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The Designing of Interactive Learning Media at Yogyakarta's Sandi Museum Based on Augmented Reality

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***Abstract*— Sandi Museum is one of museums that exhibits various collections of historical code in the forms of realia, replica, machine, picture and document related to codes. As the information sources of national cultural wealth, the existence of Sandi museum has not been visited by the tourists yet. It is because of the lack of museum promotion to community. Besides that, there is a stigma of community that museum is only the place to store the historical goods, therefore, the community activities when visiting the museum tend to be passive, in which they only look around the collections of historical goods without any interactions happened in visiting the museum. In order to get attraction of tourists when they are visiting the Sandi museum, the museum's officials are able to use the interactive learning media based on the technology of Augmented Reality in introducing Sandi museum. The visitors are able to visualize the object or historical good in 3 dimension (3-D) which is real time. The museum introduction based on Augmented Reality enables visitors to be able to interact with the objects or the historical goods through intuitive and interesting way. In this research, it is going to make AR-Sandi application as the information media to introduce Sandi museum to the community. The research approach used is research and development approach with the development model of waterfall. The Model of waterfall consists of five phases, namely analysis, design, implementation, testing and maintenance. The result of the research is that the application of AR-Sandi has been successfully developed in accordance to the methodology of waterfall. Based on the acceptance testing of AR-Sandi application with the framework of TAM (Technology Acceptance Method) towards 30 visitors of Sandi museum, it is obtained that the majority of visitors agrees, the AR-Sandi application is acceptable by the users, it has functionality and work performance well.**

***Keywords*— interactive learning media, augmented reality, waterfall, Technology Acceptance Method, user acceptance, functionality, performance.**

I. INTRODUCTION

The utilization of Information Technology (IT) in the process of information delivery is growing rapidly. One of technologies used in the delivery of technology is the technology of Augmented Reality (AR) [1]. The user is able to visualize the object in 3-dimensions, therefore, AR has interactive advantage and real time[2]. At first, AR was implemented in the field of military, industry, health application, and then it is developed in many other fields such as architecture, commercial, building construction, game, education, sport, and entertainment [2]. The interesting one is that the implemention of AR in education field has been getting increase in using it since 2003. There were 32 studies of AR which were published from 2003 to 2013 in 6 indexed journals [3]. The amount of AR implementation study in education field got up in 2013-2016 in which there were 55 studies that had been published based on empirical study on the indexed journal of Social Sciences Citation Index (SSCI) [4]. The technology of AR is rated effective for improving learning interest and user interaction in learning process [4].

The application of interactive learning media with AR technology is implemented on MARIE (Multimedia Augmented Reality Interface for E-Learning). By this technique, the user is able to interact with Virtual Multimedia Content (VMC) which consists of the dimensions of objects, pictures, animations, texts and sounds on the AR technology [5]. The other application of interactive learning media by

using AR technology is MARS (Multi-Touch Augmented Reality System). By MARS technique, There are two screens that are used as student's learning media. The first screen displays information map contextually and the second screen displays information about historical events in 3D on that location [6].

Besides the implementation of AR as the interactive learning media in education field, AR technology is also able to be used as interactive learning media for introducing cultural heritage to community, one of them is a museum [1].

The characteristic of AR technology which is interactive is able to become a media by museum organizers to attract visitors' interest. Visitors are able to visualize objects or historical objects into 3-Dimensions which is real time. Introducing museum based on AR enables visitors to interact with the content in an intuitive and interesting way [7].

Based on the explanation regarding to the advantages of the utilization of AR technology on media information of museum introduction, therefore, this research is going to be made an application of AR-Sandi. AR-Sandi is designed as a solution for visitors, who tend to be passive when they visit to a museum, only look around the collections of historical objects without any interactions happened. As the only one of Sandi museum in the world, The Sandi museum becomes the icon for the world of code in Indonesia, therefore, its exsistence has to be kept continuously and introduced to wide community. Besides, adding promotion media, it also needs to be added another learning media as the media to improve visitor's interaction in museum. One of the ways is by making introduction media of Sandi museum based on Augmented Reality. The focuses of this research are on (i) designing an application of AR-Sandi (ii) testing the application acceptance of AR-Sandi with the framework TAM (Technology Acceptance Method).

II. Literature Review

In this chapter, it is discussed about augmented reality, the implementation of augmented reality as an interactive learning media of museum introduction, and the other researches which are relevantly related to the AR implementation in museum.

