Jurnal E-Komtek
Vol. 9, No. 2 (2025) pp. 474-487
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Implementation of Augmented Reality (AR) as a Learning Medium for Introducing Hijaiyah Letters (A Case Study at UMP Kindergarten)

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https://doi.org/10.37339/e-komtek.v9i2.2614

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
30-07-2025
Revised:
04-08-2025
Accepted:
06-08-2025
Online first:
06-01-2026

Abstract

In today's digital era, Augmented Reality (AR) technology is increasingly being utilized as a learning medium to increase children's interest in learning, including in introducing hijaiyah letters to kindergarten children. The problem that is often faced is the lack of interactive educational applications that are suitable for this age. This research aims to develop AR based educational applications using the Multimedia Development Life Cycle (MDLC) method, which includes six stages, namely concept, design, material collection, manufacture, testing, and distribution. The application was tested using the black box testing method on various Android devices. The test results show that all features such as camera access, marker scanning, 3D appearance of hijaiyah letters, interactive quizzes, instructions for use, and author information function properly. This application supports learning media that is interactive, fun, and helps children recognize hijaiyah letters better.

Keywords: *Augmented Reality, Hijaiyah Letters, Educational Application, MDLC, Black Box Testing, Learning Media*

Abstrak

Dalam era digital saat ini, teknologi *Augmented Reality* (AR) semakin banyak dimanfaatkan sebagai media pembelajaran untuk meningkatkan minat belajar anak, termasuk dalam memperkenalkan huruf hijaiyah kepada anak-anak TK. Permasalahan yang sering dihadapi adalah kurangnya aplikasi edukasi interaktif yang sesuai untuk usia tersebut. Penelitian ini bertujuan mengembangkan aplikasi edukasi berbasis AR menggunakan metode *Multimedia Development Life Cycle* (MDLC), yang meliputi enam tahap yaitu konsep, perancangan, pengumpulan bahan, pembuatan, pengujian, dan distribusi. Aplikasi diuji dengan metode *black box testing* pada berbagai perangkat Android. Hasil pengujian menunjukkan bahwa seluruh fitur seperti akses kamera, pemindaian *marker*, penampilan objek 3D huruf hijaiyah, kuis interaktif, petunjuk penggunaan, dan informasi *author* berfungsi dengan baik. Aplikasi ini mendukung media pembelajaran yang interaktif, menyenangkan, dan membantu anak-anak mengenal huruf hijaiyah dengan lebih baik.

Kata-kata kunci: *Augmented Reality, Huruf Hijaiyah, Aplikasi Edukasi, MDLC, Black Box Testing, Media Pembelajaran*

1. Introduction

The rapid development of digital technology has brought about major changes in the world of education. Both educators and students increasingly need creative and interactive learning methods to facilitate conceptual understanding and sustain learning motivation. One technology that offers great potential in this regard is Augmented Reality (AR). AR is a technology that combines real objects with virtual components, thus creating a more interesting and immersive learning experience. Through hardware support, such as cameras, sensors, and displays, AR can superimpose additional information directly on real objects. AR technology allows interaction between users and their environment that has been enriched with digital elements **[1].**

Muhammad, Wardhono, and Afirianto developed an Android based mobile application that uses AR technology as a medium for introducing hijaiyah letters for early childhood. This application is developed using the Waterfall method, proceeding through the stages of analysis, design, implementation, and testing. The results of this study showed that the AR application developed was able to increase the average score of students by 11.19% compared to before using the application. In addition, children become more enthusiastic and focused in the learning process **[2].**

Fadli and Ishaq with their research entitled "Application of Letter Recognition and Makharijul Hijaiyah Letters with Android based augmented reality" proposed an Android based application with AR features as an introduction to hijaiyah letters and makharijul letters. This research uses Unity 3D, Vuforia, and Blender to create 3D models and letter pronunciation. This application also provides practice questions to test children's abilities after learning. The test results show that the application makes a positive contribution in memorizing and understanding hijaiyah letters, and is considered very helpful by users based on the results of the questionnaire **[3].**

Lidianti et al. also developed AR based learning media for hijaiyah letters and makhorijul letters, with a marker based approach. This study emphasizes on improving the understanding of the shape and pronunciation of the hijaiyah letters. The results showed that, compared to conventional learning methods, AR can increase students' interest and make learning more fun and interactive **[4].**

Hafidhoh et al. in their research focuses on developing AR applications that display hijaiyah letters along with punctuation marks. The test results show that the application made with the marker based AR method using Unity 3D and Vuforia is effective in helping children recognize hijaiyah letters as a whole, including various ways of pronouncing them with punctuation marks **[5].**

At an early age, children's ability to understand and store information in memory is generally better than when they are older. The introduction of hijaiyah letters in children requires a fun and effective learning strategy so that the learning process is not boring and children can still concentrate. With the creation of an AR based Hijaiyah letter recognition application, it is hoped that the learning objectives can

be achieved optimally. [6]. By making this hijaiyah letter recognition application, it is hoped that it can increase students' interest and willingness to learn.

