Enjoyable Informal Learning at Cultural Heritage Site using Mobile Augmented Reality: Measurement and Evaluation

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***Abstract*—An instrument of evaluation to measure enjoyable informal learning at cultural heritage site is proposed and discussed in this paper. Content and face validity (first cycle) was conducted and then followed by a reliability analysis (second cycle). From both analyses, it was found that the proposed instrument was reliable to be used to measure enjoyable informal learning dimension at cultural heritage site among visitors. The instrument was used to test a prototype application named as AR@Melaka at Melaka heritage site. The result from 200 respondents proved that the prototype has successfully helped visitors to experience enjoyable informal learning at cultural heritage site. It is proven that AR@Melaka is applicable in assisting tourist to learn in enjoyable way at cultural heritage site.**

***Index Terms*—Instrument; Mobile Augmented Reality; Enjoyable Informal Learning; Evaluation.**

I. INTRODUCTION

Enjoyable informal learning should be implemented at cultural heritage site because visitors are encouraged to gain knowledge at cultural heritage site [1]. However, the existing interpretive media at cultural heritage site does not support enjoyable informal learning experience [2]. Therefore, this study implements mobile Augmented Reality (AR) by providing enjoyable informal learning experience at cultural heritage site. Mobile AR is a technology that combines real and virtual, interactive in real time, and registered in 3D [3], and is experienced through smart-phones or mobile devices [4]. Meanwhile, enjoyable informal learning that is based on interpretation theory (informal learning at cultural heritage site) and enjoyment theory. Enjoyable informal learning aspect enables visitor not to feel he/she is learning, but at the same time, he/she is achieving some new knowledge [5].

Unfortunately, enjoyable informal learning is lacking in the existing measurement. Most of measurement caters enjoyable [6] and informal learning [7] separately. Therefore, it is difficult to measure enjoyable informal learning entirely. In response to this problem, the study attempts to develop an instrument for measuring enjoyable informal learning specifically at cultural heritage site.

This paper provides brief explanation of measurement development and evaluation conducted for our study. The development process consisted of two main cycles: content validity and face validity (first cycle) and reliability test (second cycle) [8]. The evaluation of study as the implementatation of instrument is provided after the section of measurement development. The explanation comes along with the findings and result of evaluation. At the end, the conclusion and future work also are provided in final section.

II. CONTENT VALIDITY AND FACE VALIDITY (FIRST CYCLE)

Content validity is the degree to which items in the instrument represent relevant operational definition of a construct which is purposed for certain assessment [9, 10]. Therefore, before conducting content validity, the items were firstly designed. The items consisted of dimension and statement which was taken from the concept of enjoyable informal learning [11]. The concept shows informal learning and enjoyable aspects were the main component of the instrument which made these as the dimension of instrument. Then, the process continued by constructing the statements. The statements were obtained from analysis of component of the first version of our proposed conceptual model [11]. Next, all these statements were compiled and formed to the first version of instrument. The detail of first instrument of measuring enjoyable informal learning is provided in Figure 1.

Then, the process went to the second step, which is a content validity. Content validity involved three experts as the minimum requirement for content validity [12]. The experts 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. The process of validation went through by sending them the first version of instrument by their emails. Then, experts reviewed the instrument and sent the result back to the researcher. The review of experts revealed that the instrument contains some inappropriate items and incorrect formatting.

Thirdly, the instrument continued to be validated by a face validity method. Face validity was purposed to evaluate the language structure of the instrument. Seven students of Universiti Utara Malaysia from 15 to 50 years old who represented visitors of cultural heritage site involved in the face validity. These students were local students and international students who had good skill in English language. They reviewed the instrument and found that the instrument had a good language structure that made them easy to answer and understand those questions as what they were intended.

After both of the content and face validity were completed, the process continued by reconstructing the items through eliciting the literature. The items were related to informal learning and enjoyable. Informal learning items were adapted from Learning in Museum questionnaire [7]. Some items were added by linking the expected outcome of visitors after using the mobile AR application (AR@Melaka) and mapping between the available functions of the application and informal learning.

Meanwhile, items of enjoyable have been adopted from the study of measuring the enjoyment of web experiences developed by [6]. 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 the scope of study, which is, cultural heritage site. Furthermore, the instrument has been proven reliable through content validity, factorial validity, reliability, convergent validity, discriminant validity and nomological validity [13]. In addition, the items also matched with the concept of enjoyable informal learning [9].

	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 certain 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 1: First version of Instrument to measure enjoyable informal learning at cultural heritage site

Reconstruction of items for this instrument has also been completed. Next, the process was continued to the fifth step, determine the scale of instrument. The seven scale measurements with the range of interval 0.86 (strongly disagree to strongly agree) was used as the scale (refer to Figure 3). This number was achieved by dividing the range of scale and the scale as suggested by [14]. This process resulted in the second version of instrument (refer to Figure 2).

