Development of Interactive Media Based on Augmented Reality for Early Childhood Learning Around the Home

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Abstract—In the current digitization era, it is essential to develop interactive learning media that engage children. Also, a learning approach that includes both real and digital media can be made more exciting and less tedious. This can be achieved through fun learning while still valuing traditional and interactive approaches. Therefore, this study aims to develop media solutions for early childhood and kindergarten teachers to facilitate teaching and learning. The created media include Android applications that use Augmented Reality (AR) technology to make the experience more fun and book media based on the kindergarten curriculum. Parents and caregivers can use these media to teach their children about the living room, toilet, and other places. When the Android application scans a picture, it will show animated 3D objects through Augmented Reality. Also, the application has a free picture coloring option, and it needs to be supervised by parents or teachers through a process called digital parenting. The development and verification results showed this media is suitable for implementation in schools and kindergartens.

Keywords—kindergarten, early childhood development, augmented reality, e-parenting, blender 3D, coloring book

1 Introduction

Early Childhood Education (PAUD) is a type of learning that teaches children about the world around them, and it is implemented before starting school. Activities like Posyandu, Playgroups (KB), and TK/RA benefit children from birth until the age of six. However, PAUD has experienced numerous challenges regarding its implementation. Teachers often repeatedly use the same learning materials when they are not confident enough to create new ones, hence, the children become bored. Also, the materials are occasionally outdated and inappropriate, resulting in children receiving a sub-standard education.

Based on the observation at TK Firdausi Nuzullah in the Padang Pariaman district, the teachers still use physical materials in the classroom. Although teachers have

started using computers, but they only display pictures of plants, animals, and provide explanations. Therefore, the children find it boring and lose concentration.

Children need interactive media at a young age, such as games that help improve their cognitive and motor skills. According to Lee, people can communicate in new ways with interactive media. This is because the interactive approach changes the media environment in creative ways [1][2][3][4].

Several children like mobile-based media because it is fun. During an interview, Opet Fitri Mariani, the Principal of Firdausi Nuzulla Kindergarten, asserted that children can play with technology and often use their parent's cell phones at home which makes them knowledgeable. Therefore, parents should ensure their Children do not use devices and games inappropriately even though the usage has positive effects.

Netti Herawati, the General Chairperson of a group of Indonesian PAUD educators called Himpaudi, stated that "*We believe PAUD is committed to strengthening the country's foundation and developing young people*". As a result, all stakeholders, including parents, should support these activities.

Most of the factors people want are digital and can be met by technology. In fact, technology has evolved into the world of children. This makes it difficult for parents and PAUD teachers to deal with children during the Fourth Industrial Revolution.

The people of Philadelphia who participated in a study by Common Sense Media stated that four years old children already had personal smartphones. Furthermore, 25% of parents remarked that they let their children play with gadgets at night, 33% claimed their three to four-year-olds like to use phones, while 42% said their one-year-olds like to use devices to play games, watch movies, and use applications. More than two-thirds of the parents claimed they let their children between the ages of six months and four years play with iPhones, and predominantly play games while they do schoolwork.

Alternatively, several parents have let children as young as two years old play with technology. Many children under the age of five enjoy playing games on PlayStation, online, and on their phones, tablets, and iPads. Often, parents and teachers are unable to control their children or seize the phone which results in arguments and temper tantrums. Gadgets in daily life can help children learn better when used appropriately because widgets facilitate learning. Furthermore, studies have established that young children who use technology have improved mental health [5][24]. As a result, several application developers are seeking to make PAUD learning applications and place them on Google Play Store. With the employment of PAUD, several applications will appear in search results.

It is not always easy to consider the negative effects of using application and gadgets early in life. Therefore, real media need to be exploited to make up for the lack of mobile phones as teaching tools [12][13]. This is because when an individual uses a device or computer for a long period, their blink rate will reduce, leading to dry eyes. Smartphone screens are very small, hence, they are placed close to the eyes to read and look at images, videos, etc. Many studies showed that this also strains the eyes [6][14][15][23].