A. Augmented Reality

Augmented Reality (AR) is one part of Virtual Environment (VE) or it is usually known as a Virtual Reality (VR). AR gives description to user about the joining of real world and cyberspace which is seen at the same place. AR has a characteristic that is interactive according to real time and in the shape of 3D [2]. The following is a diagram of AR illustration.

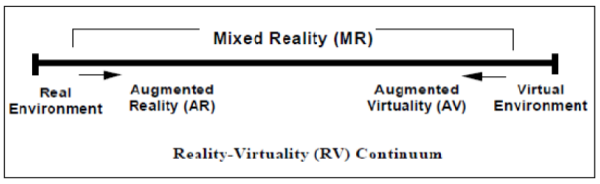


Fig 1. Illustration Diagram of Augmented Reality

Generally, there are 4 methods of AR which are developed at this time, namely marker-based AR, marker less based AR, image-based AR and location-based AR [8]. In this research, it is going to be used the method of marker-based AR with flow diagram as follow.

B. The implementation of Augmented Reality as an Interactive Learning Media of Museum Introduction

Learning media is a media used in the process of learning. The function of learning media in the process of teaching learning is to improve the student's stimulation in learning activity. Whereas the meaning of interactive is the response given by student toward learning media which is used. In the technology implementation of Augmented Reality, the user is able to visualize the object in the shape of 3 dimensions, therefore, AR is interactive and real time [2], so the technology of Augmented Reality can be classified into category of interactive learning media.

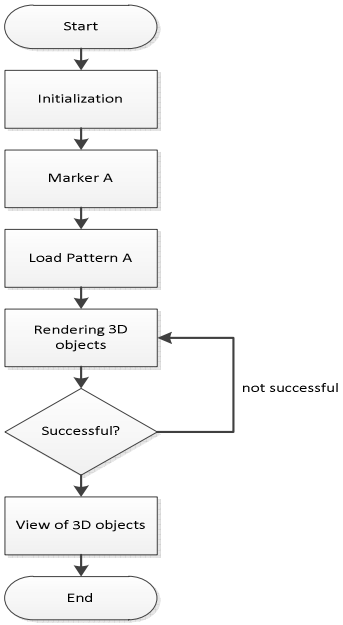


Fig. 2 Flow Chart from Marker Based AR

The implementation of AR as an interactive learning media is widely applied in lots of fields, one of them is museum introduction [1]. Based on the empirical study which was done towards 87 visitors of cultural heritage, information introduction of cultural heritage using AR technology is more effective and the visitors faster understand the information which is delivered than introduction of cultural heritage which only uses by sound [9]. The technology of Augmented Reality is also implemented on travel guide book. The AR application is going to show the video and the 3D animation to user about the route to get through the city that shows all the historical buildings. Each picture has QR code which gives access to the information and the user scans the code of QR (Quick Response) with their smartphone [10].

III. Methodology

AR-Sandi was designed by using the development model of waterfall. The procedure of the development model of waterfall consisted of five stages, namely analysis, design, implementation, testing and maintenance [11]. Each phase of waterfall model can be seen on figure 3.

The following is the explanations of each phase on the development model of waterfall:

1) Analysis
   In the analysis stage, the process of data collecting was to get information about the software which was developed based on the need and the user's request. The techniques of collecting data in this analysis stage could be done by observations, interviews as well as questionaires.
2) Design
   The stage of design was used to translate the need of software from the stage of analysis to design. The designed made was the sketch of application design.

3) Implementation
After the design was made, the next stage was to make or to develop software application which was application that used technology of Augmented Reality
4) Testing
In the stage of testing, the verification and the validation of software application were conducted. The stage of testing was used to find out the error or debug when making the application. The stages of overall testing included unit testing, integration testing, system testing and acceptance testing.
5) Maintenance
The last stage of waterfall model was the stage of maintenance. The processes of product instalation and maintenance were conducted in the stage of maintenance.

IV. Result and Discussion

The discussion of the research stage done is as follow :

A. Analysis

In the stage of analysis, it was conducted the process of data collecting in order to get information about the software that was going to be developed in tune with the user's need and request. Table 1 is information about all items needed on the application of AR-code that is going to be designed..

TABLE 1
ITEM OF THE APPLICATION NEEDS

Item	Note
Type of application	Interactive learning media based Augmented Reality
Target device	Android Smartphone
Target users	Museum Sandi Visitors (covering all age groups)
Application settings	Programming Languages: C # Resolution: 3508x2540
Graphical user interface (GUI)	Main Menu, About
Images	Backgroud Image
Video	Video Profile Museum Sandi
Audio	Background Sound
Application synopsis	AR-Sandi is an application of Augmented Reality-based Museum Sandi where the objects displayed include the video profile of museum Sandi, the display room of museum Sandi information about coding machines.

