

Development of “Museum Sandi” Information Application based on Augmented Reality

Andra B. E. Setiawan
Graduate School
Universitas Negeri Yogyakarta
Yogyakarta, Indonesia
andrabedyekosetiawan@gmail.com

Ali Muhtadi
Graduate School
Universitas Negeri Yogyakarta
Yogyakarta, Indonesia
ali_bintangku@yahoo.co.id

Abstract— Some people argue that museums are the building for saving antiquities. However, based on Government Regulation No. 6/ 2015, it is noteworthy that museums have other vital functions to educate and entertain people. For education purposes, museums can provide information and communication about their collection to visitors. One of the museums in Yogyakarta, which has communicated and informed the collections properly, is Museum Sandi. The museum is amazingly famous nowadays because of the number of visitors that constantly increases in each month. This is because the museum is located in a strategic place and that it is free of charge. However, the museum only has a few number of educators that do not suffice the number of visitors. It causes many difficulties to transfer the information about the collection optimally to the visitors. On this account, visitors are not able to get the whole knowledge provided by the museum's collections. It is possible to resolve this problem by an innovated application based on augmented reality. This application is developed using ADDIE model, which is expected to solve the problem in delivering the information and knowledge about the museum independently to the visitors. Thus, it is expected that visitors can grasp more insight about the museum's collections.

Keywords—augmented reality, information application, Museum Sandi

I. INTRODUCTION

Essentially, museum is a place that aims to provide education and recreation to visitors. A museum is not only used to place obsolete objects which are full of historical and cultural values. It was supported by Government Regulation (PP) No. 6 of 2015, which stated that the purpose of museum is to research, educate and entertain. As a media for research and education, museums can be defined as a learning center, a source of knowledge, and a source of information for many objects which are considered as a heritage. Whereas, as a media of recreation (entertainment), museums can be generalized as a vacation place for everybody by enjoying museum collections and doing fun activities with family on weekends.

In Indonesia, museums are only considered as a building which store old and ancient objects. The paradigm is reasonably contradictory to the actual purpose of museums. In contrast, in some developed countries, museums are treated as favorite places for its citizens. The high interest of people about museums is shown by their enthusiasm and frequency to go to museums. People do various kind of activities in museums. This is unlike the situation in Indonesian museums since they will only be crowded during holidays, institutional visit, observation and research carried out by students. Most public visitors were not interested to visit museums, because

they did not care about the history and culture of their nation. People generally think that museums are just an ancient place and far from technological touch that must be a boring place.

One of the museums in Indonesia that is quite popular is Museum Sandi. The museum, which is located on Jalan Faridan M Noto No. 21 Yogyakarta, is free of charge. In addition, Museum Sandi is located in a strategic location which is easily accessible by visitors. The Museum Sandi attracts visitors by providing facilities such as a free community space that can be used for studying, discussion and organizing a community event. This is one of the reasons for the increasing number of visitors to the Museum Sandi. However, the limited number of educators is the problem for the museum. The educators found it difficult to inform and educate many visitors which constantly increase every year. Some collections in Museum Sandi also have no information text, making visitors unable to read collection information independently since they can only collect the information from educators. Many visitors finally did not get the information and assistance at the museum. Therefore, the museum fails to deliver the detail information about its history and its collection. In other words, museums also cannot accomplish their purpose as a media of education.

On this basis, it is necessary to develop an innovated technological application to support the job of the educators in Museum Sandi. The application is based on Augmented Reality that can deliver the information about every collection of Museum Sandi to the visitors. This application is expected to reduce the workload of the educators and enable the visitors to get the information about the museum's collection independently and completely.

II. LITERATURE REVIEW

A. AR (Augmented Reality)

A part of the Virtual Environment or generally known as Virtual reality is Augmented Reality. Generally, Augmented Reality (AR) is a combination of real objects and virtual objects. The system of Augmented Reality (AR) differs from Virtual Reality. According to Azuma in 1997 [1], Augmented Reality (AR) is a new multimedia technology that can connect two worlds, which are reality and cyberspace. This technology has an interaction based on real time and 3D. The Virtual reality system uses entirely a virtual environment, while the Augmented Reality can be used to complement or enhance existing reality. The different diagram between Augmented Reality (AR) and Virtual Reality (VR) is shown in Fig 1.



