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Indonesian Sign Language (SIBI) Vocabulary Learning Media Design Based on Augmented Reality for Hearing-Impaired Children

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***Abstract*—The lack of mastery of spoken and written vocabulary makes hearing-impaired children have inadequate vocabulary designations. A case study in a kindergarten school for hearing-impaired children in Surabaya, the students are taught to understand vocabulary through media recognition with original objects, artificial objects, and images. For media recognition through images usually use media in the flashcards form. The rapid development of Information and Communication Technologies (ICT) such as the Augmented Reality (AR) should also be utilized to support the learning media for hearing-impaired children. In this study an application based on AR technology has been integrated with flashcards as a learning tool for children with hearing impairment in learning the vocabulary of the Indonesian sign language (SIBI) In designing the learning media, we use Luther's version of multimedia development method, include concept, design, material collecting, assembly, testing, and distribution. Based on the test results, it would be concluded that the AR application system would run well, as evidenced by the buttons on this AR application 100% running according to its function. Markers on the flashcard 97% are detected by the system and would be integrated with appropriate video displays. As for this AR application that runs offline in which all assets and videos are stored in the application database installed on the device, the RAM and processor capacity is very influential on the success and speed of detection of markers and access to display video. So it is recommended to use a device with a minimum of 1.5 GB RAM and a 1.4GHz Quad-core processor. With this AR application, we hope hearing-impaired children become more interested in learning and increasing their vocabulary independently.**

***Keywords*— Augmented reality, hearing-impaired children, Indonesian sign language, vocabulary, video**

I. INTRODUCTION

Hearing-impaired children have obstacles or disorders of the sense of hearing, both permanent and non-permanent [1]. They generally do not have physical differences with other children. The difference only lies in the ability to receive or capture stimuli, process stimuli, and store stimuli through the hearing instrument caused by obstruction or disturbance in the sense of hearing [2]. Hearing-impaired children have obstacles in terms of communication, both communicating verbally and in writing. An uphill challenge for deaf children could read vocabulary acquisition [3]. Besides, the lack of mastery of spoken and written vocabulary makes them have an inadequate vocabulary designation. Knowledge of verbal and written vocabulary could affect the ability of hearing-impaired children in terms of communication, reading [4], and writing [5], as well as the ability to understand symbols used in conversation or so-called sign language. The development of Indonesian sign language among deaf people is divided into two sign languages, namely SIBI (Indonesian Sign Language System) and BISINDO (Indonesian Sign Language) [6]. A case study in a kindergarten school for hearing-impaired children in Surabaya, the students are taught to understand vocabulary through media recognition with original objects, artificial objects, and images. For media recognition through images usually use media in the flashcards form.

The rapid development of Information and Communication Technologies (ICT) such as the Augmented Reality (AR) as a support for learning media has been applied to support history lesson [7], formal education [8] to higher education [9]. Research [10-12] shows that the application of AR can have a significant impact on increasing children's learning motivation. The studies [13-16] proved AR succeeded in becoming a learning media for sign language topics. However, the use of AR as a learning media for hearing-impaired children has not been developed in Indonesia. Several studies related to the development of learning media for hearing-impaired children, such as [17,18], have not utilized AR technology in them. The utilization of AR to learn sign language has just been done [19]. Still, the research aims to facilitate ordinary people to learn sign language to be able to communicate with hearing-impaired children. The utilization of AR for learning media for hearing-impaired children has been done [20] using Arabic sign language and Augmented Sign Language Modeling (ASLM) with interaction design on a smartphone for the inclusive classroom in India [21].

In this study, an application based on AR technology has been integrated with a flashcard as a learning tool for hearing-impaired children in learning the vocabulary of the Indonesian sign language. We chose to use the SIBI type sign language to refer to the kindergarten curriculum in Surabaya. With this AR application, we hope hearing-impaired children become more interested in learning and increasing their vocabulary independently.

The paper is organized as follows: Section 2 of this paper reviews the application development methodology, such as concept, design, material collecting, assembly, testing, and distribution. Section 3 reviews the test result and discussion. The conclusions and suggestions would be discussed in section 4.

