Enjoyable Informal Learning at Cultural Heritage Site using Mobile Augmented Reality: A Conceptual Model

Ulka Chandini Pendit & Syamsul Bahrin Zaibon

School of Multimedia Technology & Communication, Universiti Utara Malaysia, Kedah, Malaysia

Abstract: Currently, learning at cultural heritage sites is not adequately provided and supported by the current existing information display provided at the sites although visitors require it. Mobile augmented reality is an alternative way to cater the problem which could enhance the visiting experience through the concept of enjoyable informal learning. Therefore, this study proposes a conceptual model of mobile augmented reality for cultural heritage site towards enjoyable informal learning experience for the visitors. Critical analyses, literature review, and comparative studies of seven related conceptual models are conducted to define the research gap and suggest the components of the proposed model. The outcome of this study is the proposed model which is expected to be as a guideline for the development of mobile AR application for cultural heritage sites, where visitors would enjoy and learning informally with the application.

Keywords: mobile augmented reality; informal learning; cultural heritage site; conceptual model

1. Introduction

Tourism has become a choice to learn new things than just for leisure and refreshing experiences [1]. Due to that, visitors are encouraged to learn something informally at cultural heritage sites. Informal learning is a type of learning where it is not constrained to be taken place in educational institutions and this type of learning relies heavily on intrinsic motivation. It would make the learning process enjoyable [2]. However, learning at cultural heritage sites is not adequately provided and supported by the current existing information display provided at the sites although visitors require it. Based on the study of availability of interpretive media in Central and East Java, there are only 8% of the cultural heritage which provides digital media at the site [3]. Most of the interpretive media are signs, information boards, and maps which are not interesting and interactive. Visitors cannot grasp all the historical information which the cultural heritage sites offer to them [4]. Moreover, based on the study of [5], it indicates that visitors want to have experience in cultural heritage sites by using the new emerging technology, such as augmented reality (AR).

AR technology has been implemented in some cultural heritage sites for the past twelve years. Mostly, AR applications at cultural heritage are developed to enhance the visitor experience at cultural heritage site. However, the AR applications which focus on enjoyable informal learning are limited. Therefore, this study emphasizes on enjoyable informal learning concept in cultural heritage sites using the mobile platforms. The consideration of using mobile platform is due to the increase usage of mobile phone for at least 37 million subscribers in Malaysia in early 2012 and the numbers are increasing [6]. In addition, with the advance features on mobile devices could improve the quality of AR and ease for the mobile user tracking, by using accelerometer and magnetometer functions [7].

Hence, this paper discusses the main study which is the conceptual model of mobile AR for enjoyable informal learning in cultural heritage site. In addition, the components of proposed conceptual model will be explained. This paper is organized in five sections. The second section provides the critical analysis on related existing conceptual models on mobile augmented reality for cultural heritage sites. In the third section details out the methodology used in the study while in the fourth section elaborates the finding and discussion. The last section is the conclusion of the study.
2. Critical Analyses of Conceptual Models of Mobile AR

Seven conceptual models of mobile AR for cultural heritage sites are critically analyzed to find the research gap. The followings are the analyses of the conceptual models:

**Personalized System Architecture of Augmented Reality-based Cultural Heritage On-Site GUIDE (ARCHEOGUIDE):** The system architecture of ARCHEOGUIDE developed by [8] is based on client-server architecture. It consists of three modules: site information centre, mobile units, and communication infrastructure. The site information server is a central computer comprises a relational multimedia database. It stores audio-visual, textual information, 2D images, and 3D models. The mobile unit is the unit of wearable system worn by user. The system architecture of ARCHEOGUIDE is complicated and difficult to understand as it has many components and units. It can be seen that a heavy bulky wearable system is implemented to present the application at Olympia Site, Greece. Nevertheless, ARCHEOGUIDE is the first mobile AR system project that is conducted at cultural heritage site.

**Framework and Data Flow of AR-based on-site Tour Guide:** AR-based on-site tour guide is implemented at Gyeongbokgung Palace, Korea and developed by [4]. The application uses framework that contains data flow of application which consists of two agents, the contextual management agent, and map management agent. The contextual management agent manages the visitor’s profile and location. It sends visitor’s detail to the database and presents the pre-recorded narration to the output agent. The map management agent detects the location of visitor and provides the tour map, AR service zones, and visitor’s exact location. The limitation of this framework is the detail components and flows for the mobile unit are not provided.

