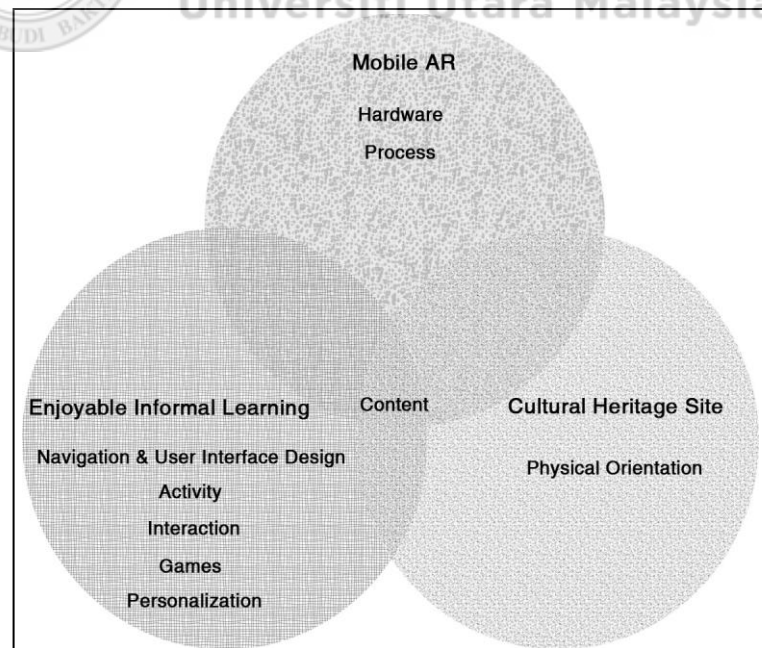
Figure 4.11. Overview of Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

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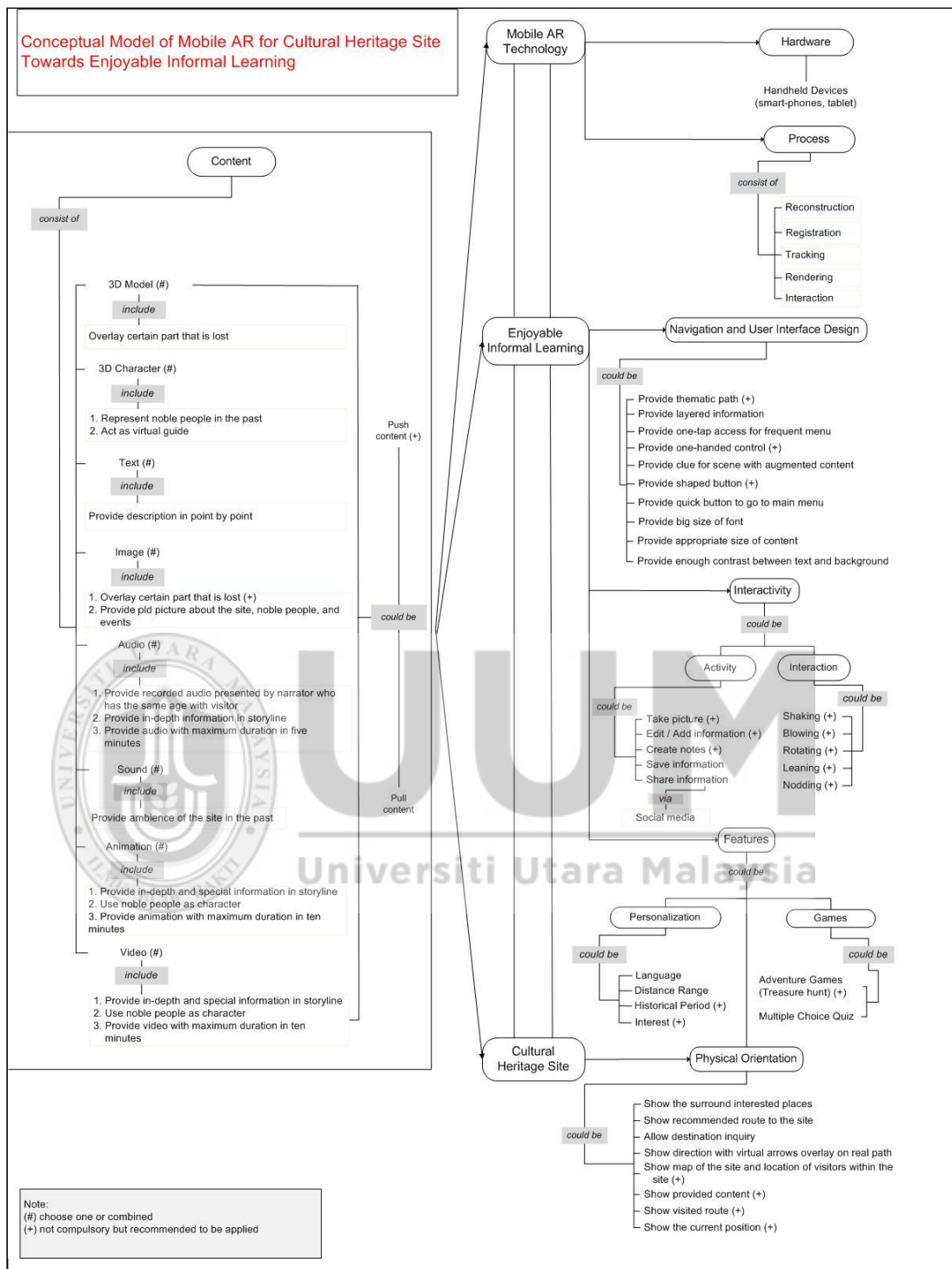
Figure 4.11. Overview of Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

4.5 Summary

This chapter describes about the development phase and validation phase of the conceptual model. Development phase consists of literature review and comparative analysis. Meanwhile validation phase comprises expert review and focus group discussion. In between expert review and focus group discussion, field study of enjoyable informal learning content and review of the conceptual model of mobile AR for cultural heritage and review of mobile guide were completed to act in

phases formed conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning which consists of three structures, six components, and twenty nine elements.

The conceptual model aims to help developer in developing mobile AR for cultural heritage site towards enjoyable informal learning. It can be implemented to any platform, to a whole domain (mobile AR for cultural heritage site towards enjoyable informal learning) and to each domain (mobile AR, enjoyable informal learning, and cultural heritage site).

To prove the validation of this conceptual model, the prototype was developed based on the conceptual model. The prototype development process is explained in the next chapter. Moreover, the evaluation of prototype is also provided.

CHAPTER FIVE

VALIDATION OF CONCEPTUAL MODEL OF MOBILE AR FOR CULTURAL HERITAGE SITE TOWARDS ENJOYABLE INFORMAL LEARNING USING PROTOTYPING

Introduction

This chapter demonstrates the development of mobile AR prototype for cultural heritage towards enjoyable informal learning as a validation phase followed by the evaluation that is based on enjoyable informal learning experience. This study chose prototype as it is one of validation methods in design research (Shiratuddin & Hassan, 2013).

5.1 Prototype Design and Development Process

In validating the conceptual model, a prototype has been developed, which is called, AR@Melaka. It has been developed by using Junaio through the means of three phases of production: pre-production, production and post-production. The pre-production executed the design phase for all components of conceptual model, followed by production phase which created the content, such as, audio, video, and multiple choice quiz for 'content', 'activity', and 'games', and lastly, created the programming language and the channel for application in post-production. Further explanation on these development phases are provided in the following sections.

5.1.1 Pre-Production Phase

The pre-production phase was started by designing the interface of structure, continued to component, and lastly, element of conceptual model. The first was

structure which is represented by homepage. Homepage is the main page of application that displays AR location in the form of pop-up balloon. Visitors can click on one of the cultural heritage sites to view the content (text, image, audio, sound, animation, and video). Next, the second page of structure of conceptual model which is referred to search page. Search page displays the search button to find a channel, address of AR content (refer to Figure 5.2). Next, the process continued by designing the interface for component of conceptual model which is represented by sign viewer page. Sign viewer page shows the map and list of locations of the cultural heritage site (refer to Figure 5.3). Lastly, the process ended by creating the element that is represented by information menu page. This page provides variation of content (text, image, audio, sound, animation, video, and etcetera) for the chosen cultural heritage site.

(Current channel)
This icon shows the current channel

(Junaio options)
Tap this to go to login & setting page for Junaio apps

(Channel Scanner)
Tap this to scan QR codes and get instant access to other information by using camera

(Search Channel)
Tap this icon to search the channel

(Radar)
To show and guide the visitor to go to the location

(AR Location)
Tap this location to show the description about location

Real/Live view

Figure 5.1. Homepage Design
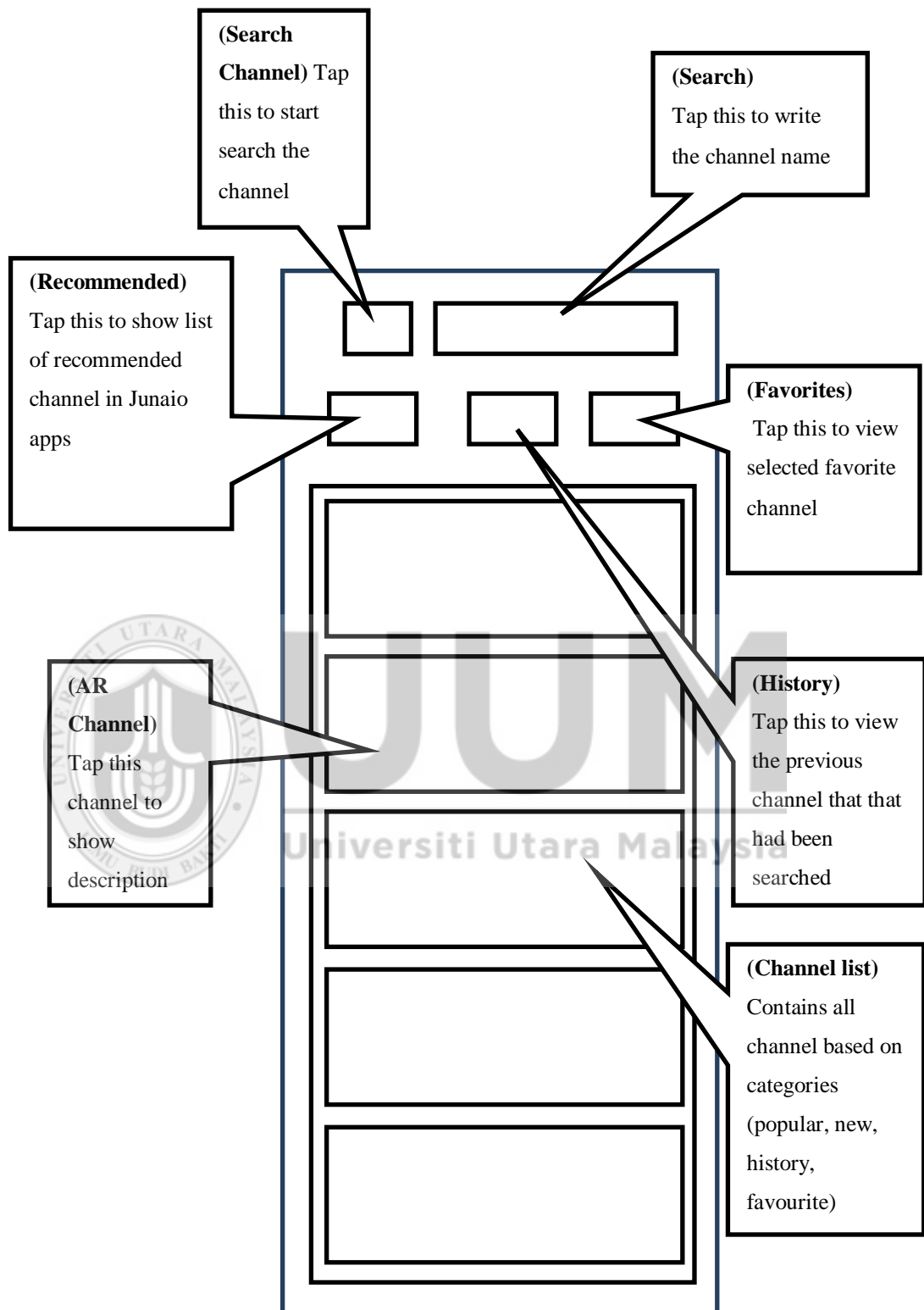
Figure 5.2. Search Channel Page Design