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II. Research Method

In designing this learning media, we use Luther's version of the multimedia development method [22], as in Figure 1. There are six stages that each step does not have to be done sequentially but can be in parallel. But the planning stage, including concept and design, must begin first.

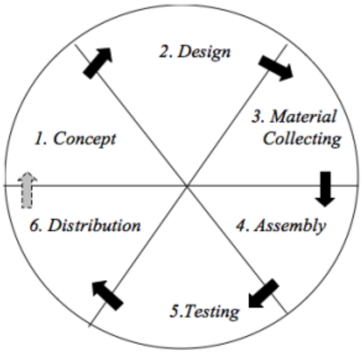


Figure 1. Multimedia Application Development Cycle

A. Concept

At this stage, the goal of developing an AR application is to facilitate the hearing-impaired children who are in kindergarten school to learn vocabulary independently. So that the vocabulary material raised in the AR application adjusts the curriculum of the kindergarten school, as in Table I. The AR application is designed to be able to run offline without connecting to the internet network. Therefore all the assets and video displays are stored in a database attached to the .apk file:

TABLE I
Vocabulary Matters Based on kindergarten school in Surabaya

Theme	Human Limbs	Objects of Daily Necessity	Transportation
Vocabulary	Eyes	Ball	Bus
	Cheeks	Dress	Rickshaw
	Mouth	Hat	Bike
	Hand	Book	Train
	Foot	Shoes	Car
	Ear	Table	Plane
	Nose	Chair	Ship
	Teeth	Bag	Motorcycle
	Hair	Clock	Delman
	Lips	Ribbon	Taxi

B. Design

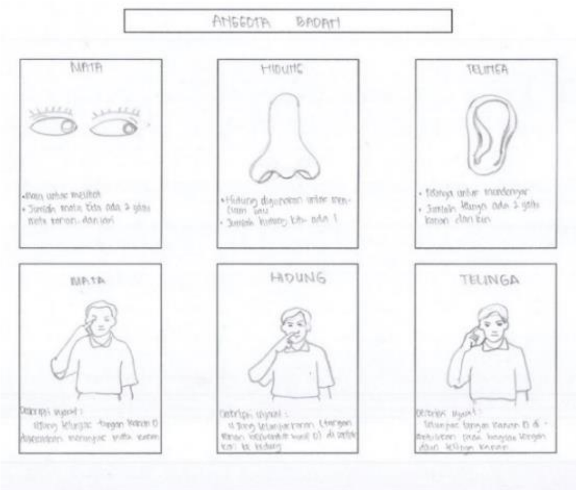


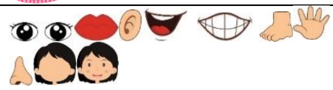
Figure 2. Flashcard Sketch

At this stage, the sketches and layouts of each vocabulary used were drawn. This sketch will be implemented later on the flashcard. Figure 2 is an outline of some of the vocabulary used.

C. Material Collecting

At this stage, we are listing flashcard assets from the results of the previous sketch. Then each asset is digitalized using a computer like Table II. The flashcard digitalization results are presented in Figure 3.

TABLE II
Digitalization of Flashcard Assets

No.	Description	Digital Assets
1.	Female character as a model for sign language movements	
2.	Assets of human limbs: eyes, lips, ear, mouth, teeth, foot, hand, nose, hair, cheeks	
3.	Assets of daily necessities: ball, clock, dress, bag, table, chair, hat, shoes, book, ribbon	
4.	Transportation assets: Delman, plane, bike, motorcycle, taxi, car, rickshaw, bus, train, ship	

(a) (b) (c)

Figure 3. Flashcard Digitalization Results

TABLE III
. Specification of Video Recording Equipment

No.	Equipment	Specification
1.	DSLR Camera	Type: Canon EOS 60D Color: Black Megapixels: 18 MP Video Resolution : 1920x1080 Focal Lenght: 18-55 mm Lens Range Aperture: f/3.5-5.6
2.	Tripod	Folded Height: 52 cm Max height: 150 cm
3.	Green Screen	Width : 6 meters Length : 4 meters
4.	Redhat Lighting	Power: 800 W Properties: Warm Color: Yellow (4000 kelvin) Output: Continuous Light Power Output: Switch On & Off
5.	Lightstand	Four pieces

Besides designing flashcard assets, we also produce videos of Indonesian sign language (SIBI) demonstration as assets. This video involves kindergarten students as talent. The video production process includes the stages of storyboarding, video recording, and video editing, such as Figures 4 and 5. Table III is the specification of the equipment used when shooting video.