**Client-Server Architecture System of Augmented Reality:** This type of architecture system is the most used system for mobile AR application [9]. There are two types of the system, client-server architecture that involves server and client-server architecture that does not involve server. The client-server architecture system is simple and easy to understand. It has the main component of mobile AR system such, camera and tracking. The example of application that uses the system is the SkyLineDroid [10]. This is an example of AR system architecture for cultural heritage sites.

**Architecture System of Sutoon-Hoo Mobile Augmented Reality:** Sutoon Hoo application is an AR education games about Sutoon Hoo archaeological site. It uses architecture system with the flow of process for the application [11]. The architecture is divided into two parts: initialization, and object categorization by involving components, such as object assignment, inventory, and museum database. The limitation of the system is the content structure and mobile technology components are not explained in detail.

**TechCoolTour:** TechCoolTour is a cross-media platform for promoting Roman and Byzantine tourism. It provides interactive experience while visiting cultural heritage site by augmenting 3D reconstruction, 3D virtual character, video, 360 degrees panorama related with the history of the site. It also provides website that contains detail information about each heritage site which is linked with the application [12]. Visitor is able to view the route of tour by opening the brochure and see the 3D model on each location. TechCoolTour is an example of application that does not only use AR but also is combined with the traditional media in order to help enhancing visitor’s experience.

**Intelligent Tourism and Cultural Information through Ubiquitous Service (iTACITUS):** iTACITUS provides compelling experience at cultural heritage site [13]. It uses technique of superimposed environment, annotated landscape, and spatial acoustic overlays to present the AR information. The information is filtered through the visitor’s location, interests, and history. In addition, visitor is also able to manage their itinerary using itinerary planning. iTacitus is a good mobile AR guide application that uses smart phone as a display device for cultural heritage site.
Mobile Augmented Reality Tour (MART): Mobile augmented reality tour is developed for National Palace Museum of Korea. It provides context-awareness and the information provision about the artefact in the museum. However, the paper does not give any information about the conceptual model or system architecture related to the application which is important as the guideline for developing the mobile AR application [14].

It can be concluded that most of the existing conceptual models do not address the enjoyable informal learning concept. They also do not have the same guideline for developing the mobile AR application for cultural heritage site. These points become the research gap of this study which the need to propose a conceptual model of mobile AR for cultural heritage site towards enjoyable informal learning.

3. Methodology

As shown in Fig. 1, this study implemented three phases to come out with the proposed conceptual model. Firstly, the existing conceptual models were critically analyzed in order to find the gap of the study.

<table>
<thead>
<tr>
<th>Phases</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Analysis of Conceptual model of mobile AR for cultural heritage site</td>
<td>Research Gap</td>
</tr>
<tr>
<td>Literature Review: Finding theories in learning, criteria of enjoyable informal learning and application of mobile tourism and mobile learning</td>
<td>Concept of learning theories, criteria of enjoyable informal learning, and suitable mobile tourism and mobile learning application.</td>
</tr>
<tr>
<td>Comparative Analysis of mobile AR for cultural heritage, mobile tourism and mobile learning</td>
<td>Component of Conceptual Model of Mobile AR for Enjoyable Informal Learning in Cultural Heritage Site</td>
</tr>
</tbody>
</table>

Fig. 1. Summary of Phases

Secondly, the criteria of enjoyable informal learning, theory of learning, and suitable application of mobile tourism and mobile learning were discovered. All these phases are needed to be completed because the criteria of enjoyable learning experience are the basis to construct the element of component of the conceptual model. While, the learning theories are the underpinning theories of the conceptual model. In addition, some applications of mobile tourism and mobile learning were also compared for analysis. After the analyses were collected, in the third phase, a comparison is made to define the element of conceptual model. After all the phases were conducted, the conceptual model was developed.

4. Analyses of Theories and Concepts

Critical analysis, literature review and comparative study have been carried out to finalize the research gap and the component of conceptual model. Based on the critical analysis of the conceptual model of mobile AR for cultural heritage site, the followings are the summarized research gaps:

- Conceptual model of mobile AR for enjoyable informal learning is limited.
- Components and guidelines that should be considered when developing mobile AR for cultural heritage site are not clearly defined.