(Current channel)

This icon shows current channel

(Junaio options)

Tap this to go to login & setting page for Junaio apps

(Search Channel)

Tap this icon to search the channel

(Channel Scanner)

Tap this to scan QR codes and get instant access to other information by using camera

Map

(AR Location)

Tap this location to show the description about the sign

(Zoom in)

Tap to zoom in map

(Zoom out)

Tap to zoom out map

Figure 5.3. Sign Viewer Page: Maps Design

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Icon for the
location

535 m

Distance to
destined location
from current
location

Short
description
about this
location

View Image

(View image)

Tap this to view image

Listen Audio

(Listen
Audio)

Tap to listen
to audio

Watch Video

(Watch Video)

Tap this to watch video
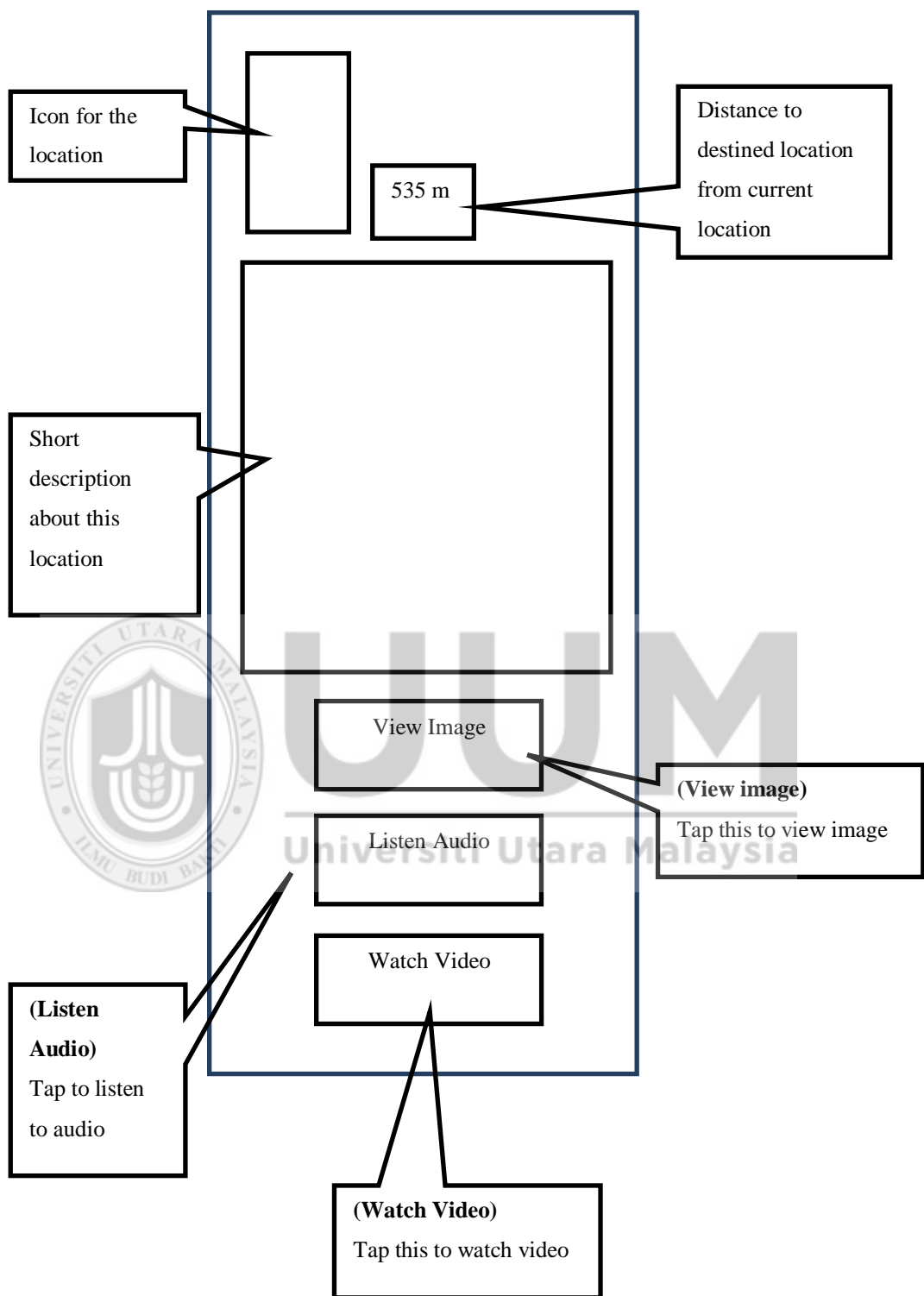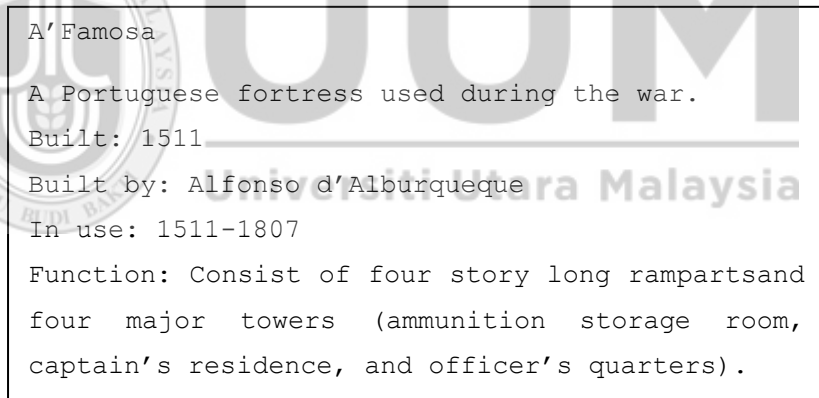
Figure 5.4. Information Menu Design

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5.1.2 Production Phase

The process was continued by creating the component of conceptual model. The components which were developed consist of 'Content', and 'Games'. These components were represented by profile, audio and video, and multiple choice quiz. The next section describes about development of profile.

5.1.2.1 Profile

Profile was developed from the analysis of history of the cultural heritage site. It is structured into point by point. Profile may include history and background information of cultural heritage site, such as, year of built, who built it and function (refer to Figure 5.5).

```
A'Famosa

A Portuguese fortress used during the war.
Built: 1511
Built by: Alfonso d'Alburqueque
In use: 1511-1807
Function: Consist of four story long rampartsand
four major towers (ammunition storage room,
captain's residence, and officer's quarters).
```

Figure 5.5. Profile of cultural heritage site

5.1.2.2 Audio and video

Both audio and video provide in-depth information in storyline. It is added with special information for video. The script for audio and video contains scenes, dialogs, characters and plots (refer to Figure 5.6). After the script was completed, audio was recorded and saved in MP3 format, while video was created by adding related pictures and save it in MP4 format (refer to Figure 5.7).

```
                           Scene: 3

                           NARRATOR

   Suddenly when the war between Portuguese and Dutch exploded,
             the Portuguese was defeated by the Dutch.

            SOUND: PEOPLE ARE FIGHTING IN THE WAR

                          PORTUGUESE

                          We lost!

                           NARRATOR

   The Dutch destroyed all buildings. Even the fort was taken
                             over.
```

Figure 5.6. Script of audio
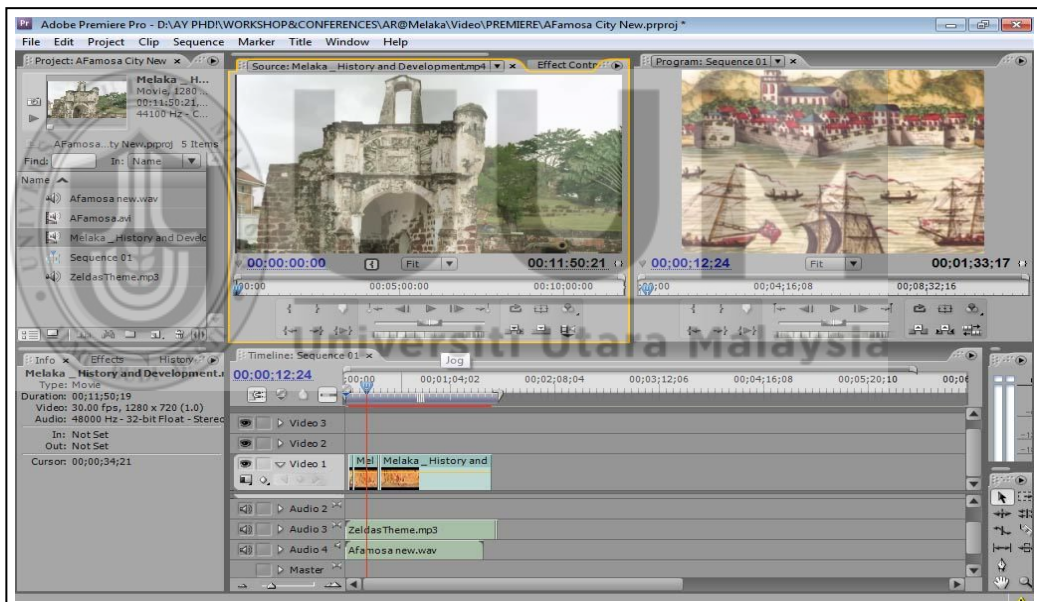
Figure 5.7. Editing the video

5.1.2.3 Multiple Choice Quiz

Multiple choice quiz contains a set of questions which ask about the history of cultural heritage site. The questions were derived from content (text, image, audio, and video) provided in the prototype. The quiz was created by using Proprofs quiz maker (refer to Figure 5.8).
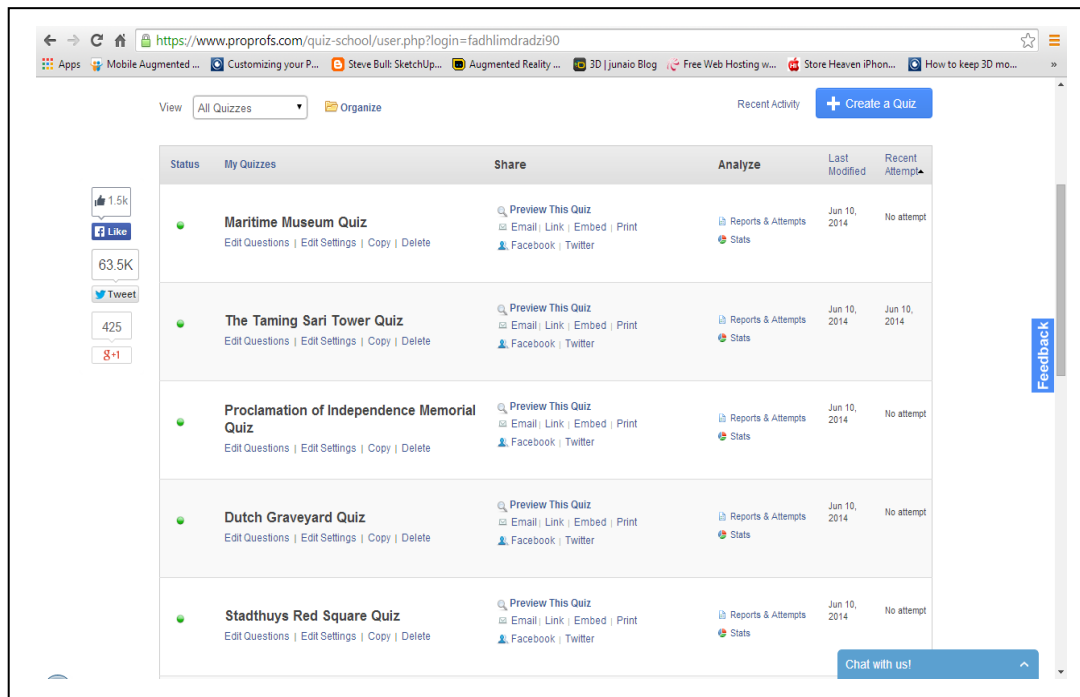
Figure 5.8. Database of multiple choice quiz

Besides, the rest of the content, such as, image, sound, 3D animation were obtained from online database. Then, they were edited and compressed to meet the criteria in the model. In addition, setting range of distance, navigation component and activity component have already been provided in Junaio. Lastly, the content in English Channel (AR@Melaka) was translated into Malay to be included in the AR@Melaka (Malay) channel.