Android is a Linux based mobile operating system designed for handheld devices such as smartphones and tablets. A modified Linux kernel manages interactions with sensors and other hardware through an abstraction layer (Hardware Abstraction Layer), while the Android Runtime (ART or Dalvik) and native libraries allow execution of applications developed using the Java or Kotlin programming languages [7] [8]. Augmented Reality (AR) itself is a technology that enhances the user's perception of the real world by inserting digital elements such as 2D or 3D images, audio, and video in real time into the environment, thus allowing interaction between virtual objects and the real world simultaneously [9]. In the context of learning, learning media functions as a means that facilitates the delivery of material and interaction between educators and students, thus creating a concrete and interesting learning experience. Learning media can be any form of tool or means that supports interaction to facilitate or improve the effectiveness of the teaching learning process, while learning technology includes theories and practices related to the design, development, utilization, management, and evaluation of learning processes and resources [10] [11].

Hijaiyah letters or Arabic letters are the script used by Muslims around the world to read the Qur'an, so the introduction of hijaiyah letters is a very important basic stage in instilling the basis of Qur'anic literacy in children [12]. To support the development of AR based applications, Unity 3D is used as a game engine as well as a cross platform application development platform that supports the creation of 2D, 3D interactive applications, as well as AR and VR technologies. Unity 3D has an easy to understand interface, supports the C# programming language, and can be integrated with other SDKs such as Vuforia [13]. Vuforia Engine itself is a cross platform AR SDK that provides facilities for developers to detect, track, and position virtual objects in the form of 2D images, 3D models, or special markers in the real environment through computer vision technology. In education, Vuforia is widely used to create AR based learning media that can increase student motivation and help visualize material that is difficult to understand. The C# programming language plays an important role in application development in Unity because of its simple, expressive syntax, and is supported by the .NET ecosystem and an extensive developer community. In developing AR applications with Unity and Vuforia, C# is used to build interaction logic, control 3D objects, and organize application flow in an efficient, modular, and structured manner [14] [15].

2. Method

In this research there are 2 main parts used in research methods, namely data collection methods and system development methods.

2.1. Data Collection Methods

Methods are used at this stage to facilitate the research analysis process. The data used are as follows:

1. Primary Data

   Data such as images from the internet, 3D models, audio data, interviews, and observation results are considered primary data, which is the data required directly to build this application. In this research, interviews were conducted with UMP Kindergarten as the main need for this application to be designed.

2. Secondary Data

   Secondary data is data obtained from other sources such as journals, ebooks, and other references related to augmented reality technology and devices used for this research.

2.2. Data Development Method

The system development of this application was carried out using the Multimedia Development Life Cycle (MDLC) method as shown in Figure 1. This system development method is specifically designed to facilitate the creation of multimedia products, such as interactive learning media, presentation applications, and educational games.

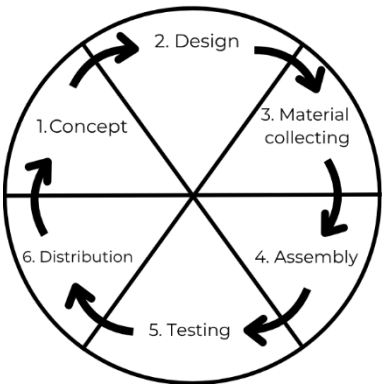

Figure 1. MDLC Method Stages

In general, MDLC consists of six main stages, namely:

1. Concept

   This is the initial phase where the main idea of the multimedia application is formulated. Developers identify user needs, set application creation goals, and determine the target audience. The result of this stage is a general description of the application to be developed and the scope of the project.

2. Design

In the design stage, the navigation design, interaction flow, and interface design that will be displayed are made. This design also includes determining the media format, software used, and the overall structure of the application.