Five learning theories are applied to this study; multimedia learning, constructivism, experiential learning, situated learning, and collaborative learning theories. In addition, mindfulness theory is also included to stress on the media communication.

Multimedia Learning Theory

Multimedia learning is a process where learner constructs the mental model from words and pictures [15]. Words, in this context, are in the form of verbal (printed text or spoken text) and pictures (photos, illustration and videos). The activity to present the words and pictures in the purpose of learning is called multimedia instruction. Besides, Mayer [15] also founded twelve principles in cognitive multimedia learning, which are, modality, redundancy, spatial-contiguity, multimedia, personalization,
voice, segmenting, pre-training, signalling, temporal contiguity, coherence, and image.

Therefore, this theory suggests multimedia elements for learning in AR which could help visitors learn better at cultural heritage sites.

Constructivism Theory

Constructivism is divided into cognitive constructivism and social constructivism. Cognitive constructivism emphasizes the process of learning that is gained by learners whereas social constructivism is more into socially constructed process. In the theory, Vygotsky distinguishes the situation where students can learn alone and whether they need assistance from peers. This makes students to seek help from their environments as well as improve their existing knowledge and achieve new knowledge [16]. That is why constructivism considers learners as an active element in knowledge forming [17]. Apart from that, Hein has found how this theory relates with the museum learning in 1995 which can be implemented in AR for cultural heritage sites:

- A good learning process is an activity that engages both physical and mind of learners. Museums should invite learners in participatory program that involve the learners’ mind and physical [18].
- Learning takes two activities, firstly is to understand the term or definition; and secondly, to apply the term into the context where it lies. Museums need to give the explanation of chronology before they present something related to chronology of independence history.
- Learning is a social activity where the engagement with other people is important. Museum needs to encourage a group discussion among the family members to talk about the specific exhibit which will lead them to understanding.
- Learning is a reflective process. The most effective learning is when learners can connect the learning context with their prior experience in life. In this context, museum needs to provide different kind of modality as the learning method. The wide range of modality from hearing, touching, smelling, seeing and listening will help visitors to help visitors to learn and more, to attract visitors to come and see.
- Learning process needs an adequate amount of time to understand the new knowledge. Museum as the place for visitors to come and go need to have special technique how to make the learning process is a moment that they will always remember.
- Motivation is the key to learning. As what [19] said in her Mindfulness Model that interest or motivation is one of factors for visitors to learn in museum.

Situated Learning Theory

This theory deals with the social contexts. It reveals how to approach the technology as a culture that influences the perception of informal learning in community. It is also configure how is the role of teacher and experts in the community of learning [22]. Situated learning involves the participation of members in community. There are three characteristics of situated learning as [23] explained which are also considered in AR for cultural heritage sites:

- Community, workplace, family allows people to gain high-level in knowledge and skill.
- Learners need to specify their focus of learning to becomes expert or capable in the field.
- Social process is a part of learning.
- Knowledge is gained through practice that transformed into the goal-directed behaviour.

Experiential Learning Theory

Experiential learning considers experience as the source of getting the knowledge [24]. Knowledge is gained through processing and transforming the experience occurs in everyday life. Kolb explains there are four stages for acquiring the knowledge through experience: concrete experience (CE), abstract conceptualization (AC), reflective observation (RO) and active experimentation (AE) as illustrated in Fig. 2. Kolb’s theory divides the two main process for learning process: getting and processing the experience. Each learner have their own style to get and process the experience. This theory is suitable to be applied
for informal learning at cultural heritage site because it emphasizes on experience that visitors gain through visiting cultural heritage site.

**Fig. 2. Experiential Learning [24]**

**Collaborative Learning Theory**

Collaborative learning theory considers the collaboration between learners for working together and finding the solution of problem [25]. Teachers are not the main source to share the knowledge but more as facilitator to help students engaging in learning activity. Collaborative learning is more effective since it triggers involvement, cooperation and teamwork and civic responsibility for learners. Users of AR for cultural heritage site will apply this theory through the collaboration and sharing information with other users or visitors.