This study aims to develop an application that helps students learn about PAUD and enable goal accomplishment while considering their health. Furthermore, the

application is used with tangible items, such as a book. The application can also use Augmented Reality (AR) [16][17], which has various functions and parts. Augmented Reality refers to a technology that superimposes a computer-generated image and provides a composite view. Before the Augmented Reality system shoots the virtual item, it first ascertains the location [3][25]. The tracking operation is carried out on the item that identifies the location of the object. Subsequently, the item will be recognised or graded. Finally, the computer locates and examines the object's position and orientation, and processes the image, which appears on the screen. This application permits children to keep in touch with their phones and other physical media, such as books, even when their parents are not present. Also, the children usually look away from the screen because they simultaneously use both books and phones [20][21][22].

2 Method

Choosing and setting up an approach for developing and implementing information system software is not as challenging as it appears. Each company has its set of rules as discussed in the following section [8]. The Linear Sequential Modelling method is a systematic and sequential process that starts with system requirements analysis, design, coding, testing (implementation), as well as verification. This method can be employed to make a new system. Figure 1 demonstrates how to develop application media.

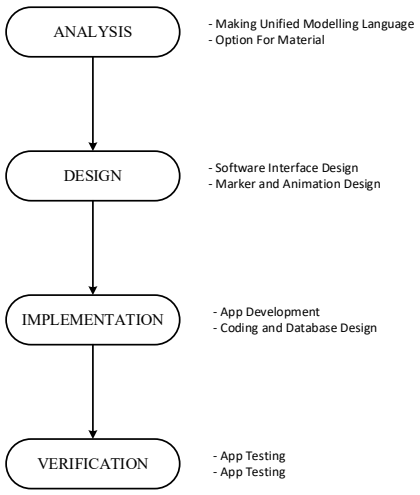

Fig. 1. Method for developing application media

2.1 Title and meta-data for the document

Analyses functional. The functional analysis explains the features associated with the Colouring application. Mobile Augmented Reality has changed considerably over

the last decade, including its perception. Also, people who wear goggles can use mobile Augmented Reality because they can see and interact while moving [9]. The following are some of the traits:

1. Capable of presenting three-dimensional objects created by colouring pages
2. Incorporates more information from the Augmented Reality Book and Applications
3. The ARC colouring application allows users to examine 3D objects in animations ranging from tiny to large and rotate 360 degrees including music.
4. Procedural Analysis - Procedural analysis is essential for this program to function appropriately. It consists of two stages, namely application design processes and usage as shown in Figure 2.

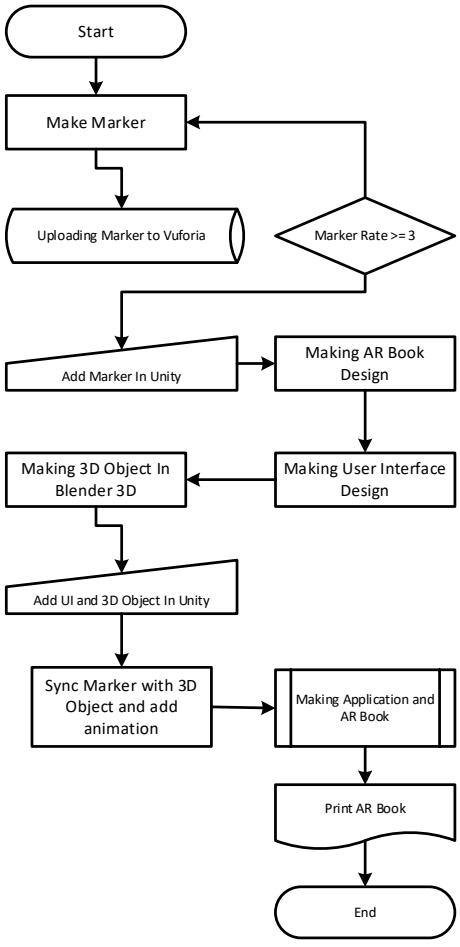

Fig. 2. Analyses of procedures

2.2 Design of the application

A replica of placeplus.id website was made to be tested and understood for the next step, which is when the real website will be created. Also, the Unified Modelling Language (UML) is the tool applied to make objects appear the way they are. It is one way to design and build object-oriented systems.