The following is the list of scale:

1.00 – 1.86 : Strongly Disagree
1.87 – 2.73 : Disagree
2.74 – 3.59 : Somewhat Disagree
4.00 – 4.45 : Neither Disagree nor Agree
4.46 – 5.31 : Somewhat Agree
5.32 – 6.17 : Agree
6.18 – 7.00 : Strongly Agree

Strongly Disagree ← 1 2 3 4 5 6 7 → **Strongly Agree**

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 2: Second Version of Instrument to Measure Enjoyable Informal Learning at cultural heritage site

III. CONTENT VALIDITY AND RELIABILITY ANALYSIS (SECOND CYCLE)

In the sixth step, 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 or 3D Animation. The review obtained good result where the revised instrument produced better version than the first version. However, it is 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. The questions were reconstructed to the informal learning dimensions which were taken from the concept of enjoyable informal learning [9]. The concept was analysed and matched with the purpose. The process produced the third version of instrument (refer to Figure 3).

The seventh step was a pilot study. The pilot study was purposed to test the instrument in order to recognize any limitation in advance [15] which involved 92 respondents. The number was determined based on principal factor analysis sample size which was between 50 to 100 [15]. The pilot study resulted the final version of the instrument which was analysed using factor analysis and Cronbach alpha for measuring the reliability of the instrument.

The factor analysis was started by calculating the value of Kaiser-Meyer-Olkin (KMO) and Bartlett's test of spherecity as the requirement. The result of KMO must be greater than 0.50 and p's significant value must be less than 0.05 for Bartlett's test of spherecity. After calculation, the result showed that value of KMO is 0.903 and Bartlett's test significant is 0.000.

The factor loading showed all items have achieved 0.5 (refer to Table 1) as determined in requirement [13]. Then, the next step, which is the eighth step, rotating the data using varimax method (refer to Table 2). The result of rotation showed items are classified into three factors. These factors were grouped based on characteristics. In addition, the blank space was loaded because of the output suppression for factor that is less than 0.1 [16].

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 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.

	Strongly Disagree ◄——————————► **Strongly Agree**								
		1	2	3	4	5	6	7	
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: Third version of instrument to measure enjoyable informal learning at cultural heritage

Table 1
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
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.	.963
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

Table 2
Rotated Component Matrix

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.

The rotation showed all items in factor one are related to enjoyable so it is labeled as a factor of enjoyable. Items in factor two are related with informal learning, which makes this factor a labeled factor of informal learning. Furthermore, items in factor three are related with informal learning at cultural heritage, then it is a labeled factor of learning at cultural heritage site. The rotated components are shown in table 3 until table 5.

Table 3
Factor of Informal Learning

No	Informal Learning
A3	The Mobile AR application allows me to learn in enjoyable way via different type of media in 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 in cultural heritage site.
A1	The Mobile AR application allows me to keep attention to the content of application.

Table 4
Factor of Enjoyable

No	Informal Learning
A3	The Mobile AR application allows me to learn in enjoyable way via different type of media in 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 in cultural heritage site.
A1	The Mobile AR application allows me to keep attention to the content of application.

Table 5
Factor of Informal Learning at Cultural Heritage Site

No	Informal Learning at Cultural Heritage Site
A22	Learning about cultural heritage site using mobile AR application was worthwhile
A21	Learning about cultural heritage site using mobile AR application was useful
A19	Learning about cultural heritage site using mobile AR application was fulfilling
A20	Learning about cultural heritage site using mobile AR application was rewarding
A5	The Mobile AR application allows me to control the information get during the visit
A2	The Mobile 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 (ninth step). The value of Cronbach's Alpha was 0.964 that shows that the value met the minimum condition, which is 0.7 (17). Furthermore, in order to know the items to be deleted, the analysis was continued to the tenth step, test the Cronbach's Alpha value if the item is deleted. The results show that the values of Cronbach's Alpha for each item when deleted do not have a significant difference. 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 4.

The instrument was added by demographic question in the beginning and respondent's opinion (yes/no question) and comment and suggestion at the end of intrument. The dimensions (Figure 4) became the main section of instrument. Then, all questions were compiled together and spread to respondents during the evaluation.

		Strongly Disagree ← 1 2 3 4 5 6 7 → Strongly Agree						
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:							
	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
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:							
	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	1	2	3	4	5	6	7

Figure 4: Instrument to Measure Enjoyable Informal Learning in Cultural Heritage Site

IV. Evaluation and Findings of Measuring Enjoyable Informal Learning at Cultural Heritage Site

The evaluation was purposed to measure enjoyable informal learning experience at cultural heritage site. It was done in Melaka, specifically in three areas, which are, Jalan Merdeka, Dataran Pahlawan, and Bandar Hilir on 11th June 2014 (refer to Figure 5 and Figure 7). The approach of evaluation was done by asking respondents who visited Melaka Heritage site randomly to use the application and afterwards, filled in the questionnaire by implementing the proposed instrument.