Figure 4. Video Recording Process

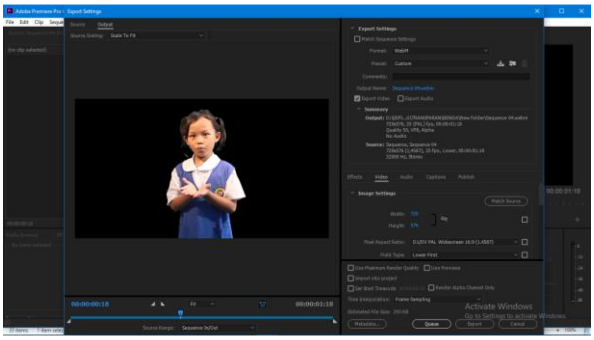


Figure 5. Video Editing and Rendering Process

D. Assembly.

At this stage, all existing assets are integrated into the AR application but need to be preceded by the steps of determining the AR application user interface as Table IV.

An augmented reality application requires markers on the scanned object. Markers are determined using the Vuforia SDK, which is integrated with Unity 3D. The image used as a marker is part of the image on the flashcard. The image was uploaded on the vuforia website. Figure 6 is an image that has been uploaded on vuforia.com.

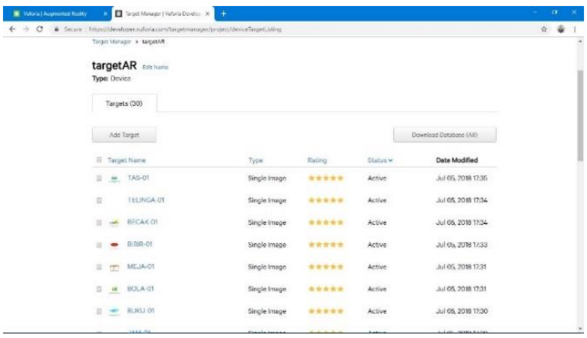
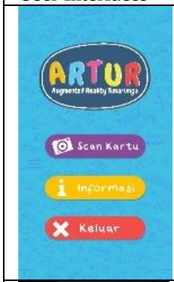


Figure 6. Upload Marker & Rating Acquisition Process

TABLE IV
USER INTERFACE

User Interfaces	Description
	Main Menu Page: The screen that appears after the splash screen disappears. On the main menu, three buttons contain card scan buttons, information buttons, and exit buttons, each of which is connected to another screen.
	Usage Instruction Page: This screen appears when the card scan button is pressed. This screen contains instructions for using the application.
	Camera Display Page: This screen appears after the usage instructions page. This screen displays an Indonesian sign language (SIBI) video as a result of the marker scanning process on the flashcard.
	Information Page: This information screen will appear when the information button is pressed. This screen contains information about the AR application.

After uploading all the images in vuforia, then download the database for the unity package. This package will be imported into the 3D unity software and arranged according to the target image, as in Figure 7. Each marker on the flashcard is automatically given an identical rating by vuforia. The more star ratings obtained means that the tag is more identical than the other markers.

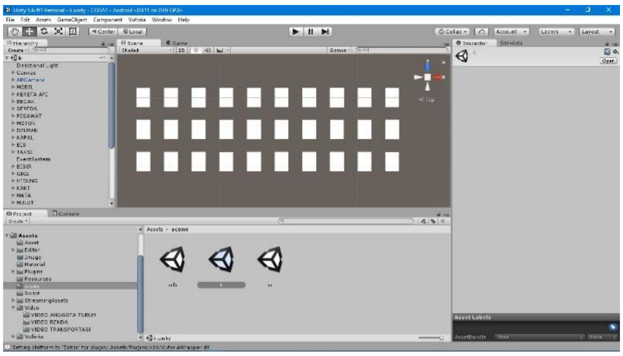


Figure 7. Import-Package Process

The working system of this AR application is depicted in the flowchart in Figure 8. Firstly the camera scans the flashcard; after the library detects the marker on the flashcard, the app would play the Indonesian sign language (SIBI) video by the flashcard image.