Fig 1. The Difference Diagram Between AR and VR [5]

Augmented Reality has 3 main characteristics, namely: interactive, real time and 3-dimensional [2]. The interactivity in Augmented Reality can be used to increase user interaction and perception with the real world. While real time means that augmented reality occurs directly at the same time. Augmented reality is basically a process of imaging a three-dimensional image that seems to be an object which turns out to be real. The output of the virtual objects can be 3D animation, text or can also be videos which can be combined with the actual environment. Thus, users can experience virtual objects in their environment.

There are two AR methods currently developed nowadays, namely: Marker Based Tracking and Markerless Augmented Reality. Marker Based Tracking is the Augmented Reality that uses two-dimensional markers which have a specific pattern. The marker can be read by a computer via a camera or webcam. Usually, the marker will be a black and white square illustration with a thick black border and a white background.

On the other hand, according to Yudiantika in 2014, markerless augmented reality is a method of AR, in which a marker not necessarily display digital elements. This method uses the position of the camera to track the objects without using any single marker. This kind of AR can use a smartphone to detect the objects quickly, efficiently and based on real time. Markerless AR is a kind of AR which use no marker to detect an object. This kind of AR is more efficient because tracking object, which needs space to place, is unnecessary. Markerless AR uses the object only to scan and show the information interactively and attractively. Markerless AR tracks the position between a camera/user and the object using feature points such as edge, corner, line or 3D model. It is quite different from Marker AR. Marker AR tracks an object based on the position of the camera and a certain marker [3].

AR works by, firstly requiring users to capture the markerless image using smartphone camera or webcam. The markerless image will be detected by the feature of the system of the application. Secondly, Software Development Kit (SDK) provide the object tracker to track the object. After the tracking process, the output will be shown on users' computer or smartphone screen. The information is shown on the screen based on real time.

B. AR using Android System Operation

The development the AR application on android system is based on several factors. According to Istiyanto in 2013, there are 4 factors to consider the android as the base system to develop the AR application. [4]

1) *Speed factor*, which can be proven by the efficiency of the application to provide the data, to process and display the output quickly, exactly, and based on what users want.

2) *Productivity factor*, which is defined as the application rate of utility to the users' productivity.

3) *Design creativity*, which can attract users' interest to use the application.

4) *Flexibility*, which is defined as android can be operated properly in any condition.

C. Recent Studies About Augmented Reality

There are many previous researches about augmented reality. A development research on augmented reality is conducted by Vitono, Nasution, and Anra in 2016. The research was about the implementation of Markerless Augmented Reality in Kalimantan Barat Museum. The museum used to provide information through information boards, books, brochures and oral information through educators. However, the information delivery was not optimal and deep. Hence, augmented reality was considered as a media that can deliver the optimal information about the collections of the museum. After the trial phase of the application, AR received a positive response from visitors. From 30 respondents using the application, evenly the application got 77.9 points which is categorized as "Very Good". The test was conducted using questionnaires and Likert Scale to interpret the data. By this analysis, it is possible to conclude that the implementation of Markerless Augmented Reality Application in Kalimantan Barat Museum facilitates the visitors to get detail information of the collections. [5]

He, Wu and Li in 2018 conducted a comparison study between information types of augmented reality design element, which are dynamic verbal and dynamic visual cues, and the environment augmentation, which can attract people to come to museums. This study shows that dynamic verbal information is better than dynamic visual cues because the former information type tends to increase the willingness-to-pay of the people. The virtual presence, on dynamic verbal, can facilitate the aesthetic experience of the visitors of the museums. [6]

Another study about augmented reality was conducted by Chang *et al* in 2014. They analyzed a mobile guide system that integrates art appreciation instruction and augmented reality. The system is designed as a tool for paintings appreciation instruction. This experiment study compared three groups of visitors with different conditions, which are guided by AR, guided by audio, and no guidance. The result shows that the visitors guided by AR have more effective learning results, flow experience, the amount of time spent focusing on the paintings, behavioral patterns, and attitude. The use of AR obtained positive responses and feedbacks from visitors. [7]

Based on several studies as discussed above, the main issue shared by the visitors of a museum is that they cannot get detail information about the museum collection during their visit. Hence, the visitors prefer not coming to visit museums. Additionally, many museums nowadays only display the information through text and educators, which is not interesting for visitors. Therefore, an innovated and attractive application is needed to provide detail information about the collection of the museum. The application will be based on augmented reality and can be easily accessed by using android platform. This will be an appropriate solution to solve the problem related to people's lack of interest on museum.