5.1.3 Post-Production

The post-production was done by finishing the phase after production. This phase was applied concurrently to structure, component, and lastly, element of the model. In order to develop the application, extensible Mark-up Language (XML) was chosen for configurations (refer to Figure 5.9). The XML contained coding for all parts.

```
<?xml version="1.0" encoding="UTF-8"?>
<results trackingurl="GPS">
        <object id="1">
                <title><![CDATA[A Famosa, Malacca]]></title>
                <thumbnail><![CDATA[http://hilmihaer.webege.com/afamosa2.png]]></thumbnail>
                <icon><![CDATA[http://hilmihaer.webege.com/afamosa2.png]]></icon>
                <location>
                        <lat>2.192085</lat>
                        <lon>102.250001</lon>
                        <alt>0</alt>
                </location>
                <popup>
                        <description><![CDATA[A Famosa is a Portuguese fortress located in Malacca,
Malaysia. It is among the oldest surviving European architectural remains in Asia. The Porta de
Santiago, a small gate house, is the only remaining part of the fortress still standing.]]
></description>
                        <buttons>
                                <button id="url" name="Video"><![CDATA
[http://hilmihaer.webege.com/porta de santiago(afamosa) - YouTube.mp4]]></button>
                                <button id="url" name="Image"><![CDATA
[http://hilmihaer.webege.com/A-Famosa-fortress,-Malacca.jpg]]></button>
                                <button id="url" name="Website"><![CDATA
[http://www.malacca.ws/attractions/a-famosa-melaka.htm]]></button>
                        </buttons>
                </popup>
```

Figure 5.9. Example of XML File

After all the materials had been developed, the channel was created by registering the account on Junaio website (refer to Figure 5.10). Then, it continued by creating the channel (refer to Figure 5.11). Since channel has been provided, AR@Melaka application is ready.
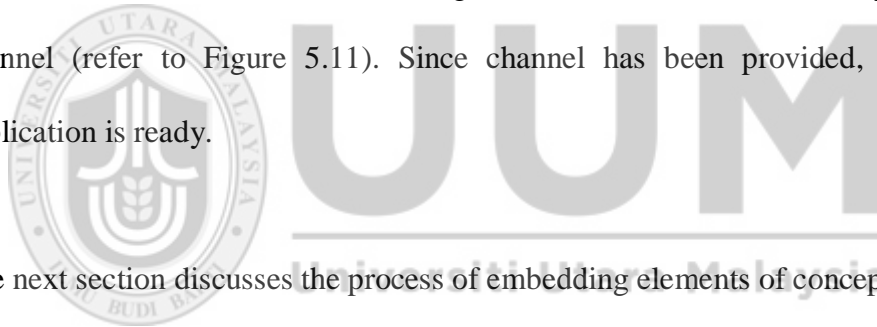
The next section discusses the process of embedding elements of conceptual model.

Figure 5.10. Developer's account registration

Figure 5.11. Create AR@Melaka channel

5.2 Embedding Components of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning to Prototype

The elements of conceptual model which were embedded in the prototype are the compulsory ones: text, image, audio, sound, animation, video, provide layered

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information, provide one-tap access for frequent menu, provide clue for scene with augmented content, provide quick button to go to main menu, provide big size of font, provide enough contrast between text and background, provide appropriate size of content, save information and share information to social media, show nearby interested places, show recommended route to site, allow user to request direction for destination, language and distance range, and multiple choice quiz.

The element 'Physical orientation' (show the surround interested places, show recommended route to site, allow user to request direction for destination), 'Tracking', and 'Interaction' were embedded in the route view and map view (refer to Figure 5.12 and Figure 5.13). This is based on the theory of mindfulness and theory of multimedia learning, which enables visitor to see his/her position, the route to go to the site and location of the sites. Next, 'Content' (text, image, audio, sound, animation, video), 'Navigation and user interface design' (provide layered information, provide one-tap access for frequent menu, provide clue for scene with augmented content, provide quick button to go to main menu, provide big size of font, provide enough contrast between text and background, provide appropriate size of content), 'Tracking', 'Interaction', and 'Rendering' were embedded in the 'Content'(refer to Figure 5.14). This relates to mindfulness theory that allows visitor to choose enjoyable and informative contents. Then, 'Activity' (save information and share information to social media), 'Tracking' and 'Interaction' were embedded in social interaction content (refer to Figure 5.15). These components apply mindfulness theory and constructivism theory where visitors are able to share and add comment on information of cultural heritage site. So visitors can save the

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information and refer back to map after the visit. Lastly, 'Games' (multiple choice quiz) is represented by 'Multiple choice quiz' (refer to Figure 5.16). This component was implemented based on theory of mindfulness to enable learning by recalling knowledge of visitors through series of questions.
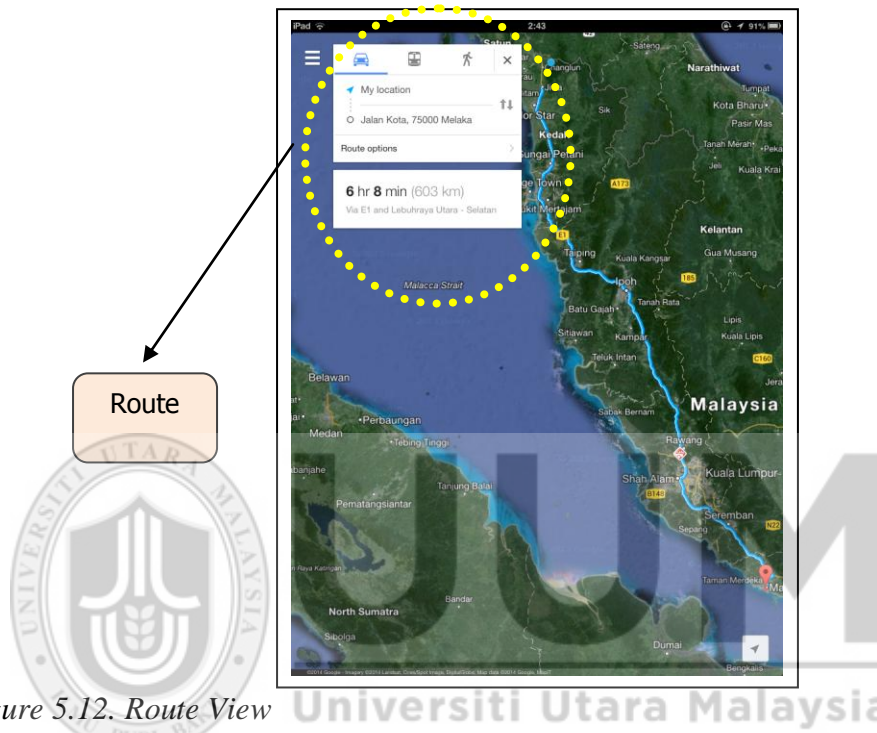
Figure 5.12. Route View
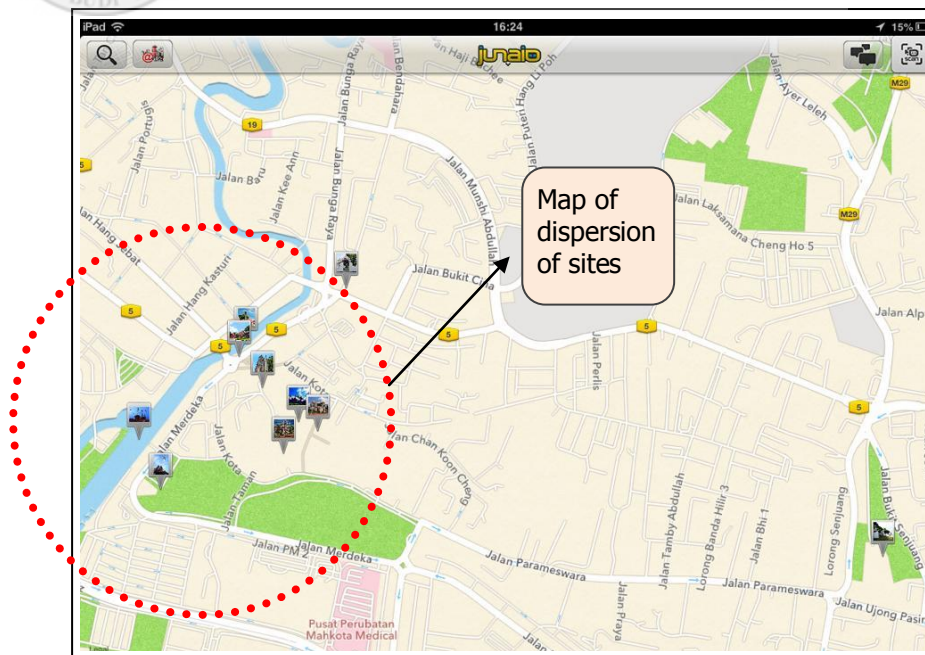
Figure 5.13. Map View
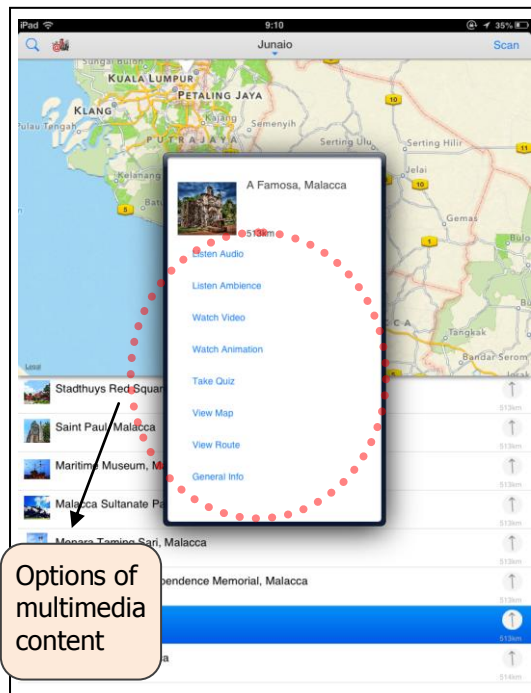
Figure 5.14. Multimedia Content
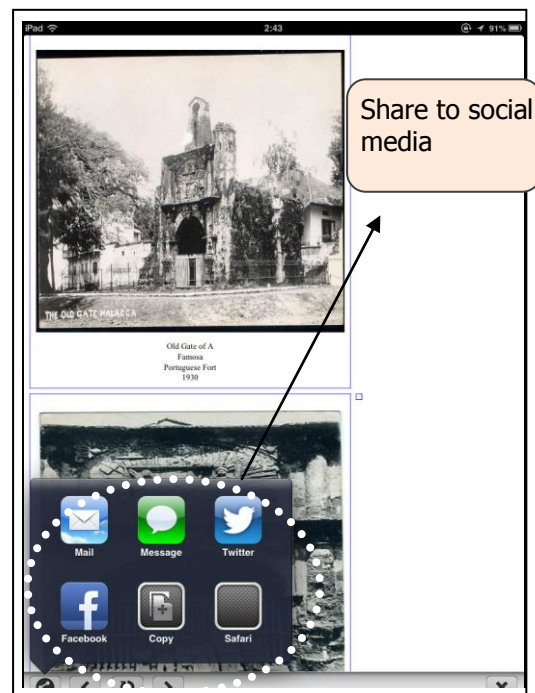
Figure 5.15. Social Interaction
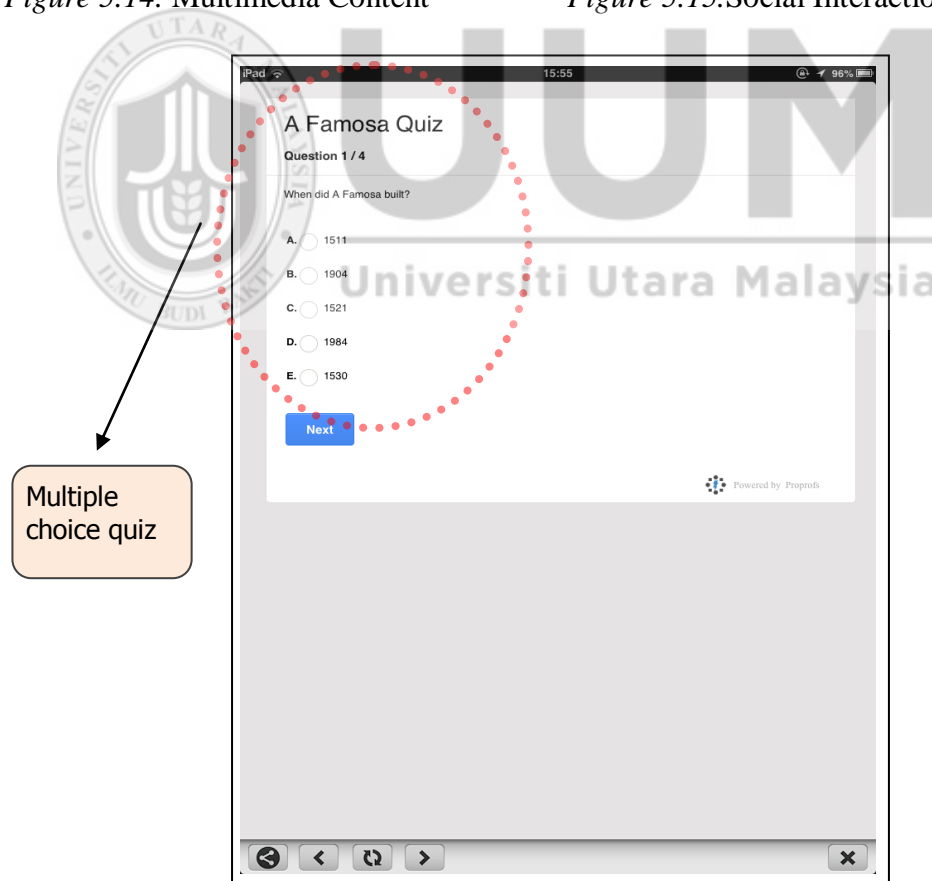
Figure 5.16. Quiz of A Famosa