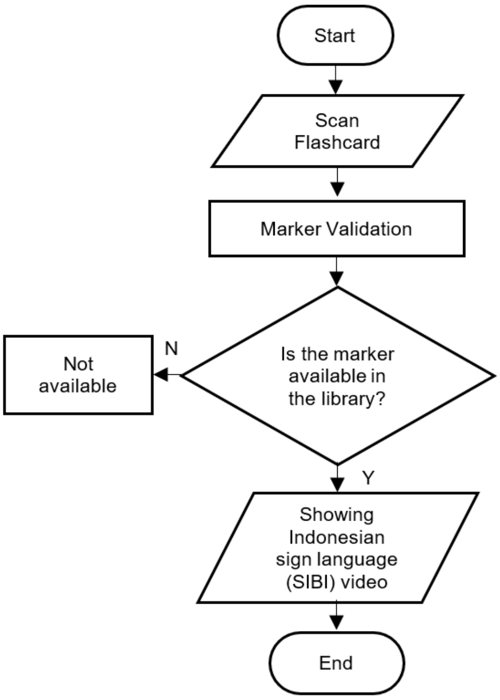


Figure 8. AR Application Work System Flowchart

E. *Testing*

After the application is built, an application test is performed, which includes testing the system functionality, testing the marker, and testing the device.

F. *Distribution*

AR application that has been built is uploaded to the play store so that hearing-impaired children could download it anytime, anywhere. After the AR application is downloaded and installed, the hearing-impaired children would use it as one of the vocabulary learning media.

III. The Test Result and Discussion

A. *Testing System Functionality*

The functionality test aims to find out which button on the application should be running according to its function. The buttons that are tested on the app include sections:

- Main Menu page
- Information page
- Usage Instruction page

The test results in Table V show that each button in each section is running according to its function without any errors.

TABLE V
SYSTEM FUNCTIONALITY TESTING RESULTS

Interfaces	Testing Material	Expected Results	Test Results
Main Menu page	Card Scan Button	The card scan page appears	V
	Information Button	The information page appears	V
	Exit Button	Exit the application	V
Usage Instruction page	Arrow Button	There is a camera process scanning the markers on the card, then the Indonesian sign language (SIBI) video is displayed	V
Information page	Arrow Button	Return to the main menu page	V

B. *Testing the Marker on Flashcard*

Every marker on the card is tested to ensure the system detects each marker, and the system can integrate it into the appropriate video display. This marker test is done by directing the camera to a flashcard that contains a marker in it. The parameter of the success of this marker test is the application succeeded in displaying Indonesian sign language videos that match the markers on the flashcard. This test uses devices with specifications, as in Table VI. Marker test results are presented in Table VII. The test results showed that 97% of markers were detected correctly by the system, and the system successfully integrated into the right video. There is one marker that has not been identified correctly; the marker on the cheek flashcard is detected as a marker of hair. Thus it is necessary to improve cheek markers and re-upload them to vuforia.

TABLE VI
DEVICE SPECIFICATIONS

Specification	Description
Android Version	8.1.0 (Oreo)
CPU	Octa-Core Max 1.80GHz
RAM	4.00 GB
Internal Storage	64.00 GB