**Mindfulness Theory**

Mindfulness theory is related with mindfulness and mindlessness characters of visitors at cultural heritage site. Mindfulness means care to the world around us and mindfulness refers to when the person does not active to process new information [19]. Fig. 3 depicts two combination factors deal with the interpretative communication at cultural heritage sites; “communication” and “visitor” factors [20]. The process starts with: each positive element in communication factor influences the visitor factor (high level of fatigue and interest in content), and then goes to the cognitive state (mindful), at the end, visitor accepts the result (more learning, high satisfaction and greater understanding). This will have the opposite result for the process which has lack of communication factor. The mindfulness model can be applied to different situations and organization aims. It is also proved how to get the mindful and mindfulness visitors at cultural heritage site. In summary, the role of communication factor is extremely important.

**Fig. 3. Mindfulness for Communication with Visitors [19]**

The followings are the explanation of communication factors for mindful character:

- The variety or change. The multisensory, audio visual, and dynamic interpretive techniques are good to enhance visitor attention and learning [20].
- Use of questions. Questions are good to increase visitor’s learning. It is one of the cognitive orientation devices for mindful visitors to recall the knowledge that they have got while wandering at the site.
- Visitor control or interactive exhibits. Interactive material is useful to catch and keep visitor’s attention as well as to improve their learning and interest [21].
- Connection with the visitors. An effective interpretation is the one which can relate the present experience with the prior experience of visitors in the past. It would be better to connect the heritage story with visitor’s story.
- Novelty, conflict or surprise. The surprise, conflict or novelty factor is important to keep the interest of visitors and wake them up from the boredom and tiring.
- Good physical orientation. Visitors who are easily to find their way inside built heritage are more mindful than those who do not.
The presence of maps and signs are highly needed for the visitors.

- Repetition. Repetition of the exhibits is not effective for interpretation as it has potentiality to induce the mindfulness.

These factors are the indicator of why visitors can be mindfulness at cultural heritage site.

5. Review of Related Applications of Mobile Tourism and Mobile Learning

A review of some related applications were also conducted which includes four mobile tourism and four mobile learning applications. Table 1 and 2 show the selected mobile tourism and mobile learning applications.

**Table 1. Mobile Tourism Applications**

<table>
<thead>
<tr>
<th>Mobile Tourism</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT1: Lol@ (Local Location Assistant)</td>
<td>The application provides complete information for cultural heritage tourism (text, architecture, history, event, audio and video). It is also has diary features where visitor can save information they get during their visit [26].</td>
</tr>
<tr>
<td>MT2: Context Aware Tourist Guide Application</td>
<td>It is a mobile guide application for tourist that provides complete information. Visitor is also able to save the information in the scrap page to be viewed again later [27].</td>
</tr>
<tr>
<td>MT3: Cyberguide</td>
<td>The application is one of the most prominent applications for guide. It provides complete features for tourists [28].</td>
</tr>
<tr>
<td>MT4: MobiAR</td>
<td>The application uses AR technology to help visitor to explore cultural heritage site. It is also has complete features, such saving information, add comments, share the information, and content creation, such as take picture, add description and upload the picture to database [29].</td>
</tr>
</tbody>
</table>

**Table 2. Mobile Learning Applications**

<table>
<thead>
<tr>
<th>Mobile Learning</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML1: MILE (Mobile and Interactive Learning Environment)</td>
<td>It provides mobile application that support student to conduct learning anytime and anywhere [30].</td>
</tr>
<tr>
<td>ML2: Butterfly-Watching Learning System</td>
<td>It is a mobile learning application that implements journal for the learners to write notes about their learning outcome [31].</td>
</tr>
<tr>
<td>ML3: Treasure Hunting Learning Model</td>
<td>It is a treasure hunting application that helps student to conduct the treasure hunting activity [32].</td>
</tr>
<tr>
<td>ML4: EULER (Environment of Ubiquitous Learning Educational Resources)</td>
<td>It is chosen because it provides mobile learning application that supports informal learning with many features such AR, video and audio [33].</td>
</tr>
</tbody>
</table>

6. The Findings of Analyses

The conceptual model is developed based on criteria of enjoyable informal learning developed by [34] as illustrated in Fig. 4.