Figure 6 shows an example of the screenshot of the AR@Melaka mobile AR application. The prototype provides various elements of enjoyable informal learning experience aspects such as text, image, audio, sound, animation, and video. The application also provides layered information, one-tap access for frequent menu, clues for scene with augmented content, and quick buttons to go to main menu. In addition, in term of interface, a big size of font, enough contrast between text and background, appropriate size of content were also included. Users could also save and share information to social media, show nearby interested places and recommended route to site, request direction for destination, language and distance range, and conduct a multiple choice quiz. All of these relate to mindfulness theory that allows visitor to choose enjoyable and informative contents, and enable learning by recalling knowledge of visitors through series of questions.

Figure 5: A group of girls and a family are evaluating AR@Melaka

Figure: 6: Screenshot of AR@Melaka at AFamosa

Figure 7: Evaluation in Progress at Menara Taming Sari, Melaka

V. RESULTS AND DISCUSSION

After the evaluation, data analysis was carried out. It has resulted findings of evaluation which consists of demographic background as backup data for future analysis (refer to Table 6), respondent's opinion (refer to Table 7) and respondents' enjoyable informal learning experience (refer to Table 8, Table 9, and Table 10).

Firstly, the result of demographic profile of respondents is provided in Table 6. It was found out 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 [18]. 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%).

Table 6
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

Secondly, the respondent's opinions are exhibited in Table 7. The opinions are categorized into three kinds of opinion. Most of the respondents (95.5%) agreed to have enjoyable informal learning experience at cultural heritage site by using AR application. Respondents also considered using AR application in the future (93.5%) and they preferred AR application to traditional media (books, maps and brochure) for learning at cultural heritage sites (94%). They preferred AR compared to traditional media because AR is convenient, fast, and useful as well as enjoyable and learnable in visiting cultural heritage site.

Table 7
Categories of Respondent's Opinion

No	Question	Frequency	
		Yes	No
C1	I will use mobile AR application for cultural heritage site in the future.	93.5%	5.0%
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%	5.0%

Thirdly, the written comments of respondents on the questionnaire (refer to Table 8). The comments were divided into three categories of responses, which are, easy and useful, need improvement and better than traditional media.

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.

Table 8
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 10)* (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)*

After results of demographic background, result of respondent's opinion, and result of respondent's comments, it is continued to enjoyable informal learning experience. The results were divided into three categories of mean values, which are, findings of informal learning experience, enjoyable experience, and enjoyable informal learning experience.

The first result is informal learning experience (refer to Table 9). The result revealed that most respondents agreed to have informal learning experience with the overall mean score of 5.473 out of 7.00. Furthermore, the score of standard deviation is 1.463 which indicated the dispersion of score is around the number 5 scale, which is, agree area.

The second result is enjoyable experience. The result exposed that most respondents agreed to have enjoyable experience with the overall mean score of 5.412 out of 7.00 (refer to Table 10). In addition, the standard deviation is 1.260 which showed that the score's dispersion is around the number 5 scale, which is, agree area.

Table 9
Mean and Standard Deviation of Informal Learning 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 in the cultural heritage site.	5.68	1.199
A3	The Mobile AR application keeps me awake during the visit at cultural heritage site.	5.60	1.220
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

Table 10
Mean and Standard Deviation of Enjoyable Experience

No	Question	Mean	Standard Deviation
While using the Mobile AR application:			
B1	I was deeply engrossed.	5.24	1.208
B2	I was absorbed intently.	5.40	1.195
B3	My attention was focused.	5.42	1.247
B4	I fully concentrated.	5.53	1.264
While using the Mobile AR application, I felt:			
B5	Happy	5.28	1.259
B6	Pleased	5.34	1.282
B7	Satisfied	5.49	1.273
B8	Contented	5.65	1.343
	Overall	5.412	1.260

The third result is the overall 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 11). 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 11
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
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

All results above 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 visitors wrote in the comment, they thought AR@Melaka was useful, enjoyable, and learnable device.

This concluded AR@Melaka is usable for conducting enjoyable informal learning experience at cultural heritage site. This finding is consistent with previous research where mobile AR is proven effective for learning and provides enjoyable experience for visitors [18; 19; 20; 21; 22].

VI. Conclusion and Future Work

For the conclusion, the instrument has been produced through content validity, face validity, pilot study and reliability analysis. It took analysis of informal learning items and adoption of enjoyable instrument for developing the first version of instrument. Then, instrument was tested in content validity and face validity, then finally, it was tested again in content validity and reliability analysis for the last phase. All process proved the instrument is reliable to measure enjoyable informal learning at cultural heritage site. Therefore, the instrument is valid to be used for measuring the enjoyable informal learning at cultural heritage site.

The result of evaluation of study showed that visitors agreed that they had experienced enjoyable informal learning. They did experience the learning process from the component provided by AR@Melaka. These positive results proved that the conceptual model is applicable and usable. This also found that AR@Melaka application has helped respondents learn about the cultural heritage site.

However, there is lack in evaluation where it did not cover the level of enjoyable informal learning experienced by visitor. It was only covered to the extent of respondent's perception only. Since the evaluation was done by asking the visitor using the application and answering the questionnaire. Therefore, it is recommended 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 as the future work [23, 24].

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