3. Material Collecting

All supporting elements such as images, videos, sound, animation, and text are collected at this stage. The source of materials can be self produced, licensed materials, or materials from legitimate open sources.

4. Assembly

At this stage, all multimedia materials that have been collected begin to be assembled and combined using specialized software. Multimedia products are built according to the design that has been made, until they become application prototypes that can be tested.

5. Testing

The testing stage is carried out to ensure that all functions work as expected. Tests include technical aspects (program functions, navigation, and media).

6. Distribution

The final stage of the MDLC is product distribution to users. Products can be distributed through various media, such as CDs, websites, mobile applications, or other media.

2.3. Block Diagram System

Block diagram is a visual representation of a system, where each main function is depicted in the form of blocks and connected with lines to show the relationship between parts. The workflow of the Hijaiyah letter recognition application is visualized in Figure 2.

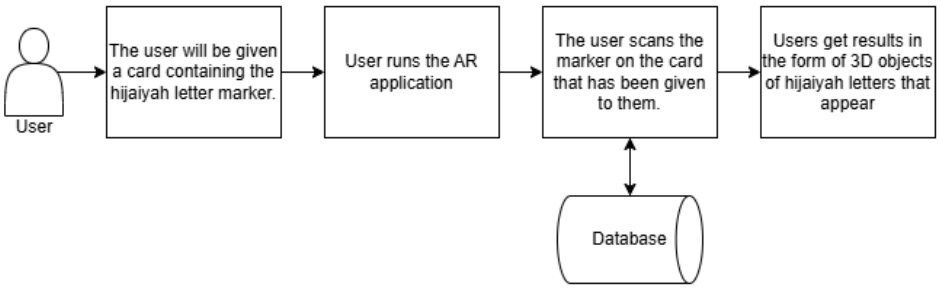

Figure 2. Block Diagram System

The system block diagram illustrates that at the initial stage, before the application is run, the user already has a card that contains markers and information related to the augmented reality based hijaiyah letter recognition application. Next, the user opens the application, activates the camera, and scans the

marker. After the marker is detected, the system will process and display 3D objects taken from the database.

2.4. Flowchart System

The flowchart here plays a role in explaining the process of running the application system, as shown in Figure 3 below.

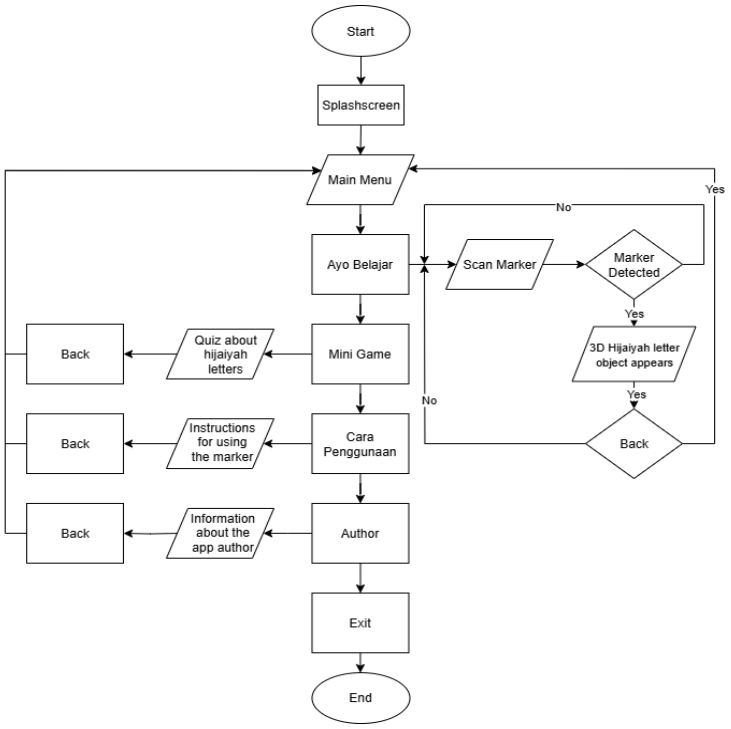

Figure 3. Flowchart System

In the system flowchart above, it can be seen when the process starts from the start, namely the splashscreen then enters the main menu page, on the main menu page there are 4 choices of features available. The first feature is let's learn, in this feature the application will access the camera on the user's smartphone and scan the marker, after the marker is successfully scanned, a 3D object will appear accompanied by an audio description of the object. Furthermore, there is a mini game feature that contains a simple quiz. There is a how to use feature that contains procedures for using marker cards owned by users. The process ends when we click the exit or end button on the flowchart.