TABLE II
ITEMS FROM THE APPLICATION STRUCTURE

Item	Note
Scene design	Scene 1 : Main Menu Scene 2 : About Scene 3: the video profile of museum Sandi, the display room of museum Sandi information about coding machines.
Menu and navigation	Main menu, about,start, link GPS, exit
Object	Scene video Scene 3-dimensional model Scene 2-dimensional text objects
Button	Fuctional button: Zoom, rotate, on off sound Navigation button: Next

From the application structure item shown on table 2, There are 3 main scenes, scene 1 contains of main page of AR-Code, scene 2 contains of information of address and GPS link of Sandi museum, and scene 3 contains of objects displayed which consist of video profile of Code museum, exhibition room map of code museum on the first and second floor in 3 dimesions as well as information about code machines.

B. Design

The stage of design was used to translate the need of software which was from the analysis stage to design stage. In this research, the design was the implementation of table 2 which was information about application structure that was going to be designed. On the scene of exhibition room map of Sandi museum, the display of 3-dimension object is made by using software support of Google Sketch-Up. The following is the object display of 3 dimensions of exhibition room map on the first and second floor.

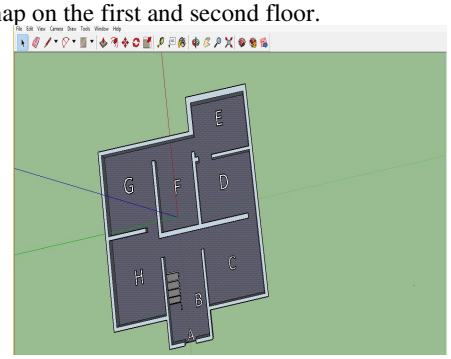


Fig. 4 1st floor showroom using Google SketchUp

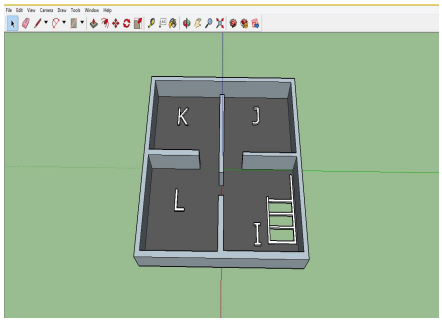


Fig. 5. 2 floor showroom using Google SketchUp

Fig. 6 Design the main menu display

Fig. 7 Design the about display

C. Implementation

After the design was made, the next stage was the making of AR-Sandi application. The making of AR-Sandi used software of Unity3D, 2017 2.0 version and Vuforia SDK. To make the database from picture of *marker* that was going to be used could go through the website of vuforia with previously making *accout* on that w*ebsite*. The followings are the steps for making marker through vuforia.