5.3 Evaluation of Study: Measuring Enjoyable Informal Learning at Cultural Heritage Sites

This evaluation was conducted to measure the enjoyable informal learning experience. It was done in three areas, Jalan Merdeka, Dataran Pahlawan, and Bandar Hilir on 11th June 2014 (refer to Figure 5.17 to Figure 5.19). The approach of evaluation was done by asking respondents who visited Melaka Heritage site randomly to use the application and fill in the questionnaire afterwards. The evaluation was measured by questionnaire, named 'Measuring Enjoyable Informal Learning at Cultural Heritage Site' (refer to Appendix F). Details of questionnaire are provided in Chapter 3 Section 3.6.4.

Figure 5.17. Evaluation in Progress at Menara Taming Sari, Melaka

Figure 5.18. A group of girls and a family are evaluating AR@Melaka
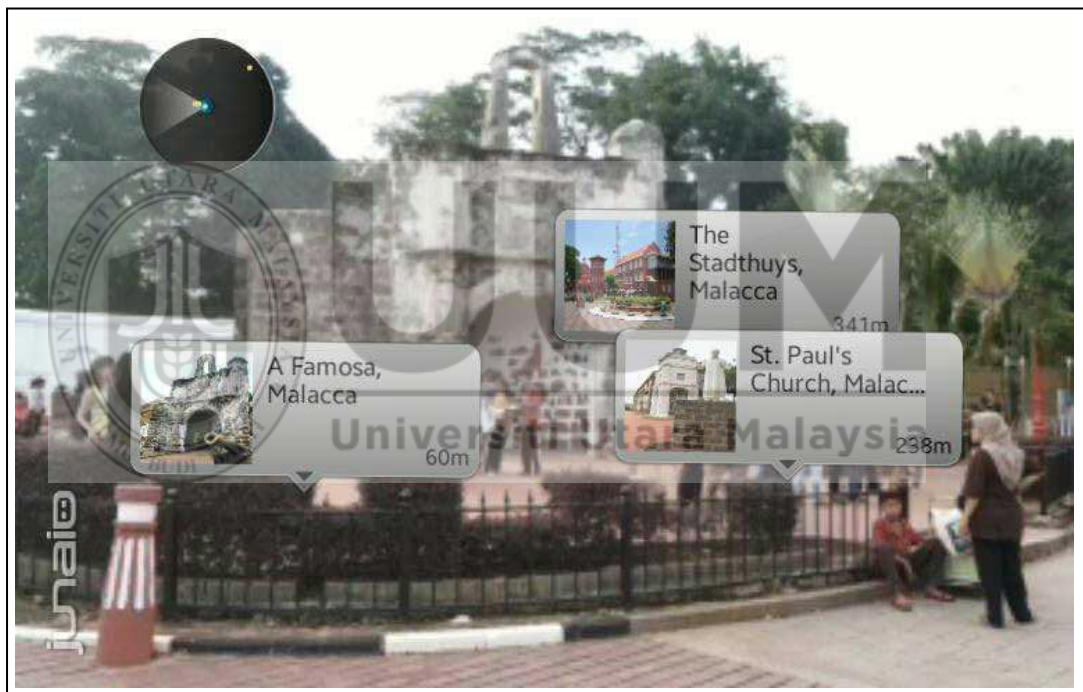
Figure 5.19. Screenshot of AR@Melaka at A Famosa

After the evaluation, a data analysis was carried out. It has resulted findings of evaluation that is explained in detail in the next section.

5.4 Findings of the Study

Findings of evaluation consist of respondents' demographic background as backup data for future analysis, respondent's opinion and respondents' enjoyable informal learning experience. The next subsection sets out the demographic background of respondents.

5.4.1 Demographic Background

There were 200 respondents from 15 to 50 years old who had participated in the study. This number of respondent is considered adequate as it is similar to what has been done in the study of hypermedia tour guide for Costa Aquarium in Italy (Bellotti et al., 2002). Most of the respondents were male (54.5%) and the remainder were female (45.5%). They were majority in the group of age of 15 to 19 years old (38.5%) and most of them went to secondary school (58.5%). Details about the demographic profile of respondents are provided in Table 5.1.

Table 5.1

Demographic Profile of Respondents

Age	Gender		Total
	Male	Female	
15-19	44	33	77
20-24	31	32	63
25-29	16	13	29
30-34	6	9	15
35-39	6	3	9
40-45	3	1	4
45-50	3	0	3
Total	109	91	200

5.4.2 Visitors' Opinion

It was found that most respondents (95.5%) agreed to have enjoyable informal learning experience at cultural heritage site by using AR application (refer to Table 5.2). These who considered using the AR application in the future are 93.5% while those who preferred the AR application to traditional media (books, maps and brochure) for learning at cultural heritage sites are 94% because it is convenient, fast, and useful as well as enjoyable and learnable about cultural heritage site visit.

Table 5.2

General Findings

No	Question	Frequency	
		Yes	No
C1	I will use mobile AR application for cultural heritage site in the future.	93.5%	5%
C2	I agree that the mobile AR application helps me to learn informally in enjoyable way at cultural heritage site.	95.5%	3.5%
C3	I prefer mobile AR application compared to traditional media (books, maps, and brochure).	94%	5%

Respondents also wrote comments on the questionnaire. Below are the comments from respondents which were divided into three categories of easy and useful, need improvement and better than traditional media (refer to Table 5.3). However, some comments were changed in terms of diction but the meaning was maintained.

Most of the comments stated that the application is easy, fast and useful. It has much information that helped respondents to gain knowledge. However, it is needed to be improved by adding places, features and transform the application to be a standalone application. In overall, respondents said that it is better than books for learning at the cultural heritage site and the availability of such application in the market is waited.

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5.4.3 Informal Learning Experience

The result revealed that most respondents agreed to have informal learning experience with overall mean score of 5.473 out of 7.00 (refer to Table 5.4). Furthermore, the score of standard deviation is 1.463 which indicated dispersion of score is around the number 5 scale, which is, agree area.

Table 5.3

Comments for Mobile AR for Enjoyable Informal Learning at Cultural Heritage Site

Category	Comments
Easy and Useful	(a) Good application for tourist and helps a lot in finding ways. *(Participant No 3)* (b) I have learned a lot from this application. It makes it easier for me to get information without going to the place. *(Participant No 45)* (c) It helps me know about cultural heritage with interesting way and deeper. *(Participant No 93)* (d) It attracts my attention. Got many information. Easy to use. *(Participant No 55)* (e) Useful, worthwhile and save time. *(Participant No 97)*
Need Improvement	(a) Would be helpful if the app would provide more cities. *(Participant No 6)* (b) Add more features. Add more places. No connection when no internet data. *(Participant No 53)* (c) Improve the graphic. *(Participant No 102)* (d) Advertise in social media. *(Participant No 66)* (e) Some more pictures/photos of information such as the local Malay/weapons and also the Dutch and Portuguese. Some more info such as the social conflict between the cultures. *(Participant No 122)*
Better than traditional media	(a) It is convenient and helps me to reduce the weight of the books while enjoying the beautiful scenery. I hope this AR apps come out in market soon with free download. *(Participant No 111)* (b) It is fast and useful. No need to bring books while traveling is enjoyable but learnable from the cultural heritage. If it is free to download is better but with minimum charge, it is still acceptable. *(Participant No 112)*

Table 5.4

Mean and Standard Deviation of Informal Learning

No	Question	Mean	Standard Deviation
A1	The Mobile AR application allows me to keep attention to the content of application.	5.41	1.229
A2	The Mobile AR application allows me to find the location in the cultural heritage site.	5.68	1.199
A3	The Mobile AR application keeps me awake during the visit at cultural heritage site.	5.6	1.22
A4	The Mobile AR application allows me to choose the content that i would like to know about	5.83	1.199
A5	The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.	5.33	1.157
A6	The Mobile AR application allows me to learn through storyline.	5.51	1.215
A7	The Mobile AR application helps me gain new knowledge about cultural heritage site.	5.85	1.231
A8	The Mobile AR application helps me recall what I have learnt about the cultural heritage site.	5.69	1.266
A9	The Mobile AR application allows me to learn about cultural heritage Site anytime and anywhere.	5.73	1.31
A10	Learning about cultural heritage Site using mobile AR application was:		
	a. Fulfilling	5.61	1.158
	b. Rewarding	6.21	1.172
	c. Useful	5.87	4.441
	d. Worthwhile	6.27	1.229
Overall		**5.473**	**1.463**

5.4.4 Enjoyable Experience

The result exposed that most respondents agreed to have enjoyable experience with an overall mean score of 5.412 out of 7.00 (refer to Table 5.5). In addition, the standard deviation is 1.26 which showed that the score's dispersion is around the number 5 scale, which is, agree area.