3. Results and Discussion

The results and discussion in this study contain the achievements of each stage in the Multimedia Development Life Cycle (MDLC) method, which will be explained in detail in each section.

3.1. Concept

At the concept stage, researchers designed an augmented reality (AR) based hijaiyah letter learning application aimed at kindergarten children. The purpose of this application is to provide an interactive

and fun learning experience through AR technology that displays 3D objects of hijaiyah letters accompanied by their pronunciation sounds.

This application includes several main features, namely:

1. Ayo Belajar: Displays hijaiyah letters in 3D when the marker is scanned, complete with pronunciation sounds and harokat or tanwin options.
2. Mini Game: Interactive quiz to test letter recognition skills with score and time system.
3. How to Use: An illustrated guide to using the app.
4. Author and Exit: Author information and exit feature.

This concept is expected to increase interest in learning and understanding hijaiyah letters with a visual and auditory approach in a fun way.

3.2. Design

The design stage is carried out to develop application designs with a UML based modeling approach. This design includes the preparation of diagrams to describe the flow and structure of the system, as well as supporting elements such as storyboards, marker design, and 3D object design. In this article, an example diagram is shown, namely the use case diagram, which represents the main interaction between the user and the system found in Figure 4.

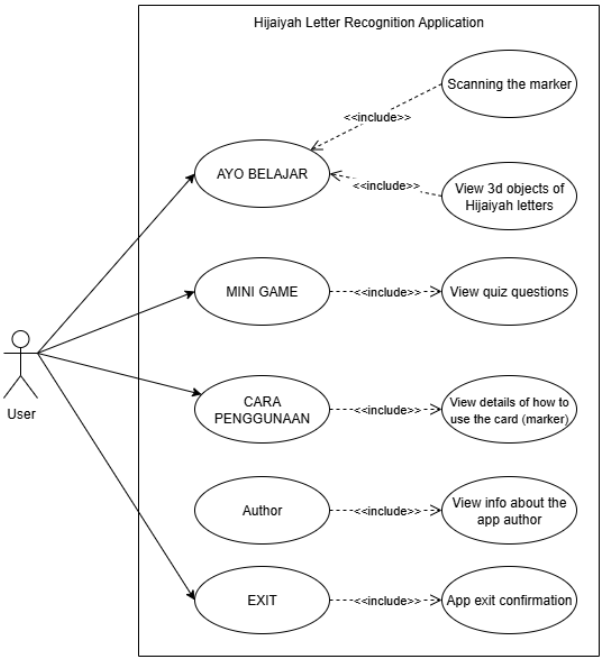

Figure 4. Usecase Diagram

The use case diagram illustrates the interaction between the user and the application system, where the user can see 3D objects when the card is detected, besides that the user can also see quiz questions in the mini game menu and see details on how to use it in the how to use menu.

Storyboard is a sequential visual representation used to describe the flow of user interaction with the application, starting from the initial display to all accessible features. In the development of this Augmented Reality based hijaiyah letter recognition application, storyboards play an important role in designing user experience in a systematic and structured manner. Each page of the storyboard shows the display scenario that will appear, such as the main menu page, the marker scanning process to display 3D hijaiyah letters, to interactions in mini games and navigation to the help page (Cara Penggunaan). With the storyboard shown in Table 1, the design of the application interface becomes more focused and consistent, and facilitates the development process so that each feature-such as Let's Learn, Mini Game, and Author-can be arranged according to the needs of kindergarten users with an intuitive and attractive appearance.

Table 1. Storyboard

Scenarios	Description
Scene 1 – Main Menu	This scene is the main display which consists of four buttons: Ayo Belajar, Mini Game, Cara Penggunaan, and Author. Each feature has an educational and informative role.
Scene 2 - Ayo Belajar	This scene accesses the device's camera automatically. The child is asked to scan the Hijaiyah letter card marker. When the marker is recognized, the app displays a 3D object of the Hijaiyah letters along with their pronunciation. The user can also add harokat or tanwin through the on-screen selection panel.
Scene 3 – Mini Game	The scene moves to a simple quiz game. The questions are displayed above, and the child chooses an answer letter from buttons containing random pictures of Hijaiyah letters. The system will give an audible and visual response whether the answer is correct or incorrect.
Scene 4 – Cara Penggunan (How to use)	This scene contains visual and text explanations on how to use the app and scan markers. This feature is useful for teachers or parents who accompany children in learning.
Scene 5 - Author	This scene displays information about the application creator, including the developer's name, institution, and role.