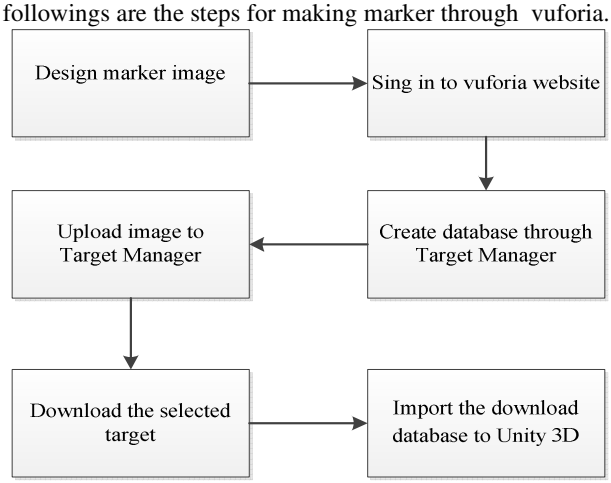


Fig. 8. Marking steps on the vuforia website

Fig 9. The marker image in the AR-Sandi application

The next was the making features of *zoom* and *rotate* as the interactive features that was on AR-Sandi. The Features were made by using language of C#.

```
void Update () {

    if (Input.GetKeyUp(KeyCode.Escape))
    {
        if (MainMenu.activeSelf)
        {
            SimplePopupManager.Instance.CreatePopup("Are you sure to quit?");
            SimplePopupManager.Instance.AddButton("Yes", delegate { Application.Quit(); });
            SimplePopupManager.Instance.AddButton("No", delegate { SimplePopupManager.Instance.HidePopup(); });
            SimplePopupManager.Instance.ShowPopup();
        }
        else if (!MainMenu.activeSelf)
        {
            exitAbout();
        }

    }

    for (int i = 0; i < Models.Length; i++) {
        //Rotation
        if (isPressedRightRot)
        {
            Models[i].transform.Rotate(Vector3.up * Time.deltaTime * 100);
        }
        else if (isPressedLeftRot)
        {
            Models[i].transform.Rotate(Vector3.down * Time.deltaTime * 100);
        }

        //Zoom
        if (isZoomIn)
        {
            Models[0].transform.localScale += new Vector3(0.001f, 0.001f, 0.001f);

            Models[1].transform.localScale += new Vector3(0.01f, 0.01f, 0.01f);
        }
        else if (isZoomOut)
        {
            Models[0].transform.localScale -= new Vector3(0.001f, 0.001f, 0.001f);

            Models[1].transform.localScale -= new Vector3(0.01f, 0.01f, 0.01f);
        }
    }
```

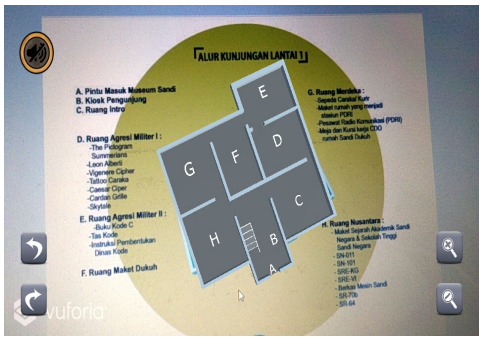
```
//Rotasi
public void RightPressedRot()
{
    isPressedRightRot = true;
}
public void RightReleasedRot()
{
    isPressedRightRot = false;
}

public void LeftPressedRot()
{
    isPressedLeftRot = true;
}
public void LeftReleasedRot()
{
    isPressedLeftRot = false;
}

//Zoom
public void ZoomINPressed()
{
    isZoomIn = true;
}
public void ZoomINReleased()
{
    isZoomIn = false;
}

public void ZoomOUTPressed()
{
    isZoomOut = true;
}
public void ZoomOUTReleased()
{
    isZoomOut = false;
}
```

Fig 8. Source Code for zoom and rotate features



a

b c)

Fig. 9. a) display of floor 1 showroom marker
b) display marker book code C c) display marker museum Sandi profile

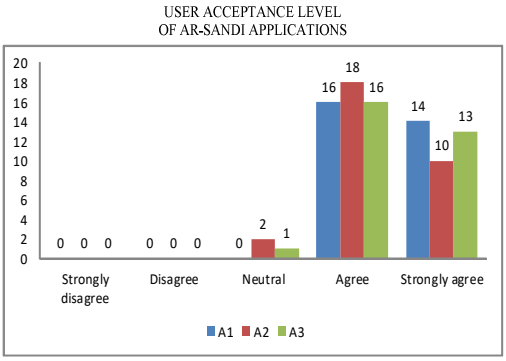
D. Testing

On the testing stage, the verification and the validation of sofware application were conducted. The stage of *testing* was used in order to find out the error or *debug* when making the application. The testing of AR-Sandi was done by using examination of *blackbox testing*, *whitebox testing*, and testing by user.

The examination of *blackbox testing* was done in order to test the validity of application process of AR-Sandi. From the testing result, it is obtained that all the processes of AR-Sandi application work well, which begin from the first time application is run up to exit the application, it works well. Likewise, the feature of *rotate* and *zoom* on picture 3-dimensions on the first and second floor, they have also worked well. The testing was also conducted by using 3 *smartphones* which have different specification. From the testing result, the application of *Augmented Tour* of Sandi Museum is able to work well on those 3 *smartphones*.

The examination of *white-box testing* was carried out in order to know the work of software internally. From the testing result, it is gained that all the functions of *source code* work in tune with its function and work well and right.