III. METHODOLOGY

This study used ADDIE development model that perfectly fits the development of learning content and learning design, because it has a simple, systematic and generic structure [8]. ADDIE can be an instructor in creating an effective and efficient learning design by following these steps: analysis, design, development, implementation and evaluation [9]. ADDIE model is defined as a generic model which is used by many learning designers and developers to create a learning system [10]. This model allows an improvement through the rapid prototyping, which is resulted from the assessment of every step, which allows people to give feedbacks and comments to the learning products [11].

Firstly, the analysis consists of 4 steps, namely analyzing the learners' characteristic, instructional purposes, developing the analysis, and listing the targets to be achieved. Design includes formulating the assessment's design, choosing form of the course in the application, and creating the learning strategy for learners. After the completion of the first two phases correctly and appropriately, the third phase follows. This phase includes 3 steps, which are making a prototype (sample), developing learning material, and finalizing the product based on the design. Furthermore, the implementation of the instructional product is related to the real condition. Thus, it is important to concern on three aspects, namely training the instructor, preparing the learners, and organizing the learning environment.

Lastly is the evaluation phase that includes both internal and external aspects [12]. The internal evaluation (or, formative evaluation) aims to know the effectiveness and the quality of the learning product that serves as a feedback for improvement. This evaluation consists of one to one, small group, and trial in field [13]. Whereas, the external evaluation (summative evaluation) aims to evaluate how far the learners understand the competency after using the product. This evaluation concerns on the learners' feedback on the instructional design and material.

IV. RESULTS AND ANALYSIS

The research uses ADDIE model to develop the instructional product (the AR application) which consists of 5 steps: analysis, design, development, implementation and evaluation. The analysis of these steps of the model is discussed below.

A. Step 1. Analysis

At this step, an analysis of the characteristic of the learners, the purposes of the instructional, and developing analysis is conducted which is finalized by listing the target of the application. The first step is analysis of the users by investigating their characteristics. This step is crucial, because the study about the characteristic of the users means the analysis of the trend of the number of the visitor coming to the museum. In Museum Sandi, the monthly and yearly data of the number of the visitors are collected, which includes all visitors coming to the museum, including students. The data are used to develop the specific application which is suitable to the museum. The data show that there was a total of 2653 visitors from various schools in 2018. The visitors were mostly from the formal institutions, such as schools and universities. It means that the student as the subject for the development of the augmented reality application is suitable.

The data inform that the highest number of visitors of the museum occurred in July with 490 students visiting the museum from 3 various education institutions. However, in November and December, there was no institution to visit the museum. This trend took place because of the school holiday in the end of the year. Then, the data were collected by observing and interviewing the learners to identify what information is needed by the learners.

Secondly, the purposes of the instructional is formulated from vision and mission of Museum Sandi. The vision and mission of Museum Sandi is given in Table I. Lastly, the analysis phase is finalized by translating the vision and mission of Museum Sandi, which considers 3 aspects, namely knowledge, behavior and skills. The translation is given in Table II.

TABLE I. VISION AND MISSION OF MUSEUM SANDI

Vision
Socialization and learning media for young generation
Mission
1. Maintaining and presenting the coding historical collections that can educate visitors
2. Becoming a socialization media to citizen
3. Becoming a learning media to citizen about coding in Indonesia Independence process
4. Becoming a media that can increase the nationality values
5. Becoming a learning media about coding

According to the observation and interview result, this development research refers only on the first mission of Museum Sandi, because the learners need to know about the history and collections of Museum Sandi.