3.3. Material Collecting

At this stage, all the supporting elements needed for the application design have been prepared. In this application, the collected materials include 3D objects as visualizations of the Hijaiyah alphabet, markers that function as triggers to display augmented reality objects, and audio to display the pronunciation of the Hijaiyah alphabet as shown in Table 2. These materials will be used in the assembly stage to align with the designed layout.

Table 2. Material Collecting

No	Materials	Description	Size	Format
1	3D Object	Hijaiyah letter object	1320kb	.fbx
2	3D Object	Harokat object	213kb	.fbx
3	Markers	Asset marker	1060kb	.png
4	2D Object	Hijaiyah letters	106kb	.png
5	Audio	Pronunciation of hijaiyah letters	2810kb	.mp3

3.4. Assembly

In the assembly stage, all materials that have been collected, such as 3D objects and markers, begin to be integrated into the application using development software, one of which is Unity 3D combined with Vuforia Engine. This process includes placing objects, setting interactions, and organizing the application workflow according to the design that has been made before.

The main menu of this application contains four main features, namely Ayo Belajar, Mini Game, Cara Penggunaan, and Exit. In the AyoBelajar feature, when the user presses the button on the main menu, the application will automatically activate the device camera to scan the card or marker. After the marker is successfully recognized, the system will display a 3D object of hijaiyah letters, and the user can select the harokat through the harokat panel that has been provided as shown in Figures 7 and 8.

Figure 5. Main Menu Interface

Figure 6. Ayo Belajar Feature Display

The Mini Game feature in this application is designed to provide practice questions through the display of question columns and answer columns, which are equipped with 36 buttons of hijaiyah letters arranged randomly, as shown in Figure 9. In addition, users can understand how to use cards or markers through the Cara Penggunaan menu, whose interface is shown in Figure 10. As for information about the

identity of application developers, including their names, institutional affiliations, and respective roles, can be accessed through the Author feature as shown in **Figure 11**.

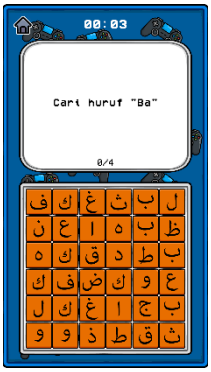

Figure 7. Mini Game Feature Display

Figure 8. Cara Penggunaan Feature Display

Figure 9. Author Feature Display

3.5. Testing

Application testing is conducted using the black-box testing method to evaluate the functionality of each application feature based on the input and output produced, without examining the program code structure. Each feature is tested to ensure the application can work as expected. This testing stage is conducted on five Android devices to ensure the application functions properly across a range of devices.

The black box test results for the main features of the app are summarized in Table 3. All features, including let's learn, mini game, how to use, author, and exit succeeded as expected. Camera access, appearance of 3D hijaiyah letters, presentation of quiz questions, delivery of usage information, and confirmation of exiting the application have adequately functioned in all tests. Table 4 shows the results of testing the compatibility of AR objects on various android devices. The application is able to display 3D objects.

Table 3. Blackbox Testing Results

No	Process	Action	Results
1	Ayo belajar	Accesses the camera, scans the marker and displays the 3D object.	The application successfully accesses the camera, detects the marker, and displays the 3D object of the hijaiyah letters correctly on the screen.
2	Mini *game*	Displaying quiz questions	The application successfully displays quiz questions that can be accessed and answered by the user.
3	Cara penggunaan	View how to use feature page	The application successfully displays detailed information on how to use the card (marker) clearly and informatively.
4	*Author*	View app developer information	The application successfully displays information about the creator or developer of the application.
5	*Exit*	Accessing exit page	The application successfully displays a confirmation to the user to confirm

	whether they want to exit the application or not.