Use case diagram. The diagram shows a group of use cases and the users. As demonstrated in Figure 3, this diagram is very important for organizing and modeling what users expect from a system, in order to create user-friendly applications.

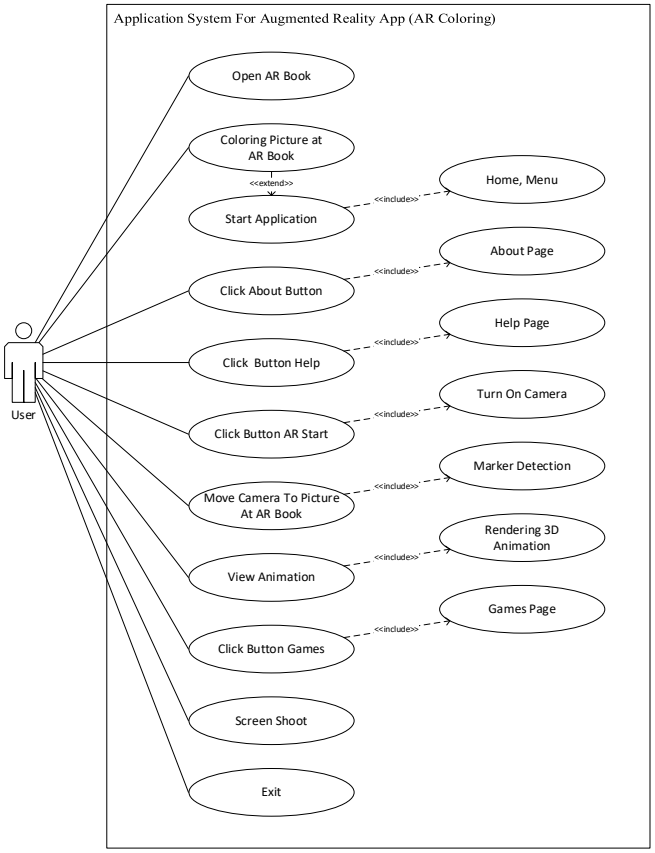

Fig. 3. A use case diagram for Augmented Reality applications

Class diagram. Class diagrams show the organization in a system and how they interact with each other. Each class diagram has its attributes and methods that are part of the design. Figure 4 shows the class diagram for the ARC colouring application.

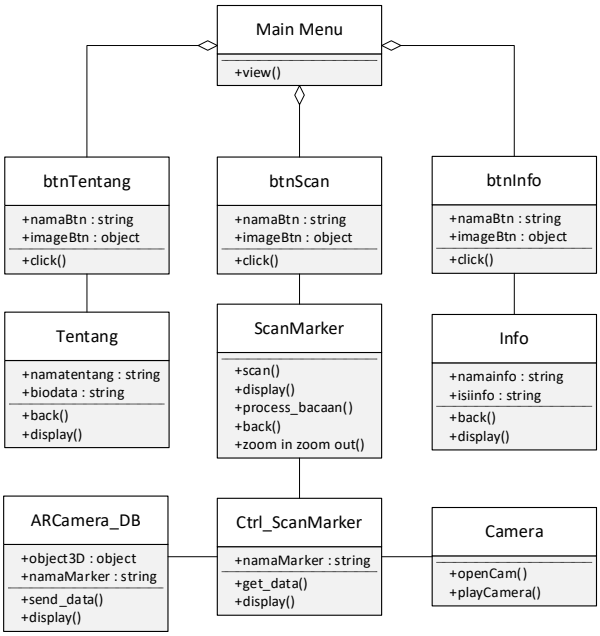

Fig. 4. Class diagram application design

Storyboard application design. Microsoft Visio was used to make the application storyboard. Page 1 of the application is shown in Figure 5.