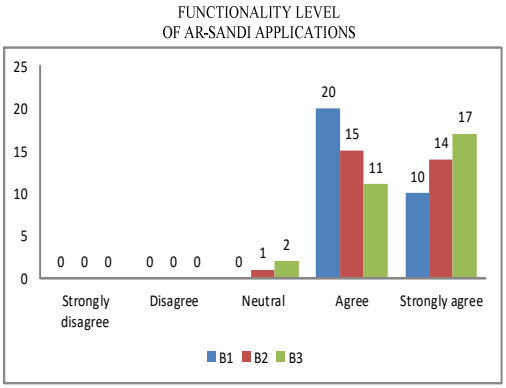
The last testing done was testing by the user. This testing was carried out towards 30 visitors of code museum. The testing used the framework of TAM (*Technology Acceptance Method*) which consisted of variables of user acceptance, functionality, and application performance [12]. The variable of user acceptance consisted of 3 questionnaire indicators about the acceptance of AR-Sandi application by user. Based on the obtained data, as many as 100% of users agree that the application of AR-Sandi is interesting, 93,33% of users agree that they get new knowledge from the using of application of AR-Sandi, and 96,67% of users agree that the application of AR-Sandi is fun. Generally, the users agree toward the acceptance level of AR-Sandi application. The following is the picture of acceptance level of AR-Sandi application.



Question:
- A1- The AR- Sandi application is interesting
- A2- I get new knowledge of the use of AR- Sandi application
- A3-AR- Sandi application is fun

Fig. 10. User acceptance level of AR-Sandi Application

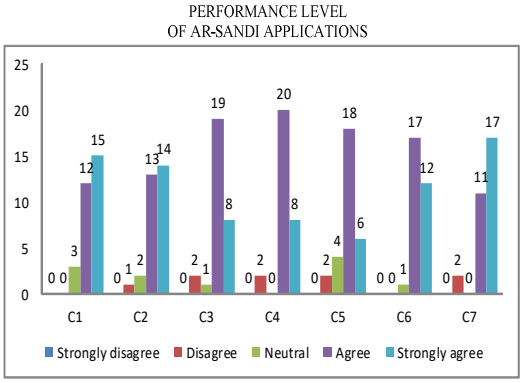
On the measuring variable of functionality, there are 3 questionnaire indicators about functionality of AR-Sandi application. Based on the data obtained, 100% of users agree that the application of AR-Sandi is stable when it is run on *mobile device*. 96,67% of users agree that the buttons on the application of AR-Sandi work well and as many as 93,33% of users state that the quality of multimedia element in the application of AR-Sandi is integrated and arranged well. Generally, the majority of users agree that the application of AR-Sandi has well functionality. The functionality level of AR-Sandi application is able to be seen on figure 11.



Question:
- B1-The AR- Sandi application is stable when run on a mobile device
- B2-Button in the AR- Sandi application works fine
- B3-The quality of multimedia elements in the AR- Sandi application is well integrated and managed

Fig. 11. Functionality level of AR-Sandi application

On the measuring variable of performance, there are 7 questionnaire indicators about the application performance of AR-Sandi. Based on the data obtaine, as many as 90% of users agree that navigation in the application of AR-Sandi is easy to be understood and well controlled, the design of display is appropriate to the theme in the application of AR-Sandi and the multimedia element in the application of AR-Sandi is integrated and has good quality. As many as 93,33% of users agree that information showed is clear, 80% of users agree that art in the application of AR-Sandi is fun, 96,67% of users agree that text, illustration and icon used are appropriate in every display, and 93,33% of users agree that the application of AR-Sandi is able to work well. Generally the users agree that the application of AR-Sandi has well performance.



Question:
C1- The navigation of the AR- Sandi is easy to understand and controlled
C2- The screen design Is suitable with the theme featured in the AR- Sandi
C3- The multimedia elements in AR- Sandi is integrated Properly and in good quality
C4- The Presentation of the information and instruction are clear
C5- The art in AR- Sandi is fun
C6-THe words, illustrations and icons used Are suitable in each screen display
C7- The Overall AR- Sandi application can Functions perfectly

Fig. 12. Performance level of AR-Sandi applications

E. *Maintenance*

The last stage of the waterfall model is the stage of *maintenance*. The process of product instalation and the maintenance is conducted in the stage of *maintenance.* The application of AR-Sandi is expected to be implemented continuously at Sandi museum and installed in the shape of AR *desktop* as well as AR *mobile*.

V. Conclussion

The conclussion of this research is that the application of AR-Sandi has succeeded to be developed in tune with the methodology of waterfall. It is expected that the application of AR-Sandi is able to be used as the other alternative in using museum learning media. The application of AR-Sandi which is developed is able to visualize the object in the shape of 3 dimensions that is *real time* characterized, therefore, it enables visitors to interact in an intuitive and interesting way. Based on the testing that has been done, the user also agrees that the application of AR-Sandi is acceptable by the user and has functionality as well as good performance.

For the further research, it can be added a menu of simple code *game* in the application of AR-Sandi and on the user testing is able to be added variable of quality as its measuring variable.

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