![Fig. 4. Criteria of Enjoyable Informal Learning](image)

Based on the criteria, elements of the proposed conceptual model are developed. The two main components of conceptual model are content structure, and mobile technology. In order to find the components of conceptual model, a comparative analysis is conducted to define such elements. The following is the comparative analysis for content structure component:

**Content Structure Component**

The structure component is obtained from the comparative analysis of mobile AR for cultural heritage site, mobile tourism, and mobile learning applications. Elements in the content structure consist of opening, media elements, activity, navigation, social interaction, games, and presentation style.

A. Media Element

Media element consists of the media that should be provided in the mobile AR for cultural heritage towards enjoyable informal learning. Table 3, 4 and 5 are the comparative analysis of mobile AR for cultural heritage, mobile tourism, and mobile learning applications. The consideration for taking the media element is based on the score conditions: (score 1-3) discarded, (score 4-6) recommended, and (score 7-9) compulsory. Whereas for mobile tourism and mobile learning applications are (score 1-2) recommended, and (score 3-4) compulsory.
By looking at the results, it is concluded that text, audio, image, and video are compulsory as the media elements. However 3D model and 3D character/animation elements are not compulsory media but recommended to be applied. The proposed media elements component is illustrated in Fig. 5.

Fig. 5. Model for Media Elements

Based on the research on designing mobile AR guide in cultural heritage, [35] said that application should provide the right approach both for active and passive tourist. By doing so, the push content and pull content should be applied in the application. The push content is the content that is automatically appear when visitor enter the site. Whereas, visitor should request if they want to know the detail information about the artefact by using the pull content. This approach enable visitor to choose about their reaction to the information [35].

B. Navigation Element

Navigation element includes the map as a tool to help visitor to navigate around the cultural heritage site. The followings are the navigation comparative analysis (refer to Table 6 to 8):

Table 6. Navigation of mobile AR for cultural heritage

<table>
<thead>
<tr>
<th>Navigation</th>
<th>MAR 1</th>
<th>MAR 2</th>
<th>MAR 3</th>
<th>MAR 4</th>
<th>MAR 5</th>
<th>MAR 6</th>
<th>MAR 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of interest</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>User Position</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Visited places</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7. Navigation of mobile AR for tourism

<table>
<thead>
<tr>
<th>Navigation</th>
<th>MT1</th>
<th>MT2</th>
<th>MT3</th>
<th>MT4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of interest</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>User Position</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Visited places</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8. Navigation of mobile learning

<table>
<thead>
<tr>
<th>Navigation</th>
<th>ML1</th>
<th>ML2</th>
<th>ML3</th>
<th>ML4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
C. Activity

Activity is the action of user to the information that is provided by the application. There are some activities, such as: add comment, take picture of a place, add description, upload picture, and etc. Table 9 to 11 show the comparative analysis of the activity.

**Table 9.** Activity for mobile AR for cultural heritage

<table>
<thead>
<tr>
<th>Media Element</th>
<th>MAR1</th>
<th>MAR2</th>
<th>MAR3</th>
<th>MAR4</th>
<th>MAR5</th>
<th>MAR6</th>
<th>MAR7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add Comment</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Take picture of place</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Add description</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Upload picture</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 10.** Activity for mobile tourism

<table>
<thead>
<tr>
<th>Media Element</th>
<th>MT1</th>
<th>MT2</th>
<th>MT3</th>
<th>MT4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add Comment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 11.** Activity for mobile learning

<table>
<thead>
<tr>
<th>Activity</th>
<th>ML1</th>
<th>ML2</th>
<th>ML3</th>
<th>ML4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take picture</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Create note</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Share presentation &amp; notes</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Save notes</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Access notes</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Conduct survey</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Upload data via internet</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Add comment</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evaluate sheet</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Talk with others via mobile</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Map of friends’ location</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>File sharing</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Chat</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

As seen in the comparative analysis, the majority response to information that user can do is to add comment in the information. The rest of the components are considered as recommended. By looking at the result, it is concluded that create notes, share notes and save notes are compulsory as activity component. Take picture is considered as recommended component to be applied.

In addition, according to [36], visitors do need to bring something to home after their visit, therefore the diary component is embedded as the platform to save the information and to continue the learning process. This diary can be accessed through computer, tablet, or smartphone after installing the application. Fig. 7 illustrates the activity component.

