User Experience on Enjoyable Informal Learning via Mobile AR: Development and Evaluation

Ulka Chandini Pendit, Syamsul Bahrin Zaibon, and Juliana A. Abubakar

Abstract—Mobile augmented reality is recommended to be implemented at cultural heritage sites to enhance visitor's experience. Visitors enable to learn informally about the cultural items, values, and history of the sites while enjoying their visit. However, at our initial study, it is found that such mobile augmented reality has not been implemented atcultural heritage sites in South-East Asia region including Malaysia. Therefore, this study proposed a mobile augmented reality application, named as AR@Melaka, has been successfully developed to help visitor to have enjoyable informal learning in Melaka heritage sites. This paper describes the design and development of AR@Melaka including designing the user interfaces and creating content. In addition, the evaluation results of AR@Melaka are also presented. There were 200respondents involved, and majority of them agreed having an experience ofafter using the application. In summary this study shows the importance of enjoyable informal learning experience for visitors at cultural heritage sites.

Index Terms—cultural heritage site, enjoyable, informal learning, mobile augmented reality

1 Introduction

Mobile augmented reality (AR) for cultural heritage has been implemented for the past twelve years. It becomes an alternative for common existing traditional media (signs, interpretive board, and brochure) to explore cultural heritage site. However, most of existing mobile AR for cultural heritage sites do not cater the concept of enjoyable informal learning [1]. As learning has become a need for visitors during traveling, and visitors consider learning as a fun and enjoyable activity [2], it is necessary to embed enjoyable informal learning concept in cultural heritage sites.

Enjoyable informal learning is the key for learning in cultural heritage sites. It helps visitor to gain the knowledge stored in it. During the process, learners do not feel they are learning, though they are achieving new knowledge at the same time [3]. This happens as learning material is easy to learn (audio, video, image, animation) that requires less effort to analyse that makes learning process occurs naturally [2]. Learners learn without any force or pressure.

Previous studies reveal the potentials of mobile AR in cultural heritage learning, however, there is lack of study whether or not this mobile AR may provide enjoyable informal learning.This paper presents the development of AR@Melaka application. AR@Melaka is a mobile AR application to assist visitorsto experience enjoyable informal learning while exploring Melaka Heritage Sites. It is developed based on the conceptual model of Mobile AR for cultural heritage site towards enjoyable informal learning as proposed by [4]. AR@Melaka also has been evaluated in Melaka and it is discussed in the last section of this paper.

This paper consists of six sections. Background of the study is provided in section two, and the AR@Melaka application development section is explained in section three. Methodology is explained in section four while the result and discussion are discussed in the fifth section. Lastly, the sixth section is the conclusion of this study is described.

2 AR Projectsfor Cultural Heritage

Mobile AR history started since AR was discovered in 1968. However, the first Mobile AR system was developed in 1997 by Steven Feiner. Then, it had improved from year to year as it reaches the leading stage in this millenium era. The first mobile AR for cultural heritage was developed in 2002, named as ARCHEOGUIDE. ARCHEOGUIDE reconstructs the Olympia Building in Greece into 3D simulation and create personalized AR tour guide that includes monument reconstruction, ancient life simulation, database tool for creating and archiving archaeological multimedia material [5]. Then, five years later, mobile AR project which used smart-phone as the platform was developed. Intelligent Tourism and Cultural Information through Ubiquitous Service) (iTACITUS) overlays multimedia content (3D model, text, image, sound, video) with superimposed environment, annotated landscape and spatial acoustic overlays technique implemented in Reggia Venaria Reale Italy and Winchester Hall, UK [6]. It

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is followed by Mobile Augmented Reality Tour (MART) which provides intuitive interface with context-awareness and tour application for National Palace Museum, Korea [7].Next, Sutoon-Hoo Mobile Augmented Reality provides AR education games for Sutoon-Hoo archaeological site, UK [8]. The recent mobile AR for cultural heritage is Techcooltour, a cross-media platform using AR and brochure for providing interactive experience in Roman and Byzantinecultural heritage site [9]. La Lonja Site also presents mobile ARthat provides 3D models and marks to help visitor to interact with the artefact and learn at the site cultural heritage sites[10]. Overall, none of thesemobile AR projects include the enjoyable informal learning aspects in theircontent. This is the proof that enjoyable informal learning aspect for mobile AR is limited of its availability. Therefore, this study proposes a conceptual model to cater this limitation.

A conceptual model of mobile AR for cultural heritage site towards enjoyable learning is developed as the guideline to develop the mobile AR application [4]. The conceptual model consists of two levels;the first level contains three main structures of the model and the second level provides the detail of elements. The conceptual model uses situated learning theory, mindfulness theory, and constructivism theory to support the main concept of informal learning. Details explanation of this model is disccused in [4]. In order to proof the model is practical to be implemented, an application is developed.

3 AR@MELAKA DEVELOPMENT

AR@Melaka is a mobile AR application that is developed to help visitor to experience enjoyable informal learning in Melaka heritage site. It is developed by using Junaio, a free AR browser available in iOS and Android operating systems. The development process has three phases; pre-production, production, and post-production. The pre-production phase covers design of user interface, in the production phase, it covers creating the content, and lastly in the post-production phase covers the user testing and evaluation. However, this paper explains only some development activities which become the main development process.