TABLE VII
MARKER TESTING RESULTS

No	Testing Material	Expected Results	Test Results	Testing Material	Expected Results	Test Results	Testing Material	Expected Results	Test Results
1.	Marker on the eye flashcard	Eyes vocabulary video appears	V	Marker on the ball flashcard	Ball vocabulary video appears	V	Marker on the car flashcard	Car vocabulary video appears	V
2.	Marker on the	Cheeks vocabulary	X	Marker on the	Dress vocabulary	V	Marker on the	Bus vocabulary	V

	cheeks flashcard	video appears		dress flashcard	video appears		bus flashcard	video appears	
3.	Marker on the mouth flashcard	Mouth vocabulary video appears	V	Marker on the hat flashcard	Hat vocabulary video appears	V	Marker on the rickshaw flashcard	Rickshaw vocabulary video appears	V
4.	Marker on the hand flashcard	Hand vocabulary video appears	V	Marker on the chair flashcard	Chair vocabulary video appears	V	Marker on the bike flashcard	Bike vocabulary video appears	V
5.	Marker on the foot flashcard	Foot vocabulary video appears	V	Marker on the bag flashcard	Bag vocabulary video appears	V	Marker on the plane flashcard	Plane vocabulary video appears	V
6.	Marker on the ear flashcard	Ear vocabulary video appears	V	Marker on the clock flashcard	Clock vocabulary video appears	V	Marker on the motorcyc le flashcard	Motorcycle vocabulary video appears	V
7.	Marker on the nose flashcard	Nose vocabulary video appears	V	Marker on the ribbon flashcard	Ribbon vocabulary video appears	V	Marker on the train flashcard	Train vocabulary video appears	V
8.	Marker on the teeth flashcard	Teeth vocabulary video appears	V	Marker on the shoe flashcard	Shoe vocabulary video appears	V	Marker on the ship flashcard	Ship vocabulary video appears	V
9.	Marker on the hair flashcard	Hair vocabulary video appears	V	Marker on the table flashcard	Table vocabulary video appears	V	Marker on the Delman flashcard	Delman vocabulary video appears	V
10.	Marker on the lips flashcard	Lips vocabulary video appears	V	Marker on the book flashcard	Book vocabulary video appears	V	Marker on the taxi flashcard	Taxi vocabulary video appears	V

C. Testing the Devices

This test is carried out on devices that have different specifications as in Table VIII aims to determine the minimum device specifications so that the application can run well.

TABLE VIII
DEVICE SPECIFICATION LIST

No	Specification		
	Android Version	Processor	RAM
1.	4.2.2 (Jellybean)	Quad-core 1.3GHz	1 GB
2.	7.1.1 (Nougat)	Quad-core 1.4 GHz	1,5 GB
3.	7.1.2 (Nougat)	Quad-core 1.4 GHz	2 GB
4.	6.0.1 (Marshmallow)	Octa-core Max 1.4 GHz	3 GB
5.	8.1.0 (Oreo)	Octa-Core Max 1.80GHz	4 GB

TABLE IX
DEVICE TESTING RESULTS

Device	Duration of Application Opening	Period Open the Card Scan page	Period of the Marker scan process	Period Open the Information page
1.	9,2 s	-	-	1 s
2.	6,1 s	11,7 s	1 s	1 s
3.	9,3 s	20 s	4,5 s	1 s
4.	6,2 s	15,5 s	1 s	1 s
5.	4,3 s	13,7 s	1 s	1 s

Based on the test results in Table IX could be concluded that this AR application would be installed on android version 4.2.2 and above. However, for application to run a card scan page and display videos correctly, you should use a device with a minimum of 1.5 GB RAM and a 1.4GHz Quad-core processor. Since this AR application runs offline in which all assets and videos are stored in the application database installed on the device, the RAM and processor capacity is very influential on the success and speed of the marker detection process and the video access process. Units

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) The SI unit for magnetic field strength *H* is A/m.).” An exception is when English units are used as identifiers in trade, such as “14 in laptop." Avoid combining SI and CGS units, such as current in amperes and magnetic fields in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the groups for each quantity in comparison.

IV. THE CONCLUSIONS AND SUGGESTIONS

Based on the test results, it would be concluded that the AR application system would run well, as evidenced by the buttons on this AR application 100% running according to its function. Markers on the flashcard 97% are detected by the system and would be integrated with appropriate video displays. As for this AR application that runs offline in which all assets and videos are stored in the application database installed on the device, the RAM and processor capacity is very influential on the success and speed of detection of markers and access to display video. So it is recommended to use a device with a minimum of 1.5 GB RAM and a 1.4GHz Quad-core processor.

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