**D. Social Interaction**

The social interaction is the component that enable visitor to interact with their friends along the visit. This component is suggested by [36] because visitor needs tools to communicate between them. It would be better if visitor can track their friends’ location at the heritage site [36]. The component of sharing the information to social media is obtained through the result of pilot study [34] which resulted that many respondents would like to share their activities through Facebook or Twitter. The model for social interaction component is illustrated in Fig. 8.

**E. Games**

Games are the right choices to engage visitor for making them enjoy while learning similar to the concept of MGBL [41]. Multiple choice game is a series of question that asks visitor about the cultural heritage site that they have visited. As indicated in Mindfulness theory, the use of questions is a recall learning process of visitors. Another example is a treasure hunt game which implements constructivism theory.
and can be conducted in the cultural heritage site. The model for games component is illustrated in Fig. 9.

![Fig. 9. Model for games element](image)

**F. Presentation Style**

Based on the design guideline for enjoyable informal learning developed by [2], creating a storyline is a good approach to make user enjoy the learning activity. Storytelling as one of the presentation style beside separate augmented views that have been commonly used. The model for presentation style component is illustrated in Fig. 10.

![Fig. 10. Model for presentation style element](image)

**Mobile Technology Component**

This component supports the mobile AR application for cultural heritage towards enjoyable informal learning. Mobile technology component is adapted from the review of architectures and frameworks of mobile AR. The following subsections describe the architectures and frameworks that are analyzed to suggest the mobile technology component.

**ARToolkit Architecture**

As illustrated in Fig. 11, ARToolkit framework consists of openGL that is used for rendering [37].

![Fig. 11. Architecture of ARToolkit (Courtesy URL: http://www.hitl.washington.edu/artoolkit)](image)

GLUT is used to create OpenGL window and hardware-dependent video library. Standard API is used to represent the platform dependent parts. The video library is a hardware-dependent video library.

**Metaio Framework**

Metaio framework consists of four layers, which are, application, API, metaio SDK, and operating system. Application layer focuses on graphical user interface application and operation logic [38]. API is the application programming interface that depends on operating system. It uses Java for android, objective C for iOS and C++ for windows platform. The metaio SDK works for rendering, capturing and tracking process. Operating System (OS): depend on OS of mobile phone whether android, iOs or windows. Fig. 12 illustrates the framework.

![Fig. 12. Metaio Framework [38]](image)

**Mobile AR Framework**

Oui, Ng, and Khan [39] developed a mobile AR framework that is similar with Studiertube Tracker. It uses OpenGL ES as the platform for rendering and Open CV as the platform for tracking (refer to Fig. 13). According to [40], the requirement of mobile AR system is wearable input (camera), interaction devices, display, wireless networking, data storage and access, and computational platform.

By comparing the frameworks and requirements of mobile AR systems, the proposed component for mobile technology are camera, GPS, compass and sensor, wireless networking, database, tracking, rendering and registration.
Fig. 13. Mobile AR Framework [39]

The mobile technology component is illustrated in Fig. 14. Finally, all the components and elements are integrated and adapted to be a proposed model as illustrated in Fig. 15.

Fig. 14. Model of Mobile Technology Component

The mobile technology component is illustrated in Fig. 14. Finally, all the components and elements are integrated and adapted to be a proposed model as illustrated in Fig. 15.

Fig. 15. Conceptual model of mobile AR for enjoyable informal learning
Conclusion

The critical analyses on models and frameworks of mobile AR for cultural heritage site have proved that there is no model that promotes an enjoyable informal learning concept. Therefore, a conceptual model which caters the enjoyable informal learning for mobile AR is proposed. In constructing the proposed model, the criteria of enjoyable informal learning, theory of learning, and suitable application in mobile tourism and mobile learning are collected and reviewed. With the comparison of seven conceptual models, the components of conceptual model of mobile AR for enjoyable informal learning in cultural heritage site are defined. The proposed conceptual model is expected to be the guideline for the development of a mobile AR application for helping visitor learning informally at cultural heritage site in enjoyable way. The future direction of this study is to validate the conceptual model through expert review which would suggest some improvements and suggestions.

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References

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