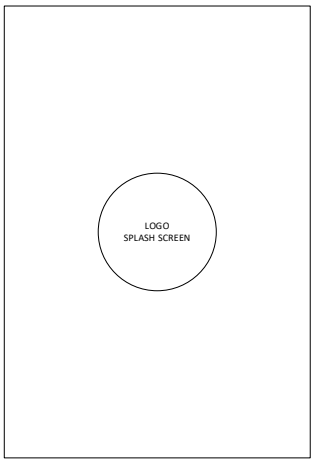

Fig. 5. Splash screen for the Storyboard page

The screen also comprises of the main application menu which has several buttons for different items. It appears in the storyboard as shown in Figure 6.

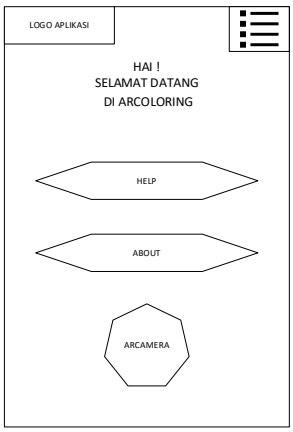

Fig. 6. The splash screen for the second page of the Story Board

When the camera is aimed at a 2D object, it takes a picture of the object in the Augmented Reality camera view.

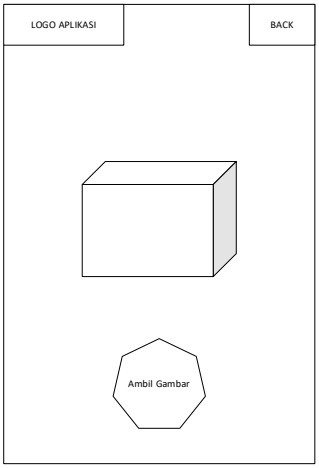

Fig. 7. Storyboard camera application of Augmented Reality

Storyboard Augmented Reality book. A blank page appears with a black outline and a sample image with colour. The user will colour the image and the page will appear blank. Also, the user will explore the site with the early childhood work colouring pages and subsequently colour them.

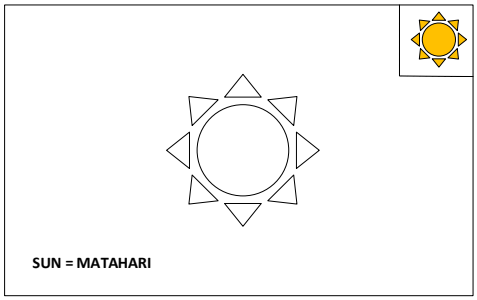

Fig. 8. Working page colouring picture

3 Result and discussion

3.1 Implementation of the design's results

This part of system analysis and design is referred to as application design because the output is fully displayed at this point. This stage ensures the application runs smoothly because of the previous design. The following is a list of items involved in creating an interface for an application system.

Application marker design. In programming, a marker is a particular sort of object. Fiducial pictures, which are sometimes referred to as markers, comprise a set of reference points that allow image processing parameters to be **evaluated** [12]. Figure 9 shows the look of the marker design created by using the Adobe Illustrator and how to make markers.

Fig. 9. Marker design example

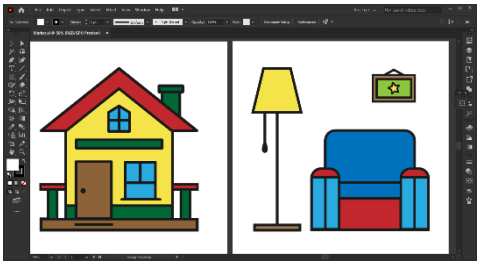

Fig. 10. Marker making process

The design is sent to Vuforia after the bookmark is made for Unity to link to the application. The Vuforia is an SDK for mobile devices employed in creating applications that use Augmented Reality. The company was previously named Qualcomm and is known as Vuforia or QCAR (Qualcomm Company Augmented Reality). A computer program called Computer Vision is used to locate and track planar images (the "Target Image") and simple 3D objects, such as squares in real-time. It can record images when they are observed through a mobile device's camera. Also, virtual objects like 3D models and other media, such as videos with real-world photos can be placed and moved as desired [13][18].