TABLE II. TRANSLATION OF THE FIRST MISSION OF MUSEUM SANDI

Maintaining and presenting the coding historical collections that can educate visitors		
<i>Aspect</i>	<i>Level</i>	<i>Indicator</i>
Knowledge	Remembering	a. Identify the masterpiece collections of Museum Sandi
	Understanding	b. Explain every kind of collections in Museum Sandi
	Understanding	c. Give an example of collections in Museum Sandi
	Evaluating	d. Conclude the collections information in Museum Sandi
Behavior	Valuing	a. Join to maintain the collections by not touching them
	Valuing	b. Join to maintain the collections by not capture them using blitz
	Valuing	c. Respect the rules applied in Museum Sandi
	Valuing	d. Respect to not littering while in the museum
	Valuing	e. Respect to not eating and drinking while visiting the museum
Skills	Imitation	a. Follow the procedures while visiting the museum

B. Step 2. Design

In the design phase, there are 3 things to concern, which are assessment's design, selecting a form of the course, and arranging the instructional strategy for the learners. The first part of design is conducted by arranging the evaluation test based on the competency to achieve. The competency is the translation of the first mission of Museum Sandi. Secondly, the form of the course in the application is delivering the

material using mobile phone. Most of visitors/learners use android smartphones because Museum Sandi provides them with free Wi-Fi for the internet connection as the form of the course. The facility in the museum can be helpful for learners to download the information application of Museum Sandi.

Furthermore, the instructional strategy is used in the program in self-learning, which allows the educators in Museum Sandi to supervise the learners while learning. Self-learning is conducted by letting the learners freely choose the collections that they want to learn. Hence, the application must be supported by several additional features to simplify the way visitors conceive every information and knowledge in the museum. The information about every collection of the museum can be delivered to the visitors, especially learners, by scanning the museum collections and the barcodes located near the collections.

Additionally, the developer also considers the motivation and feedback aspects in the instructional strategy of the application. The aspects are implemented on games of the application. By playing the games, the feedbacks are collected from true and false answers of the learners. If the answer is true, the learners get 100 points, but if it is false, they get 0 and the explanation of the right answer will be given. Hence, the learners can truly understand the learning material.

C. Step 3. Development

Development of the application consists of 3 stages, which are making a prototype, developing the instructional material and finalizing the design of the product (application). At the first stage, a prototype is developed offline and can be run by android system of smartphones. The prototype contains the sample material of the museum collections. After this, the developer tests the prototype to a sample of learners. The sample of learners give comments, critics and suggestions, which are used for revision.

Next, the development of the instructional materials is conducted based on the developed-instrument. The materials contain all museum collections of information, which have been listed and photo-shot. The photos and information were taken as the base information for the application. Then, the photos are categorized according to where they are exactly located. Furthermore, the material on the application is tested by material experts and media experts to check its validity. Then, the validation result is given and discussed by the sample of learners to obtain feedback for revision.

At last, the product development is finalized by the final development step by asking the sample of learners to conduct a trial of the AR application. It aims to investigate any errors or weaknesses on the application, before the application is downloaded by visitors/learners of Museum Sandi. The errors and weaknesses will be fixed to get the perfect application.

D. Step 4. Implementation

This step is about transforming the final developed product into the implemented one to the users. The implementation of the instructional product is related to the real condition in the museum that needs 3 aspects to concern. These aspects are training the instructors, preparing the users (students), and organizing the learning environment.

The first step, training the instructors, aims to prepare the instructors to do their job as the guide and the information giver using the product. The practice is useful to make the instructors master both the collection of information and the way to operate the product or the AR application. The instructors are the educators in Museum Sandi. The second crucial step is training or preparing the learners, because the learners are the one who will use the product. Therefore, the learners must find the application as easy to use for them. This step is conducted by considering internal and external factors. The internal factor covers the initial knowledge about Museum Sandi that the learners must have [14]. Meanwhile, the external factor covers the facilities that can support the learning process using information application of Museum Sandi. The facilities can be a mobile phone based on Android system to ease access to the application through the available internet connection to anticipate in case something bad happens to the Wi-Fi connection of Museum Sandi during the learning process. The last step to concern is organizing the learning environment. The learning environment is an external factor, which influence the application's learners. For example, the availability of the Wi-Fi in the museum facilitates the learners to access the AR application because the internet connection is required to run the application. The availability of the internet connection ensure the smooth operation of the application. On the other hand, the developer needs to consider the collections placement to match the contents of the application with every room of the museum. The learners can get the information of the collections by scanning the barcode near the objects using the application. Therefore, the barcode is vital part to support the learning environment and to facilitate a good learning process.