3.1 Designing User Interface

Four main interfaces are designed, such as home page, search page, sign viewer page, and information menu page.Homepage is the interface which displays the AR location in the form of pop-up balloon. User can click on one of the locations to view the content. Meanwhile, search page displays the search button to find channel. User can find the related channel which he/she would like to see by accessing this page. Sign viewer page shows the map and list of location in one page. User can click on the location that will automatically be shown for its location on the map. Lastly, information menu page shows options of information in the form of multimedia content for the related location. After user clicks on the pop-up balloon, he/she will be directed to this page which provides various multimedia contents (audio, video, image, and etc) to be accessed while visiting at certain location in the Melaka cultural heritage sites.

3.2Content Development

In the content development, four types of content that have been developed: profile, audio, map, and multiple choice quiz. Each of them has its own development process. The developed contents are explained in this section.

a) Profile

Profile is the description about the site that is provided in the main menu. The profile is obtained from the analysis of history of site. The important points related to the site including year of built, who built it, function, general information, and other considered important points are extracted (as example in Fig. 1). Profile is provided in a big size of font.

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).

Fig. 1. Profile of cultural heritage site

Scene: 1

NARRATOR

In 1409, there was a strong fort built by Parameswara. Its wall was made of strong woods and it has four doors. It was used to overcome enemies attack and to keep the war equipment. Suddenly, in 1511, occurred a war between Portuguese and Melaka.

SOUND: PEOPLE ARE FIGHTING IN THE WAR

NARRATOR

Finally, Melaka has been beaten by Portuguese. But the city built by Parameswara cannot be destroyed. It has inspired Alfonso d'Alburqueue, the Portuguesse captain in Melaka, to build a stone fortress.

Fig. 2. Script of Audio

b) Audio and Video

Audio and video tells the history of site in storyline format. The audio and video script is based on the history of site that is changed into a storyline. There are scenes, dialogs, characters and plots (as example inFig. 2). After

the script finished to be made, the audio is recorded and saved in MP3 format. The video is created by adding appropriate pictures that suits with the script.

c) Map

One of the supporting elements in navigation component shows the map of cultural heritage site with the year of the site was built. The map of cultural heritage site was saved and edited by adding the name and year of the site was built.

d) Multiple Choice Quiz

Multiple choice quiz contains set of questions asked about the history of cultural heritage site. The questions are derived from the content provided in the application. The quiz is created by using online quiz authoring tool (refer to Fig.3). The quiz is provided to challenge visitor's basic knowledge as part of the learning process.

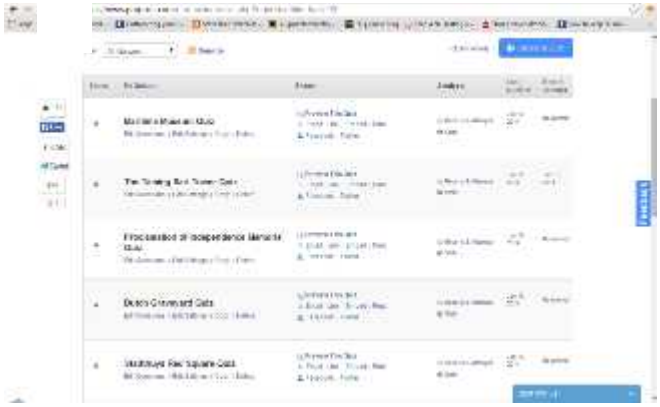

Fig. 3. Example of multiple choice quiz

Fig. 4. Live View of AR@Melaka

The rest of the content, such as, image, sound, 3D animation, and video are obtained from various free sources. Then, they are edited and compressed to meet the criteria in the application. Besides, set range of distance, navigation component, and activity component have been provided already in Junaio browser. After all, the content in English language channel is translated into Malay to be included in AR@Melaka (Malay) language channel.

Fig.4, 5, and 6 illustrate screenshots of the AR@Melaka. Visitors may perform various activities such as, live view of nearby historical sites using location-based (Fig. 4), menu (Fig. 5), and viewing contents consists of video, images, and quiz (Fig. 6).

Fig. 5. Content of AR@Melaka (Image, Video and Quiz)

Fig 6. Menu of AR@Melaka

4 USER EVALUATION OF MELAKA@AR

The evaluation of AR@Melaka has been conducted in June 2014 in few Melaka heritage sites. The purpose of the evaluation is to measure visitor's enjoyable informal learning experience while using the AR@Melaka application. The approach of evaluation was done by asking respondents to use the application and fill in the questionnaire afterwards. The questionnaire consists of twenty four (24) questions which was constructedby combining the criteria of enjoyable informal learning [3], guideline of enjoyable informal learning [11] and the measurement of enjoyment of web experiences [12]. It uses seven-point numerical scale range from strongly disagree to strongly agree. The scales are ranged as shownin Fig. 7[13].