Table 5.5

Mean and Standard Deviation for Enjoyable

No	Question	Mean	Standard Deviation
	While using the Mobile AR application:		
B1	a. I was deeply engrossed.	5.24	1.208
B2	b. I was absorbed intently.	5.40	1.195
B3	b. My attention was focused.	5.42	1.247
B4	c. I fully concentrated.	5.53	1.264
	While using the Mobile AR application, I felt:		
B5	a. Happy	5.28	1.259
B6	b. Pleased	5.34	1.282
B7	c. Satisfied	5.49	1.273
B8	d. Contented	5.65	1.343
Overall		**5.412**	**1.260**

5.4.5 Enjoyable Informal Learning Experience

The result discloses that respondents agreed to have enjoyable informal learning experience with an overall mean score of 5.61 out of 7.00 (refer to table 5.6). Moreover, the score of standard deviation is 1.20 which proved that the dispersion of score is around the number 5 scale, which is, agree area.

Table 5.6

Mean and Standard Deviation for Enjoyable Experience

No	Question	Mean	Standard Deviation
A1	The Mobile AR application allows me to keep attention to the content of application.	5.41	1.229
A2	The Mobile AR application allows me to find the location at cultural heritage site.	5.68	1.199
A3	The Mobile AR application keeps me awake during the visit at cultural heritage site.	5.60	1.22
A4	The Mobile AR application allows me to choose the content that i would like to know about.	5.83	1.199
A5	The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.	5.33	1.157
A6	The Mobile AR application allows me to learn through story.	5.51	1.215
A7	The Mobile AR application helps me gain new knowledge about cultural heritage site.	5.85	1.231
A8	The Mobile AR application helps me recall what I have learnt about the cultural heritage site.	5.69	1.266

Table 5.6 continued

A9	The Mobile AR application allows me to learn about cultural heritage site anytime and anywhere.	5.73	1.31
A10	Learning about cultural heritage site using mobile AR application was:		
	a. Fulfilling	5.61	1.158
	b. Rewarding	6.21	1.172
	c. Useful	5.87	4.441
	d. Worthwhile	6.27	1.229
	While using the Mobile AR application:		
B1	a. I was deeply engrossed.	5.24	1.208
B2	b. I was absorbed intently.	5.40	1.195
B3	c. My attention was focused.	5.42	1.247
B4	d. I fully concentrated.	5.53	1.264
	While using the Mobile AR application, I felt:		
B5	a. Happy	5.28	1.259
B6	b. Pleased	5.34	1.282
B7	c. Satisfied	5.49	1.273
B8	d. Contented	5.65	1.343
Overall		**5.61**	**1.200**

The results showed that enjoyable informal learning has occurred during the visit. The respondents agreed that they had experienced the learning process from the content, navigation and user interface design, interactivity, and feature provided by AR@Melaka. Therefore, as what they said in the comment, visitors think it was useful, enjoyable, and learnable device so they do waited for its presence in the market to be used again for the future. This result concluded that the AR@Melaka is usable for conducting enjoyable informal learning experience at cultural heritage site.

5.5 Summary

This chapter explains about validation of the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning through prototyping and evaluation of AR@Melaka towards enjoyable informal learning experience. The development of the prototype consists of pre-production, production and post-production. These three phases produced the prototype. Pre-production is the process

to design the user interface. It is continued to production where the content was created. And in the end, programming language, the channel, and the prototype was developed in post-production, with the deliverable of prototype, conceptual model has validated to be applicable (objective 3).

After the prototype has been completely developed, the prototype was disseminated to visitors to be evaluated. It was tested at Melaka Heritage site based on the measurement of enjoyable informal learning experience ("Measuring Enjoyable Informal Learning at Cultural Heritage Site"). The result showed that visitors agreed that they had experienced enjoyable informal learning. These positive results prove that the conceptual model is applicable and the prototype has helped respondents to learn about cultural heritage site.

The conclusion of the study is provided in chapter 6. In addition, it also deliberates the limitation and future work of the study.

CHAPTER SIX
CONCLUSION

Introduction

This chapter provides important aspects that can be derived from the study of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. It highlights the answer of research questions and discussion of findings. It also describes contributions of research to the body of knowledge, significance of research, limitation of study and future recommendation of study.

6.1 Answers of Research Questions

This study aims to develop a conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. Therefore, this study was conducted based on three research questions:

a) What are the components of the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

b) How to develop the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

c) How to validate the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

The answers for these questions are provided in the subsequent sections.

A) Research Question 1:

What are the components of the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

Components of conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning comprise content, navigation and user interface design, interactivity, features, hardware, and process. These components are supported by elements (refer to Table 6.1). In total, there are six components and twenty nine elements that form the conceptual model. Components are presented in detail in Chapter 4.

Table 6.1

List of Component and Element of Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

Component	Element
Hardware	Handheld devices (smart-phones, tablet)
Process	Reconstruction
	Registration
	Tracking
	Rendering
	Interaction
Interactivity	Activity
	Interaction
Navigation and user interface design	Provide thematic path through site
	Provide layered information
	Provide one-tap access for frequent menu
	Provide one-handed control
	Provide clue for scene with augmented content
	Provide shaped button
	Provide quick button to go to main menu
	Provide big size of font
	Provide enough contrast between text and background
	Provide appropriate size of content
Feature	Games
	Personalization
	Physical Orientation
Content	3D model
	3D character
	Text

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Table 6.1 continued

	Image
	Audio
	Sound
	Animation
	Video

These components were determined based on activities described in Chapter 4 which showed that the first objective of this study has been achieved and completed.

B) Research Question 2:

How to develop the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

The conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning was developed through literature review (Chapter 2), extraction of concept of enjoyable informal learning (Chapter 4 Section 4.2.1), and comparative analysis of existing conceptual model and mobile AR framework (Chapter 4 Section 4.2.2). Furthermore, detail development process also can be referred to Figure 4.1 in Section 4.1.

Based on concept of enjoyable informal learning, factors of concept were extracted and transformed into component. Next, it was continued by determining elements from comparative analyses of mobile AR for cultural heritage site, mobile tourism guide, mobile learning, and mobile AR framework. It also followed by literature review for adding the component of conceptual model. The summary of development of conceptual model is provided in Table 6.2 and Figure 4.1.

Table 6.2

Summary of Development of Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

Phases	Outcomes
Extraction of concept of enjoyable informal learning	Component of conceptual model: Media elements, navigation, activity, social interaction, games, opening, and presentation style.
Comparative analysis of mobile AR for cultural heritage, mobile tourism, mobile learning, and mobile AR framework	Element of Conceptual Model: media, navigation, activity, social interaction, games, presentation style.
Literature Review	Supporting element of Conceptual Model: media, navigation, activity, social interaction, games, presentation style.

Finally, the conceptual model has been produced. Therefore, it can be concluded that objective 2 of this research has been completed and successfully achieved.

C) Research Question 3:

How to validate the conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning?

The proposed conceptual model was validated through expert review (Chapter 4 Section 4.1), focus group discussion (Chapter 4 Section 4.3), and prototyping (Chapter 5).

Firstly, the conceptual model was validated by expert review. It was conducted by gathering seven experts in the field of AR, HCI and multimedia. This review obtained feedbacks to improve the conceptual model. Then these feedbacks were responded by embarking on a field study of enjoyable informal learning content at cultural heritage site. Next, field study resulted new components of conceptual model

(Chapter 4 Section 4.2) which were inserted to conceptual model. Next, the conceptual model was validated in focus group discussion.

The focus group discussion was conducted to other experts to review the conceptual model. Then, it was continued by review of related conceptual model of mobile AR for cultural heritage site and review of conceptual model of mobile guide in order to answer the experts' suggestions in focus group discussion. The review produced new components and revised version of the conceptual model (Chapter 4 Section 4.4).

The revision varies from the terms, name of component, structure of conceptual model, supporting element of content, supporting element of physical orientation, supporting element of activity, component of process, component of interaction, component of personalization, and component of navigation and user interface design. All the revision finally made the final version of the conceptual model which consists of six components and twenty nine elements. It was named Conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning (MARCHSTEIL) (refer to Figure 6.1).

And it continued by, the final version of the conceptual model was sent to prototyping. The prototype was developed based on the conceptual model. This step was completed to validate the proposed conceptual model. Then, the prototype was also evaluated by visitors based on enjoyable informal learning experience.
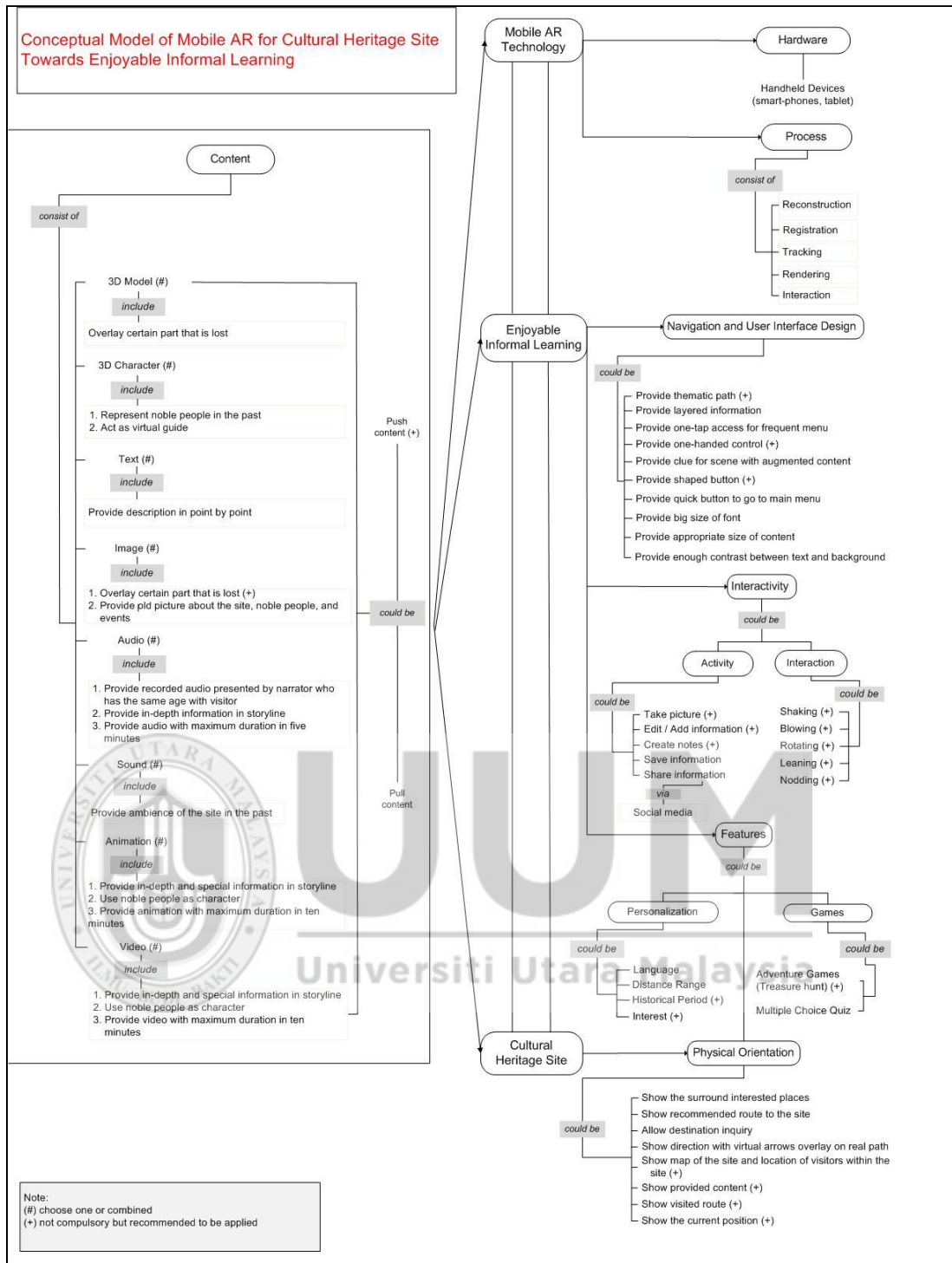
Figure 6.1. Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The results of evaluation were analysed and resulted, showing that visitors agreed that they had enjoyable informal learning during the visit. This finding is consistent with previous research where mobile AR is proven effective for learning and

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provides enjoyable experience for visitors (Bellotti et al., 2002; Owen, Owen, Barajas, & Trifonova, 2011; Gargalakos & Rogalas, 2011; Elinich, 2011; Liestøl, 2011; Chang et al., 2015; Liu et al., 2009).