In brief, the implementation is the core of all the process of ADDIE model. At this step, the product is practically used by both educators and learners. Hence, both of them must be able to operate the product, because it will impact on the evaluation step. On the other hand, the learning environment must also be conducted in the museum and through the application. The atmosphere of every development stage must not reduce the core purpose of the museum.

E. Step 5. Evaluation

The last step of ADDIE model is evaluation. There are 2 kinds of evaluations, namely formative and summative evaluation. The formative evaluation covers 3 steps, namely one to one, small group, and trial in field evaluation. Firstly, one to one evaluation is conducted by choosing 3 learners as the development sample who have different level of competence. The learners were chosen from SMP N 1 Yogyakarta who were required to conduct an initial test to identify their competence before using the application. Then, the learners were motivated and approached to use the application. At last, they were provided with the final test after they learned using the application. The final test aims to observe the achievement and effectiveness of the application. The learners had the chance to give any comments and suggestions to the application. Furthermore, after the materials were revised, they were tried by the small group on the real condition. At the small group trial, the member of the group was selected based on sampling. The group contained 8 until 20 learners. They also did an initial test and final test using the material of the application. The group, then, gave suggestions to the application and the materials. The

suggestions as the evaluation on the instrument was resulted from questionnaires, checklist and interview. That will serve as the revision and evaluation material to the product and its contents. The product can be updated based on the evaluation for improvement. After updating and revising the product, the product will be tried in field. At this trial, the product will be tested to about 30 people who are chosen differently and randomly without considering the gender, age, or level of education. The test is also conducted before and after the instructional process to identify the effectiveness of the process. The trial will be the last test to be used as the product assessment to see whether it is successful or not. This field trial mainly assesses the effectiveness and the feasibility of the instructional product. The effectiveness is measured by the behavior of learners and educator while using the application, while the feasibility is measured by its benefit, time and cost factors.

On the other hand, summative evaluation is used to measure the test result of the learners after using the application. The evaluation is conducted using qualitative descriptive and simple experiment. The former one is conducted by describing the use of information application in Museum Sandi, which is used by the junior high school student as the learners. In brief, the application is expected to ease the students who generally have smartphones. Android system is used because most people in Indonesia use the platform. The application can be downloaded by students for use in the museum. In the museum, visitors can scan any information that they want to know for free. The application is expected to have a good interaction to the users. Thus, the visitors can conceive the historical knowledge of every collection in the "Museum Sandi".

Furthermore, simple experiment is conducted by giving the initial test and final test. The initial test is conducted after the conventional learning process or before the learners use the application, while the final test is conducted after the learners use the information application or the program has been applied to the museum. The test includes the contents and the results after users run the application on the smartphones. This test is conducted by providing several questions that the learners have to answer. The score of the students' answer will be the score of the application. The high score indicates the success of the application, while the low score indicates the unsuccessful development of AR application as the product for the museum. The result of the test shows the effectiveness of the information application of Museum Sandi based on Augmented Reality.

V. CONCLUSION AND RECOMMENDATION

According to the development of the Augmented Reality application for "Museum Sandi", it is possible to conclude that: 1) the implementation of the augmented reality application based on Android in Museum Sandi is expected to be applied properly using marker detection and 3D objects; 2) the application is expected to give an interesting interaction between the collection of the museum and the visitors; and 3) ADDIE model is chosen by considering that this model has a simple framework to develop the information application of Museum Sandi, which has systematic and generic structure with summative and formative evaluation to measure the effectiveness.

Finally, there are several recommendations about the development of the augmented reality: 1) Museum Sandi needs to install a better Wi-Fi connection to apply this mobile application; 2) Museum Sandi also needs to provide excellent mobile devices based on iOS dan Android for educators; 3) Students need to have high smartphone specification, especially a good camera to use this application; 4) it is possible to use other platforms for the development of the application, such as iOS or web; 5) 3D objects may be made as animation to make the interaction more interesting; 6) Expert evaluation can be completed if there are 3-5 material experts, 1-3 instructional design experts, 1-2 media experts, and 1 language expert.

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