There were 200 respondents from 15 to 50 years old who participated in the evaluation. The number of respondents is considered adequate as it referred to similar study of hypermedia tour guide for Costa Aquarium in Italy [14].

1.00 – 1.86	: Strongly disagree
1.87 – 2.72	: Disagree
2.73 – 3.58	: Somewhat disagree
3.59 – 4.44	: Neither disagree nor agree
4.45 – 5.30	: Somewhat Agree
5.31 – 6.16	: Agree
6.17 – 7.00	: Strongly Agree

Fig. 7. Scales of measurement

Most of them are male (54.5%) and the remainder is female (45.5%). Further, 15 to 19 years old is the majority group of age of respondents (38.5%) and most of the respondents goes to secondary school (58.5%). Detail demographic profile of respondents is provided in Table 1.

TABLE 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**

4.1 Findings

The findings consist of the mean results of informal learning, enjoyable, and enjoyable informal learning. It also elaborates the user preferences and comments on the application.

a) Informal Learning

The result reveals that most of respondents agreed to have informal learning experience with the overall mean score 5.473 out of 7.00 (refer to Table 2).

TABLE 2. MEAN AND SD OF INFORMAL LEARNING

No	Question	Mean	SD
A1	The Mobile AR application allows me to keep attention to the content of application.	5.41	1.229
A2	TheMobile AR application allows me to find the location in the cultural heritage site.	5.68	1.199
A3	The Mobile AR application keeps me to be awake during the visit in 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 narrative storytelling.	5.51	1.215
A7	The Mobile AR application helps me to gain new knowledge about cultural heritage site.	5.85	1.231
A8	The Mobile AR application helps me to 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		**5.734**	**1.463**

b) Enjoyable

The result reveals that most of respondents agreed to have enjoyable experience with the overall mean score 5.412 out of 7.00 (refer to Table 3).

TABLE 3. MEAN AND SD OF ENJOYABLE

No	Question	Mean	SD
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		**5.412**	**1.26**

c) Enjoyable Informal Learning

The result reveals that respondents agreed to have enjoyable informal learning experience with the overall mean score 5.61 out of 7.00 (refer to Table 4).

TABLE 4. MEAN AND SD OF ENJOYABLE INFORMAL LEARNING

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	Overall	**5.61**	**1.20**

d) User Preferences

It is found out that most of respondents (95.5%) agreed to have enjoyable informal learning experience in cultural heritage site by using AR application (refer to Table 5). Also, they consider using the AR application in the future (93.5%). Further, they prefer using AR application compare to the traditional media (books, maps and brochure) for learning at cultural heritage sites (94%).

TABLE 5.USER PREFERENCE

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).	94.0%	5%

e) User Comments and Feedback

Respondents also wrote some comments and feedback on the questionnaire. The comments are divided into three main categories, easy and useful, need improvement and better than traditional media (refer to Table 6).

TABLE 6.COMMENTS

Category	Comments
Easy and Useful	a) Good application for tourist and helps a lot in finding ways. *(Participant #3)* b) I have learned a lot from this application. It makes me easier to get information without going to the place. *(Participant #45)* c) It helps me to know about cultural heritage with interesting way and deeper. *(Participant #93)* d) It attracts my attention. Got many information. Easy to use. *(Participant #55)* e) Useful, worthwhile and save time. *(Participant #97)*
Need Improvement	a) Would be helpful if the app would provide more cities. *(Participant #6)* b) Add more features. Add more places. No connection when no internet data. *(Participant #53)* c) Improve the graphic. *(Participant #102)* d) Advertise in social media. *(Participant #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 #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 #111)* b) It was fast and useful. No need to bring books while traveling is enjoyable but learnable from the cultural heritage. If it is free download is better but if minimum charge is still acceptable. *(Participant #112)*

Most of the comments said that the application is easy, fast and useful. It has much information that help respondent to gain knowledge. However, it is needed to be improved by adding more other places, features, and to consider the platform to be standalone application. Overall, respondents said that it is better than books for learning at the cultural heritage site and the availability of this application in the market is waited.

In conclusion, the results reveal that respondents agreed to have enjoyable informal learning experience in cultural heritage site. The three mean results reach above 5.30 which proves that respondents are agree with the statement. Further, respondents also consider using the mobile AR application again in the future. It is preferredto the mobile AR application rather thanthe traditional media(books, maps, and brochure) for learning in cultural heritage sites.

5CONCLUSION

Mobile AR application is necessary to be implemented in cultural heritage site to assist visitor learning at cultural heritage sites. The result of evaluation shows that respondents agreed to have enjoyable informal learning experience at cultural heritage site. Hence, it is safe to say that mobile AR application is effective to be applied for helping visitor to learn in enjoyable way at cultural heritage site. In summary this study also shows the importance of enjoyable informal learning experience for visitors at cultural heritage sites.

The limitation of this study is the lack of measuring to what extent the mobile AR application enhances level of enjoyable informal learning. Therefore, the future study is suggested to include interview as one of the method in evaluation to measure the level of enjoyable informal learning experience of users.

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