6.2 Significance of study

This study contributes to these fields, (a) social and (b) educative and historical value. Further explanation on these significances is provided in the followings:

A) Social

Visitors can learn history in enjoyable way which make them having new perspective about cultural heritage site as interesting place. A place where visitor learn and gain new knowledge but not boring and static place which has been perceived in citizen's mind all this time. By having this perception, it is hoped that the position of cultural heritage site will be raised in better position in society.

B) Educative and Historical Value

The provision of historical information in prototype brings out the educative and historical value. Visitors can gain knowledge, achieve the advanced understanding of cultural heritage, and explore the cultural heritage more deeply (Carillo, Rodriguez-Echavaria, & Arnold, 2007). These lead to the emotional fastening between visitor and exhibit, memory improvement, fast learning, as well as lifelong learning (Damala et al., 2008; Nofal, 2015)) that effects to the growth of knowledge, awareness of conservation, and finally, appreciation of cultural heritage site.

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6.3 Limitations and Future Recommendations

This study has some limitations from the conceptual model, prototype AR@Melaka, and evaluation of enjoyable informal learning experience. The next section explains the limitation and the future recommended action to be taken:

A) Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

The conceptual model provides six components for learning in enjoyable way at cultural heritage site, which are, content, hardware, process, navigation and user interface design, interactivity, and features. However, it lacks for providing feature that enable visitor to interact and discuss about history at cultural heritage site.
Although one feature has provided in the model, 'Shows the map of cultural heritage site and location of visitors within it', which location of visitor's members to be viewed so visitor can discuss and interact with members, it is not adequate for enabling the rich social interaction at cultural heritage site.

The future study can add the component of interpersonal interaction by adding the component that has relation to face to face interaction or computer to computer interaction (Sung, Hou, Liu, & Chang, 2010).

B) Prototype AR@Melaka

AR@Melaka has one limitation which is, the dependency of internet connection. Furthermore, future study can develop AR@Melaka in standalone therefore visitor can use offline.

C) Evaluation of Enjoyable Informal Learning Experience

The evaluation study did not cover the level of enjoyable informal learning experienced by visitor. It covered up to the extent of respondent's perception. Since the evaluation was done by asking the visitor using the application and answering the questionnaire. Therefore, the future study is to apply quasi-experimental study that assign group of participant to different situation in order to know how much enjoyable informal learning has been achieved (Lazar, Feng, & Hochheiser, 2010).

6.4 Conclusion

This study has produced a conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning. The model comprises three structures, six components and twenty nine elements. The structures represent the main topic of conceptual model, which are, mobile AR, enjoyable informal learning, and cultural heritage. The component presents the main component that are appropriate for conducting enjoyable informal learning at cultural heritage site, which are, content, navigation and user interface design, interactivity, features, hardware, and process. Lastly, the elements of content component are the backbone in realizing enjoyable informal learning.

Although suggestion and future works remain, this study proves the validity of conceptual model through validation steps and prototyping. In addition, evaluation for the prototype was also conducted to measure enjoyable informal learning experience. The results showed that visitors agreed that they had enjoyable informal learning during by using the prototype. Visitors were also preferred the prototype to

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traditional media as they want to use it again in the future. All these results conclude that the conceptual model is usable.

Finally, the conceptual model is hoped to be a guideline for developers to develop mobile AR for learning in enjoyable way at cultural heritage site. In addition, this model is also hoped to be used and to make an impact onto the existence of cultural heritage site.

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Appendix A
Awards and Recognitions

2015

a) Silver Award at Invention, Innovation, and Design on E-Learning at NUCEL (National University Carnival on E-Learning)
b) First Winner at UUM 3 Minute Thesis Competition

2014

a) First Place at IDEA ICT Innovation Expo UUM
b) Silver Award at ITEX (International Invention Innovation and Technology Exhibition)
c) Bronze Award at MTE (Malaysia Technology Expo)
d) Featured in Berita Harian on article titled "Aplikasi Papar Maklumat Tempat Bersejarah", April 3rd, 2014

2013

a) Silver Award at PECIPTA (International Conference and Exposition on Inventions of Institutions for Higher Learning)
b) Special Jury Award from Association of Polish Inventors and Rationalizers at PECIPTA (International Conference and Exposition on Inventions of Institutions for Higher Learning)
c) Exploratory Research Grant Scheme awarded by Ministry Education of Malaysia, 2013-2015

2012

a) UUM Postgraduate Scholarship

Appendix B

List of Publications

A. Journals

1. Ulka Chandini P., & Syamsul Bahrin Z., & Juliana A. Abu Bakar. (2015). Conceptual Model of Mobile AR for Cultural Heritage Site Towards Enjoyable Infomal Learning. *Jurnal Teknologi 77 (29), pp. 123-129.* [Scopus]

2. Ulka Chandini P., & Syamsul Bahrin Z., & Juliana A. Abu Bakar. (2015). Digital interpretive media usage. *Jurnal Teknologi*, 75 (4), pp. 71-77. [Scopus]

3. Ulka Chandini P., & Syamsul Bahrin Z., & Juliana Aida A B. (2014). User experience on enjoyable informal learning via mobile AR: Development and Evaluation. *International Journal of Interactive Digital Media*. 2(2), pp. 29-34, ISSN: 2289-4098; eISSN: 2289-4101.

4. Ulka Chandini P., & Syamsul Bahrin Z., & Juliana Aida A B. (2014). Mobile AR for cultural heritage site towards enjoyable informal learning: a revised conceptual model.*Information Management & Business Review*, 6(5), pp. 239-248.

5. Ulka Chandini P.,& Syamsul Bahrin Z. (2014). Enjoyable informal learning at cultural heritage site using mobile augmented reality: a conceptual model. *Journal of Advances in Science and Technology*, 2(3), pp. 93–106.

6. Ulka Chandini P., & Syamsul Bahrin Z., & Juliana Aida A B. (2014). Mobile augmented reality for enjoyable informal learning at cultural heritage site. *International Journal of Computer Applications*, 92(14), pp. 19–26.

B. Accepted Paper

1. Ulka Chandini P., & Syamsul Bahrin Z., & Juliana A. Abu Bakar. (2016). Measuring Enjoyable Informal Learning at Cultural Heritage Site. AIP Conference Proceedings on International Soft Science Conference, Langkawi, April, 11th-13th, 2016.

C. Proceedings of International Conference (Selected)

1. Ulka Chandini P., & Syamsul Bahrin, Z. (2013). Non-Personal digital interpretive media, Proceedings of the 4th International Conference on Computing and Informatics, Sarawak, (115), pp. 346–351.

2. Ulka Chandini P., & Syamsul Bahrin Z., & Juliana A. Abu Bakar. (2015). User requirement on model of mobile AR for cultural heritage site towards enjoyable informal learning. Proceedings of Asia Pacific Conference on Multimedia and Broadcasting Bali, 23rd-25th of April, 2015, pp. 61-67, IEEE.

Appendix C

Expert Review Form:

Conceptual Model of Mobile AR for Cultural Heritage Site

towards Enjoyable Informal Learning

Abstract:
Learning experience is highly necessary needed when visiting heritage sites but it is not adequately provided with the existing traditional information display. Reports show that most of the information displays are the conventional ones that are not interesting for visitors. Augmented Reality is a current emerging technology to be applied in the cultural heritage area. However, the Augmented Reality implementation is highly limited at these cultural heritage sites. Moreover, the conceptual model for developing mobile Augmented Reality at cultural heritage is also lacked. The main objective of this study is to develop the mobile Augmented Reality conceptual model to improve visitor's informal learning experience at cultural heritage site. Four learning theories and four informal learning theories are integrated in the proposed conceptual model. The main finding of this study will be the conceptual model for mobile Augmented Reality for cultural heritage site towards enjoyable informal learning.

Objective of Expert Review:
- To review the proposed Conceptual Model of Mobile Augmented Reality for Cultural Heritage towards Enjoyable Informal Learning.

Expert/Reviewer Details

Name :

Age :

Gender :

Email:

Terminology of Component

a) **Theory:** Theory that supports the content element provided for mobile augmented reality for cultural heritage towards enjoyable informal learning.

b) **Content Structure:** Structure of content that should be provided in mobile augmented reality for cultural heritage towards enjoyable informal learning.

c) **Mobile Technology:** Mobile phone technology that supports the development of MARCHSTEIL.

Description of Theory

a) **Multimedia Learning:** Learning theory that explains the process about how humans learn from multimedia element, such as, words (text and spoken words) and pictures (illustration, animation and video).

b) **Mindfulness Theory:** Theory that relates with character of visitor, which are mindfulness and mindlessness that usually induces visitor while visiting the cultural heritage site.

c) **Constructivism Theory:** Learning theory that has perception that learner constructs the new knowledge based on the past and present knowledge.

d) **Situated Learning Theory:** Theory that deals with social context and reveals the process about how to approach the technology as a culture that influences the perception of informal learning in community.

e) **Experiential Learning Theory:** Theory that provides four-stage different learning cycles which are concrete experience, reflect observation, abstract conceptualization and active experiment for different learning style.

f) **Collaborative Learning Theory:** Theory that considers the collaboration between learners for working together and finding the solution of problem.

Terminology of Content Structure

a) **Media Elements:** Media elements that should be provided in the MARCHSTEIL.

b) **Activity:** Activity that can trigger the learning process at cultural heritage site.

c) **Navigation:** Navigation that helps visitor to enjoy learning at cultural heritage site.

d) Social interaction: Social interaction that helps visitor to interact with their groups while visiting the cultural heritage site.

e) Games: Games that can help visitor to enjoy the learning process at cultural heritage site.

f) Presentation style: The style how to present the augmented reality content for enjoyable informal learning at cultural heritage site.

.

Items for Review

Based on the proposed conceptual model (as depicted in the given handout), please tick your choice.