Moreover, this Vuforia is used as a database that stores application markers as shown in Figure 11.

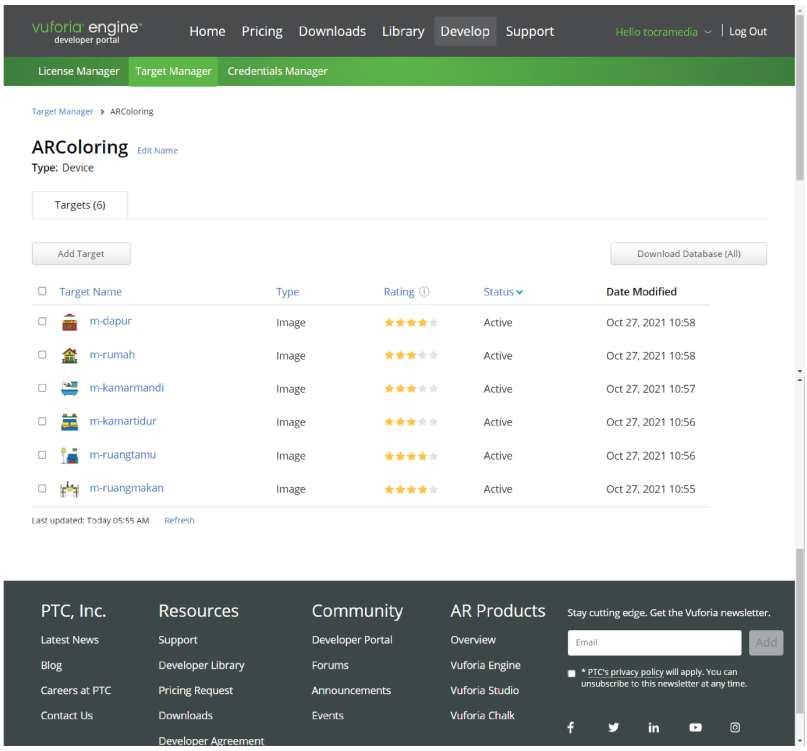

Fig. 11. Vuforia database

3D object design. This 3D object was created by using the blender software version 2.9. The 3D assets made are those that are part of the application sub-theme related to "*my home"*. After making 3D parts, they are sent to Unity, where a game engine is used to make Augmented Reality apps. Also, animated items are added to the 3D objects in this unit to create a dynamic and more interesting look. Below is a collection of three-dimensional assets explicitly made for Augmented Reality applications:

The entire house is made up of assets, which are also in each room. The assets in the bedroom include a mattress and bed, a study table, a closet, as well as a computer. The assets in the living room include a sofa, vase, and light. Some of those found in the kitchen are Storage cabinets, dishwashers, and gas stoves. Meanwhile, toilet paper and a bidet are found in the bathroom.

To help with the development, an Augmented Reality application was created with the Unity Version 2019 software and Vuforia SDK. Also, the 3D models were made with Blender 2.9.

1. Icon Page of an Application
   The application logo shows up in the Android menu and it opens when clicked.
2. Splash Page
   The splash page appears when the icon is touched and displays the name of the application. At first glance, this display looks quick, taking just 4.0 seconds to complete.
3. Main Menu Page
   The home screen of the application has several options, including an exit button that closes the page. The options in Figure 12 show this page has other numerous tasks.