Table 4. AR Object Smartphone Testing Results

No	Name	Android Version	RAM	Prosesor	Camera	Results
1	OPPO A5 (2020)	9.0	4 GB	Qualcomm Snapdragon 665	12 MP f/1.8	3D objects appear
2	OPPO A9 (2020)	10	8 GB	Qualcomm Snapdragon 665	48 MP f/1.8	3D objects appear
3	Samsung galaxy A34	13	8 GB	Mediatek Dimensity 1080	48 MP, f/1.8	3D objects appear
4	OPPO A57	12	6 GB	Mediatek Dimensity 810	13 MP, f/2.2	3D objects appear
5	Realme 8 5G	11	8 GB	Mediatek Dimensity 700	48 MP, f/1.8	3D objects appear

Beta testing is a test carried out objectively which is tested directly by questionnaires filled in by 10 students and teachers of UMP kindergarten. The beta testing results table in Table 5 contains a recapitulation of user responses to ten questions designed using the Student Experience Questionnaire (SEQ) approach. These questions are focused on evaluating the effectiveness of Augmented Reality (AR) based learning media applications in introducing hijaiyah letters, compared to conventional learning methods. The assessment was conducted by teachers, students, and guardians of UMP kindergarten students who have tried the application directly. These results become the main reference in assessing the quality of user interaction, material understanding, and children's learning experience presented by the application developed in this study. The assessment in this beta testing uses a Likert scale of 1 to 5, where a score of 1 indicates “strongly disagree,” 2 “disagree,” 3 “neutral,” 4 “agree,” and 5 “strongly agree.” This scale is used to measure respondents' level of agreement with each statement presented regarding the effectiveness and user experience of the Augmented Reality based Arabic alphabet learning application.

Table 5. Beta Testing

No	Questions	Assessments					Total
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
1	Students easily understand how to use the app	0	0	0	4	6	10
2	The app is easy to use	0	0	0	5	5	10
3	The visual display (3D images and colors) is attractive and fun	0	0	0	6	4	10

No	Questions	Assessments					Total
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
4	The sound of the pronunciation of the hijaiyah letters is clear and appropriate	0	0	0	6	4	10
5	The "Ayo Belajar" feature helps children recognize hijaiyah letters in a more interactive way	0	0	1	4	5	10
6	The "Mini Game" feature encourages children to learn while playing	0	0	1	4	5	10
7	This application makes learning Hijaiyah letters more fun than books or conventional methods.	0	0	1	4	5	10
8	This app can be used as an additional learning media at home/school.	0	0	2	2	6	10
9	Students remember hijaiyah letters faster after using this application.	0	1	0	3	6	10
10	Students look more enthusiastic in learning hijaiyah letters after using this application.	0	0	0	1	9	10

The results of beta testing involving 10 respondents through the Student Experience Questionnaire (SEQ) approach, a total score of 442 out of 100 responses was obtained, resulting in an overall average score of 4.42 on a maximum scale of 5. This value indicates that the Augmented Reality based hijaiyah letter learning application developed received a very positive response from users. Main features such as "Let's Learn" which presents 3D objects of hijaiyah letters, "Mini Game" as a medium for learning while playing, as well as audio support for letter pronunciation are proven to be able to create a more interactive and fun learning experience than conventional learning methods. Thus, this application shows strong potential to be implemented as an effective alternative learning media, especially in early childhood education at the kindergarten level.

3.6. Distribution

At this stage, the finished application is stored in digital media. The application is converted into Android Package Kit (APK) format so that it can be installed and run on Android based devices. The APK file is uploaded to Google Drive. The final stage is to distribute the application to the UMP Kindergarten, with the aim of providing interactive and interesting learning media to introduce hijaiyah letters. This innovation is expected to improve the quality of learning and user involvement in recognizing hijaiyah letters in a more fun way.

4. Conclusion

Augmented reality (AR) based hijaiyah letter learning application designed for UMP kindergarten children has been successfully developed by integrating the main features, namely let's learn to display 3D objects of hijaiyah letters through AR technology, mini games in the form of hijaiyah letter quizzes, as well as how to use, author, and exit to support user experience. Based on the test results, all of these features run well as expected. The application can access the camera, detect markers, and display 3D objects of hijaiyah letters correctly on various Android devices with different specifications, thus supporting interactive learning, increasing interest in learning, and helping children recognize hijaiyah letters more fun and efficient. This application still has room for further development to provide a more optimal learning experience. The addition of animations to 3D objects to enrich the visual appearance, the development of additional features such as pronunciation of hijaiyah letters or letter writing exercises, and optimization of application performance so that it can run lighter and more responsive on devices with low specifications can be done by future researchers. In addition, testing with a wider group of users outside the UMP Kindergarten is also important to obtain input to improve the quality of the application.

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