1	The following **terminology**	Needs very detail explanations	Needs some explanations	Is easy to understand	Comments
a)	Content Structure				
b)	Theory				
c)	Mobile Technology				

2	The **proposed elements** in the following components **are relevant**	Some are definitely not relevant	Some may be not relevant	All are relevant	Comments
a)	Media Elements				
b)	Activity				
c)	Navigation				
d)	Social Interaction				
e)	Games				
f)	Presentation Style				
g)	Mobile Technology				

3	The **proposed theories** in the following components **are relevant**	Not relevant	Relevant	Comments
a)	Multimedia Learning Theory			
b)	Mindfulness Theory			
c)	Constructivism Theory			
d)	Situated Learning Theory			
e)	Experiential Learning Theory			
f)	Collaborative Learning Theory			

4. The connections of all the theories and components are logical.

   Yes ( )   No ( )

5. The conceptual model is usable to the development of mobile AR for cultural
   heritage towards enjoyable informal learning.

   Yes ( )   No ( )

6. Overall, the conceptual model is readable.

   Yes ( )   No ( )

7. Please write your further comments:

_____

Appendix D

Kajian Mengenai Keseronokan Pembelajaran Tidak Formal di Tapak Warisan Budaya*(Study of Enjoyable Informal Learning Content at Cultural Heritage Site)*

1. Apakah jenis media yang anda mahu lihat di tapak warisan budaya? / *what types of media would you like to see at cultural heritage site?(Pilih lebih daripada satu / choose more than one)*

   a. Model 3D */ 3D model*

   b. Watak 3D / *3D character*

   c. Teks / t*eks*

   d. Imej / *image*

   e. Audio / *audio*

   f. Animasi / *animation*

   g. Video / *video*

2. Apakah jenis teks yang anda mahu lihat? / *what kind of text would you like to see?* (Pilih lebih daripada satu / *choose more than one*)

   a. Pendek */ short*

   b. Papar satu demi satu */ show point by point*

   c. Papar sejarah lengkap */ show details of history*

   d. Saiz huruf besar/ *big size of font*

   e. Saiz huruf kecil /*small size of font*

   f. Lain-lain / *others:*

   _____

3. Apakah jenis model 3D yang anda mahu lihat? */ what kind of 3D model would you like to see?*

   a. Model 3D yang menindih atas bahagian tertentu yang hilang / *3D model that overlays certain part that is* lost

b. Lain lain / *others*:

_____

4. Apakah jenis watak 3D yang anda mahu lihat? / *what kind of 3D character would you like to see?*

a. Watak 3D yang mewakili orang mulia pada masa lalu/ *the 3D character that represent noble people in the past*

b. Lain-lain / *others*:

_____

5. Apakah jenis imej yang anda mahu lihat? / *what kind of image would you like to see?* (Pilih lebih daripada satu /*choose more than one*)

c) Imej yang menindih atas bahagian tertentu yang hilang / *image that overlays certain part that is lost*

b. Gambar lama mengenai tapak warisan budaya / *old pictures of cultural heritage site*

c. Gambar lama dengan tahun dalam susunan kronologi / *old pictures with year in chronological order*

d. Lain-lain /*others*:

_____

6. Apakah jenis audio yang anda mahu dengar? / *what kind of audio would you like to listen to?* (Pilih satu / *choose one*)

a. Audio mengenai sejarah tapak warisan budaya / *audio about history of cultural heritage site*

b. Audio mengenai sejarah tapak warisan budaya melalui jalan penceritaan / *audio about history of cultural heritage site in storytelling*

c. Audio mengenai sejarah tapak warisan budaya dengan pencerita mempunyai umur yang sama dengan saya/ *audio about history of cultural heritage site with narrator who has same age with me*

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d. Audio mengenai tapak warisan budaya dengan pencerita mempunyai umur yang sama dengan saya melalui jalan penceritaan / *audio about history of cultural heritage site in storytelling with narrator who has same age with me*

7. Berapa lama anda inginkan untuk mendengarkan audio? / *how long would you prefer to listen to audio?* (Pilih satu / *choose one*)

a. 1-3 minit / *1-3 minutes*
b. 3-5 minit /*3-5 minutes*
c. 5-8 minit /*5-8 minutes*
d. Lebih daripada 8 minit/ *more than 8 minutes*

8. Apakah jenis suara yang anda mahu dengar? / *what kind of sound would you like to hear?* (Pilih satu / *choose one*)

a. Suasana di tapak warisan budaya (suara bom, orang bercakap, dan lain-lain) / *ambience of cultural heritage site (sounds of bomb, people talking, etcetera)*
b. *Lain-lain*/ others: _____

9. Apa jenis 3D animasi yang anda mahu lihat? / *what kind of 3D animation would you like to see?* (Pilih satu / *choose one*)

a. Animasi 3D yang menyerupai kehidupan masa lampau pada tapak warisan budaya / *3D animation that simulated past life at cultural heritage site*
b. Animasi 3D yang menceritakan sejarah tapak warisan budaya /*3D animation that tells history about cultural heritage site*
c. Animasi 3D yang menceritakan sejarah tapak warisan budaya melalui jalan penceritaan /*3D animation that tells history about cultural heritage site in storytelling*
d. Animasi 3D yang menceritakan sejarah tapak warisan budaya dengan masyarakat zaman dahulu sebagai watak/ *3D animation that tells history about cultural heritage site with past noble people as the character*

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e. Animasi 3D yang menceritakan sejarah tapak warisan budaya dengan masyarakat zaman dahulu sebagai watak melalui jalan penceritaan */3D animation that tells history about cultural heritage site in storytelling with noble people as character*

f. Lain-lain /*others*:

_____

10. Berapa lama anda lebih suka menonton Animasi 3D? */ how long would you prefer to watch 3D animation?* (Pilih satu / *choose one*)

a. 1-5 minit */ 1-5 minutes*

b. 5-10 minit */ 5-10 minutes*

c. 10-15 minit / *10-15 minutes*

d. Lebih daripada 15 minit / *more than 15 minutes*

11. Apa jenis video yang anda mahu tonton? / *what kind of video would you like to watch?* (Pilih satu / *choose one*)

a. Video mengenai sejarah tapak warisan budaya / *video about history of cultural heritage site*

b. Video mengenai sejarah tapak budaya melalui jalan penceritaan / *video about history of cultural heritage site in storytelling*

c. Video mengenai sejarah tapak warisan budaya dengan masyarakat zaman dahulu sebagai watak / *video about history of cultural heritage site with past noble people as character*

d. Video mengenai sejarah tapak warisan budaya dengan masyarakat zaman dahulu sebagai watak melalui jalan penceritaan / *video about history of cultural heritage site in storytelling with past noble people as character*

e. Video mengenai sejarah tapak warisan budaya dengan pencerita yang mempunyai umur yang sama dengan saya / *video about history of cultural heritage site with narrator who has same age with me*

f. Lain-lain / *others*:

_____

12. Apakah anda inginkan untuk belajar berdasarkan minat pada tapak warisan budaya? */ would you prefer to learn based on your interest at cultural heritage site?*

13. Apakah navigasi atau peta yang anda inginkan untuk membantu anda belajar dengan seronok pada tapak warisan budaya? */ what are the navigation / map that would you prefer to help you learn in enjoyable way at cultural heritage site?* (Pilih lebih daripada satu / *choose more than one*)

    a. Peta berdasarkan minat */ map based on interest*

    b. Peta berdasarkan media / *map based on media*

    c. Peta berdasarkan sejarah dalam susunan kronologi */ map based on history in chronological order*

    d. Peta yang menunjukkan posisi saya pada tapak warisan budaya */ map shows my current position at cultural heritage site*

    e. *Peta yang menunjukkan tempat menarik lain pada tapak warisan budaya* / Map shows other interested places at cultural heritage site /

    f. *Peta yang menunjukkan jalan yang sudah saya lawati di tapak warisan budaya* / Map shows the path I have visited at cultural heritage site /

    g. Lain-lain */ others*:

    _____

14. Apakah permainan yang anda mahu mainkan di tapak warisan budaya? */ what are games would you like to play at the cultural heritage site?* (Pilih satu / *choose one*)

    a. Permainan untuk melatih otak (puzzle 3D) */ brain games (3D puzzle)*

    b. Permainan Petualangan (Mencari harta karun) */ adventure games (Treasure hunt)*

    c. Lain-lain / *others*:

    _____

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15. Apakah jenis aktiviti yang anda mahu lakukan ketika mencapai kandungan aplikasi reality luasan mudah alih? */ what kind of activity would you like to have while accessing the content of mobile AR?* (Pilih lebih daripada satu / *choose more than one*)

    a. Menyimpan maklumat mengenai tapak warisan budaya */ save information about the cultural heritage site*

    b. Menyunting maklumat mengenai tapak warisan budaya */ edit information about the cultural heritage site*

    c. Mengambil gambar mengenai tapak warisan budaya / *take picture of cultural heritage site*

    d. Membuat nota mengenai tapak warisan budaya / *create notes about cultural heritage site*

    e. Merakam suara mengenai tapak warisan budaya / r*ecord voice about cultural heritage site*

    d. Berkongsi maklumat mengenai tapak warisan budaya melalui media social / *share information about cultural heritage site to social media*

    e. Lain-lain / *others*:

    _____

16. Apakah jenis interaksi yang anda mahu lakukan ketika menggunakan aplikasi realiti luasan mudah alih? */ what kind of interaction would you like to have while using the mobile AR application?* (Pilih lebih dari satu / *choose more than one*)

    a. Menggoncangkan peranti untuk mendapatkan maklumat */ shake device to view information*

    b. Meniup peranti ke atas artifak untuk mendapatkan maklumat */ blow device over artifact to view information*

    c. Memutarkan peranti untuk memberitahu kemana objek harus berpindah / *rotating device to tell where object should move to*

    d. Lain-lain */others*:

    _____

17. Adakah anda ingin untuk melakukan hal ini pada tapak warisan budaya: */ do you like to do this at cultural heritage site:* (Pilih lebih daripada satu / *choose more than one*)

    a. Anda dapat bergambar sambil memakai kostum tradisional orang mulia di masa lampau dengan teknologi realiti luasan / *you can take picture wearing the costume of noble people in the past using AR technology*

    b. Anda dapat berfoto dengan kejadian di masa lampau dengan teknologi realiti luasan / *you can take picture with the events of the past with AR technology*

18. Apakah hal yang membuatkan anda seronok ketika belajar di tapak warisan budaya? / *what are things that make you enjoy while learning at cultural heritage site?*

_____

_____

_____

_____

19. Apakah ciri-ciri lain yang anda mahu lihat ketika melawat tapak warisan budaya? / *What are other features would you like to have while visiting the cultural heritage site?*

_____

_____

_____

_____

Appendix E

Focus Group:

Evaluating Conceptual Model of Mobile AR for Cultural Heritage Site towards Enjoyable Informal Learning

Abstract:

Learning experience is highly necessary when visiting heritage sites but it is not adequately provided with the existing traditional information display. Reports show that most of the information displays are the conventional ones that are not interesting for visitors. Augmented Reality is a current emerging technology to be applied in the cultural heritage area. However, the Augmented Reality implementation is highly limited at these cultural heritage sites. Moreover, the conceptual model for developing mobile Augmented Reality at cultural heritage is also lacked. The main objective of this study is to develop the mobile Augmented Reality conceptual model to improve visitor's informal learning experience at cultural heritage site. Three learning theories are integrated in the proposed conceptual model. The main finding of this study will be the conceptual model for mobile Augmented Reality for cultural heritage site towards enjoyable informal learning.

Objective of Expert Review:

- To review the proposed Conceptual Model of Mobile Augmented Reality for Cultural Heritage Site towards Enjoyable Informal Learning.