Fig. 12. Main menu page

4. Augmented Reality Camera Page
   The Augmented Reality Camera page is a significant part of the Augmented Reality project. This page is used to scan bookmarks on a phone or tablet. The Augmented Reality camera page also helps to view the home, specifically the bathroom, kitchen, bedroom, living and dining room markers. In addition, the view that found six markers and revealed 3D objects with animations is shown below.

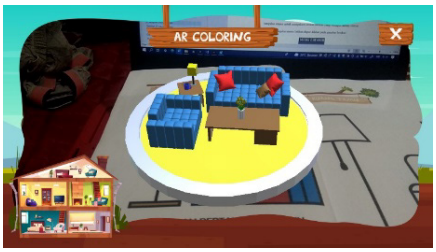

Fig. 13. Augmented Reality camera page

5. Theme Page
   The chosen theme is shown on the page where the learning material will be made and a sub-theme called "My Home" has been added. This is shown in Figure 14.

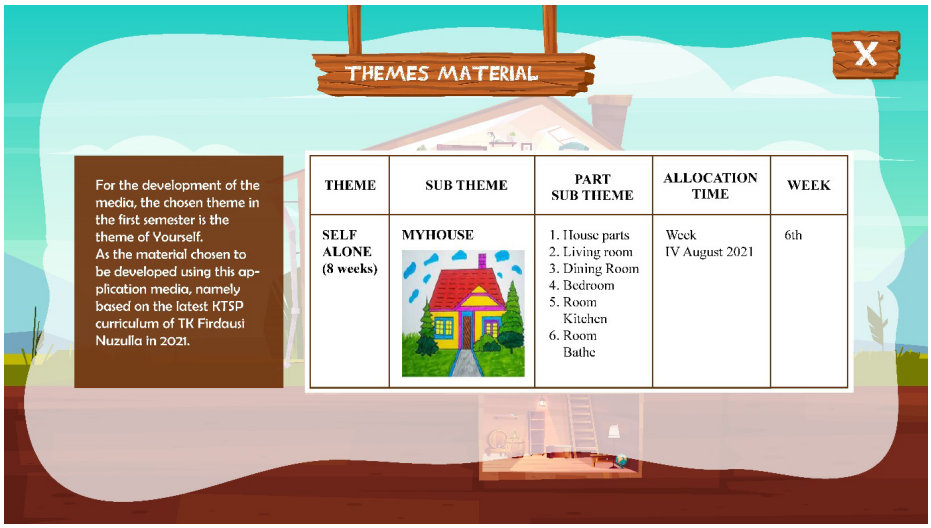

Fig. 14. Theme page

6. Game Page
   This is the digital picture to colour, and there is an example where a user colours a picture in a drawing book with instructions based on the photos provided. The 3D object is also given, where users can use pre-mined pellets to colour the 2D image on a game page. They are freely given to children to help their imaginations run wild. In addition, the game dramatically improves the analytical skills of its players, such as absorbing information, as well as making quick and accurate decisions [13][18][19][26]. It starts with a blank page surrounded by a black outline picture. The user picks a colour from the palette and chooses the area to paint. The figure below shows the next game page.

Fig. 15. Game page

7. Guide Page
   This page shows how to use the application, open a colouring book, and view an Augmented Reality animation. Also, this page briefly explains the function of each button on the main menu.