Expert/Reviewer Details

Name	:	_____
Age	:	_____
Gender	:	_____
Education	:	_____
Field of expertise	:	_____
Experience (year)	:	_____

Terminology of Component

a) **Theory:** Theory that supports the content element of proposed model.

b) **Content Element:** Element of content that supports the enjoyable informal learning at cultural heritage site.

c) **Mobile AR Technology:** Core technologies and necessary devices needed for developing MARCHSTEIL.

Description of Theory

a) **Multimedia Learning Theory:** Learning theory that explains the process about how humans learn from multimedia element, such as, words (text and spoken words) and pictures (illustration, animation and video).

b) **Mindfulness Theory:** Theory that relates with character of visitor, which are mindfulness and mindlessness that usually induces visitor while visiting the cultural heritage site.

c) **Constructivism Theory:** Learning theory that has perception that learner constructs the new knowledge based on the past and present knowledge.

Terminology of Content Element

a) **Context-awareness:** personalized setting controlled by visitor to help them learning in enjoyable way at cultural heritage site.

b) **Media Elements:** Media elements that support the enjoyable informal learning activity at cultural heritage site.

c) **Navigation:** Navigation that helps visitor to enjoy learning at cultural heritage site based on the learning route.

d) **Activity:** Activity that can trigger the whole learning process at cultural heritage site by integrating the learners, learning material, and learning environment.

e) **Games:** Games that are not only enhance the learning motivation of visitor but also help visitor to enjoy the learning process at cultural heritage site.

f) **Push Content:** Content that is automatically appear when visitor reaches certain area.

g) Pull content: Content that is not automatically appears but it needs visitor to response for viewing detail information about the object/area.

Terminology of Mobile AR Technology

a) Hardware: Physical components or elements of handheld device needed for developing mobile AR for cultural heritage towards enjoyable informal learning

b) Software: Computer programs needed for developing mobile AR for cultural heritage towards enjoyable informal learning

c) Process: Steps or actions needed to develop Mobile AR for cultural heritage site towards enjoyable informal learning

Items for Review

Based on the proposed conceptual model (as depicted in the given handout), please answer the following questions:

1. Do all proposed components are relevant?

2. Do all proposed theories are relevant?

3. Do all proposed elements and supporting elements in content element are relevant?

4. Do all proposed elements and supporting element in mobile AR technology are relevant?

5. Do all terms are relevant?

6. Do the connection between the components are logical?

7. Please write your further comments.

Appendix F

Instrument for Measuring Enjoyable Informal Learning at

Cultural Heritage Site

No: ☐☐

College of Arts and Sciences

UNIVERSITI UTARA MALAYSIA

Questionnaire

Measuring Enjoyable Informal Learning at Cultural Heritage Site

Prepared by:

Ulka Chandini Pendit

Assalammu'alaikum and Good Day,
Assalammu'alaikum dan Salam Sejahtera,

Dear respondents, we are delighted to inform you that you have been selected randomly to participate in our research (Mobile AR for Cultural Heritage Site Towards Enjoyable Informal Learning). The aim of the questionnaire is to measure the enjoyable informal learning at cultural heritage site.

Tuan/puan telah dipilih secara rawak untuk terlibat dalam kajian kami (Aplikasi Realiti Luasan Mudah Alih untuk Warisan Budaya ke Arah Keseronokan Pembelajaran Tidak Formal). Tujuan borang soal selidik ini adalah untuk mengukur keseronokan pembelajaran tidak formal di tapak warisan budaya.

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publication.

Maklumat yang diberikan akan dirahsiakan dan digunakan hanya untuk rujukan yang akan dilaporkan tanpa nama untuk tujuan penerbitan akademik.

It would be greatly appreciated is you could complete the questionnaire with honest and sincere. I would like to say thank you for your time and cooperation.

Adalah sangat dihargai jika tuan/puan dapat menjawab dengan jujur dan ikhlas.Saya mengucapkan terima kasih untuk masa dan kerjasama yang diberikan.

Yours Truly,
Yang benar,

Ulka Chandini Pendit

Demographic Information / *Maklumat Demografi*

1. Gender/*Jantina* :   Male/*Lelaki* ( )   Female/*Perempuan* ( )

2. Age/*Umur* : _____

3. Nationality/*Warganegara*: _____

4. Education/*Pendidikan*:

   Secondary School /*Sekolah Menengah* ( )   Bachelor/*Sarjana Muda* ( )

   Master/*Sarjana*   ( )   PhD/*Doktoral*   ( )

5. Do you have mobile phone? / *Adakah anda mempunyai telefon mudah alih?*

   Yes/*Ya* ( )   No / *Tidak* ( )

   If yes, please mention the brand / type of your mobile phone: / *Jika ya, sebutkan*

   nama model telefon bimbit anda: _____

INSTRUCTION: Circle the number that fits your best selection for each statement based on the following scale.

ARAHAN: Bulatkan nombor yang paling sesuai dengan pilihan untuk setiap pernyataan berdasarkan kepada skala berikut.

Strongly Disagree *Sangat Tidak Setuju*	←	1	2	3	4	5	6	7 →	**Strongly Agree** *Sangat Setuju*
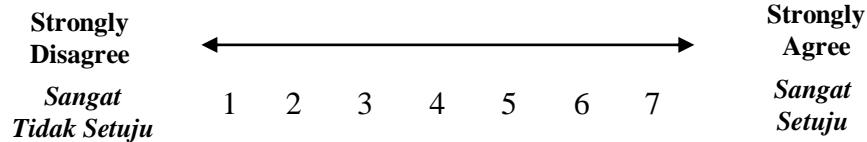
A. Informal Learning / *Pembelajaran Tidak Formal*

1. The Mobile AR application allows me to keep attention to the content of application.
   Aplikasi realiti luasan mudah alih membenarkan saya untuk menumpukan perhatian kepada kandungan aplikasi.

   1 2 3 4 5 6 7

2. The Mobile AR application allows me to find the location in the cultural heritage site.
   Aplikasi realiti luasan mudah alih membenarkan saya untuk mencari lokasi tapak warisan budaya.

   1 2 3 4 5 6 7

3. The Mobile AR application keeps me to be awake during the visit at cultural heritage Site.
   Aplikasi realiti luasan mudah alih membuatkan saya sentiasa terjaga tentangkeberadaan saya di warisan budaya.

   1 2 3 4 5 6 7

4. The Mobile AR application allows me to choose the content that I would like to know about.
   Aplikasi realiti luasan mudah alih membenarkan saya untuk memilih kandungan yang saya ingin ketahui.

   1 2 3 4 5 6 7

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5. The Mobile AR application allows me to interact and engage in a discussion with other visitors during the visit.
Aplikasi realiti luasan mudah alih membenarkan saya untuk berinteraksi dan melibatkan diri dalam perbincangan dengan pengunjung lain semasa lawatan.

1 2 3 4 5 6 7

6. The Mobile AR application allows me to learn through story.
Aplikasi realiti luasan mudah alih membantu saya belajar melalui cerita.

1 2 3 4 5 6 7

7. The Mobile AR application helps me to gain new knowledge about cultural heritage Site.
Aplikasi realiti luasan mudah alih membantu saya mendapatkan pengetahuan baharu mengenai tapak warisan budaya.

1 2 3 4 5 6 7

8. The Mobile AR application helps me to recall what I have learnt about the cultural heritage Site.
Aplikasi realiti luasan mudah alih membantu saya untuk mengingat kembali apa yang telah saya pelajari mengenai tapak warisan budaya.

1 2 3 4 5 6 7

9. The Mobile AR application allows me to learn about cultural heritage Site anytime and anywhere.
Aplikasi realiti luasan mudah alih membenarkan saya untuk belajar mengenai warisan budaya pada bila-bila masa dan di mana-mana sahaja.

1 2 3 4 5 6 7

10. Learning about cultural heritage Site using mobile AR application was:
Belajar mengenai tapak warisan budaya menggunakan aplikasi realiti luasan mudah alih adalah:

a. Fulfilling
Memuaskan

1 2 3 4 5 6 7

b. Rewarding
Bermanfaat

1 2 3 4 5 6 7

c. Useful
   Berguna   1 2 3 4 5 6 7

d. Worthwhile
   Berbaloi   1 2 3 4 5 6 7

B. Enjoyable / Menyeronokkan

1. While using the Mobile AR application:
   Semasa menggunakan aplikasi realiti luasan
   mudah alih ini:

a. I was deeply engrossed.   1 2 3 4 5 6 7
   Saya berasa sangat asyik.

b. I was absorbed intently.   1 2 3 4 5 6 7
   Saya dapat menyerap maklumat dengan penuh
   minat.

c. My attention was focused.   1 2 3 4 5 6 7
   Saya dapat memfokuskan perhatian.

d. I am fully concentrated.   1 2 3 4 5 6 7
   Saya dapat menumpukan sepenuhnya.

2. While using the Mobile AR application, I felt:
   Semasa menggunakan aplikasi realiti luasan
   mudah alih, saya berasa:

a. Happy   1 2 3 4 5 6 7
   Bahagia

b. Pleased   1 2 3 4 5 6 7
   Gembira

c. Satisfied   1 2 3 4 5 6 7
   Berpuas hati

d. Contented   1 2 3 4 5 6 7
   Senang hati

B. In conclusion / *Kesimpulan*

1. I will use mobile AR application for cultural heritage Site in the future.
   Saya akan menggunakan aplikasi realiti luasan mudah alih untuk tapak warisan budaya di masa akan datang.

   Yes / *Ya* ( )   No / *Tidak* ( )

2. I agree that the mobile AR application helps me to learn informally in enjoyable way at cultural heritage Site.
   Saya bersetuju bahawa aplikasi realiti luasan mudah alih membantu saya belajar secara tidak formal melalui cara yang menyeronokkan di tapak warisan budaya.

   Yes / *Ya* ( )   No / *Tidak* ( )

3. I prefer mobile AR application compared to traditional media (books, maps, and brochure).
   Saya cenderung memilih aplikasi realiti luasan mudah alih berbanding dengan media tradisional (buku, peta dan brosur).

   Yes / *Ya* ( )   No / *Tidak* ( )

Comments and suggestions/ *Komentar dan saranan*

Appendix G

List of Experts in Expert Review

No	Gender	Age (year)	Education	Country	Field of Expertise	Experience (year)
Expert 1	Female	36	PhD	Spain	AR	6 years
Expert 2	Female	38	PhD	France	HCI, Museum Learning & Mobile learning	5 years
Expert 3	Male	35	PhD	Korea	AR & Computer Vision	6 years
Expert 4	Male	56	PhD	Taiwan	Learning	5 Years
Expert 5	Female	-	PhD	Malaysia	VR and AR	7 years
Expert 6	Male	-	PhD	United States of America	AR	5 years
Expert 7	Female	-	PhD	Malaysia	Multimedia	5 years
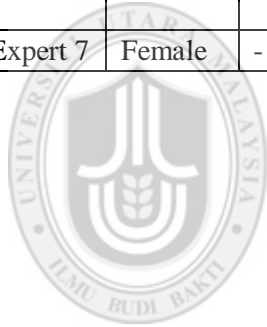
Appendix H

List of Experts in Focus Group Discussion

No	Age	Gender	Education	Country	Field of Expertise	Year of Experience
Expert 1	33	Male	Master	Malaysia	Software Engineering	10 years
Expert 2	39	Male	PhD	Malaysia	VR & Computer Graphics	15 years
Expert 3	30	Male	Master	Malaysia	Media Studies	12 years
Expert 4	28	Male	Bachelor	Malaysia	Media Studies	9 years
Expert 5	43	Male	Master	Malaysia	Image Processing	5 years
Expert 6	39	Male	Master	Malaysia	Accessibility	13 years
Expert 7	37	Female	Master	Malaysia	VR, AR, and E-Learning	10 Years