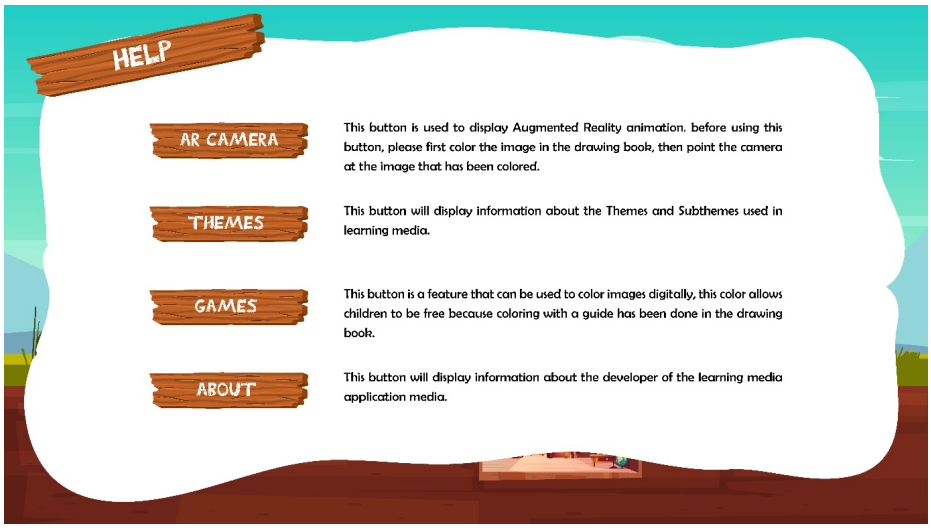

Fig. 16. Guide page

8. AR Book Design
   This type of media is made up of real items, such as picture colouring books that can be used with Augmented Reality. These books are called "Augmented Reality books". In Indonesia, they are a mix of traditional books and Augmented Reality technology. This book can be downloaded and printed for kindergartens. Figure 19 shows what the page looks like.

3.2 Cover page

This page consists of book covers and cartoons with a "friendly" feel. When the book is opened, there are two parts, namely the front and the back cover. The book's premise and title appear clear on the surface. Furthermore, there are biographies related to the author on the back cover, as well as links to free software and e-books that can be downloaded and printed by the user. Figure 17 show the front covers of the book.

Fig. 17. Front cover page

3.3 Contents page

The content page summarises the book's most important sections. It is divided into 12 sections containing six photographs from the current sub-themes. A single illustration is made up of two separate pages. The first page is filled with colourful pictures and text that leads to the next, making it look like a story about what people do at home every day. There is an outline picture on the next page that can be used as a worksheet. The children have to finish the colours on the previous page using Augmented Reality before they start drawing manually. They can choose any colour they like which available in the page. The colouring page is shown in Figure 18.

Fig. 18. Colorings page

3.4 Notes page

The teachers and parents decide what to record on this page which is essentially a blank piece of paper. Figure 19 shows how the notes page looks.

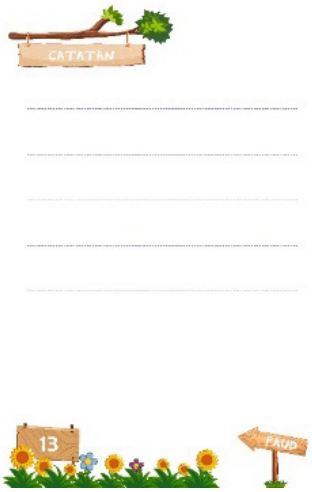

Fig. 19. Notes page

4 Conclusion

An Augmented Reality (AR) application for coloring and learning is a media solution for early childhood and kindergarten teachers to facilitate teaching and learning. The generated media includes Android applications that employ Augmented Reality (AR) technology to enhance the experience and book media based on the kindergarten curriculum. This application can be installed on a smartphone with Android OS version 5.1 (Lollipop), and a rear camera. This application helps teachers to explain the material to students, aids the learning process in PAUD, and improves outcomes. Therefore, students can use the application both at school and at home. The development and verification results showed this media is suitable for implementation in schools and kindergartens

5 Recommendations

The students of TK Firdausi Nuzula were able to use an Augmented Reality application to colour images on both the self-theme and My Early Childhood Home subtheme.

a) This application is specifically recommended to help students learn more about technology.

b) Parents are expected to use digital parenting in early childhood education by giving their children practical learning materials that are fun and interesting. This will keep them from using gadgets for a long time during their early years. Also, it is believed that young children can learn in a way that is not outdated by using physical or traditional media, as well as a technology-based approach. The same software can be used to create more applications in the future or used with other programs to make dynamic and fun learning materials.

6 Acknowledgment

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