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Implementation of Augmented Reality in Animal Introduction Learning for Students with Intellectual Disabilities

Yoga Pangestu *
Informatics Study Program, Faculty of Science and Technology, Universitas Teknologi Yogyakarta, Yogyakarta Special Region, Indonesia.
Corresponding Email: yogapangestu16@gmail.com

Sri Wulandari
Informatics Study Program, Faculty of Science and Technology, Universitas Teknologi Yogyakarta, Yogyakarta Special Region, Indonesia.
Email: sri.wulandari@staff.uty.ac.id

Irma Handayani
Informatics Study Program, Faculty of Science and Technology, Universitas Teknologi Yogyakarta, Yogyakarta Special Region, Indonesia.
Email: irma.handayani@staff.uty.ac.id

Abstract: Introducing animals and their characteristics to mentally disabled students is a complicated matter. Mental retardation is a condition where a person's intellectual and cognitive intelligence is below average, which causes limitations in thinking, solving problems, remembering, and easily losing focus. Because of this, mentally disabled students develop more slowly than normal children their age. To help overcome developmental delays and improve their memory, special treatment and education are needed that suit their needs. Schools can utilize Augmented Reality (AR) technology as an alternative educational tool to make the teaching and learning process at school more fun, interesting and interactive so that it can leave a deep impression on students. This research aims to design and build an application to introduce animals by applying augmented reality technology. This research uses the Multimedia Development Life Cycle (MDLC) method; in this method, there are six stages: concept, design, material collection, design, testing, and distribution, with the testing method using black box testing. This research results in an Android-based augmented reality application for animal recognition for mentally disabled students. This application can make the teaching and learning process more interesting and enjoyable for students and make it easier for teachers to introduce animals and their characteristics.

Keywords: Marker-Based Augmented Reality; Mentally Disabled; Animal Introduction; Android App; Education.

1. Introduction

Special Schools (SLB) are institutions operating in the education sector. This institution was formed specifically for students who have difficulty participating in the learning process due to physical, intellectual and mental disabilities but who have the potential for intelligence. Special School C Karya Bakti Foundation (SLB C YKB) – Garut, located in Garut, West Java, is one of the schools built to educate children with special needs such as autism, mental retardation, and ADHD (Attention-Deficit Hyperactivity Disorder). Children are considered to have special needs if their IQ is below average, which causes limited mental, intellectual and social abilities [1][2]. Making the learning process intensive and interesting for students can have a significant impact; early intervention programs and providing high-quality educational services are also very important to help students reach their potential [2][3]. Several materials are taught by teachers at SLB C YKB Garut, one of which is material about animals and their characteristics, taught from grade 1 to grade 4 of elementary school. This school uses picture books and blackboards as learning media. The teacher distributes picture books and explains the contents of the material in the books to students via the whiteboard. However, this still causes problems because mentally disabled students still experience a lot of confusion regarding the material presented. This is caused by the need for more information from books that only convey information through text and static images and the lack of motivation and interactivity to make students more active and involved during the learning process.

Using interesting learning media is necessary to increase children's interest in learning with special needs. A teaching and learning process that actively involves students can make delivering material easier because it can improve students' focus and memory of the material presented by the teacher [4]. Learning media in the form of the Augmented Reality Edugame (Educational Game) application can be an alternative method that makes the teaching and learning process easier and more enjoyable for students [5]. Augmented Reality (AR) is a technology that can enrich the user's view of the real world by adding new elements in the form of computer-generated images or audio, thus creating a mixed display between the real world and the virtual world [6][7]. This technology has been used in many fields, such as marketing, military, and education and can be used on mobile devices such as smartphones and tablets, which makes it very easy to access and use.

Good learning must contain inspirational, interactive, entertaining and challenging aspects to motivate students to participate actively [8]. Utilizing augmented Reality technology as a learning medium can increase students' interest and focus during the learning process because it contains entertaining, interactive aspects and involves student activity [9]. Apart from that, just like other learning media, AR Education can provide information and deliver material. In several case studies, it was found that Edugame succeeded in improving the quality of the learning process, such as learning with an augmented reality book application simulating animal breeding [8] and an augmented reality-based folklore learning application for deaf students [10], indicating that augmented reality game has succeeded in improving quality of the learning process.

Based on the analysis above, an educational application is needed to inspire, entertain, challenge, and increase students' interest in learning so that they stay energized and energized. This application can also be accessed via mobile devices such as smartphones or tablets, so students can use it at home with the help of their parents. This research created an application as a learning medium at SLB C YKB Garut, which introduced animal characteristics using augmented reality technology. This application utilizes augmented reality to display animals in three dimensions with animated movements, audio to display animal sounds, explanations of animal characteristics, and quizzes to challenge and test students' knowledge. With this application, it is hoped that students' understanding of animals and interest in learning more about animals will increase.

2. Research Method

This research was developed using the Multimedia Development Life Cycle (MDLC) methodology. This methodology has six stages: concept, design, material collecting, assembly, testing, and distribution [11]. The Work Breakdown Structure (WBS) diagram is used to clarify and structure the research and development process. Work Breakdown Structure (WBS) is a structured diagram that aims to keep activity components focused on research objectives by breaking down the project and grouping it into smaller components so that they are easier to manage [12][13] Work Breakdown Structure diagram shown in Figure 1.
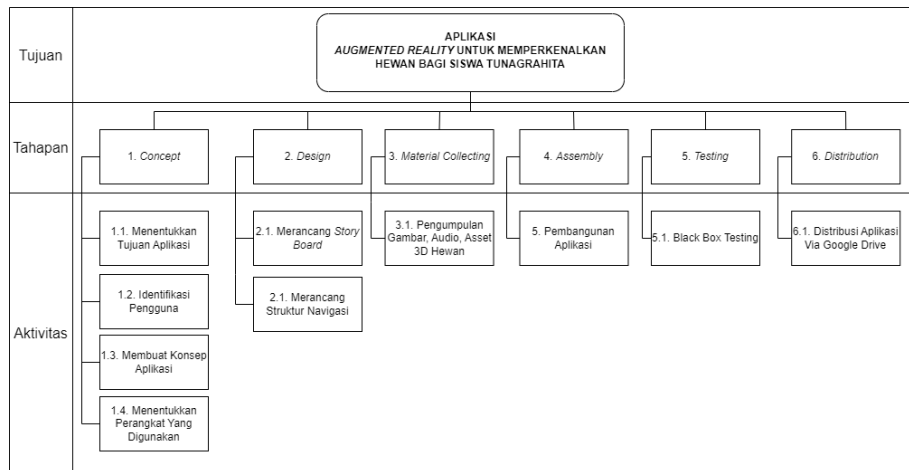
Figure 1. Work Breakdown Structure (WBS)

Based on the Work Breakdown Structure diagram in Figure 1, there are six stages and activities carried out in this research, as follows:

1) Concept Stage

At the concept stage, the first step is to determine the research objectives, identify the application's target users, determine the material that will be used in the application, and determine the minimum specifications required for the device to run the application.

2) Design Stage

At the design stage, specifications regarding the application theme, storyboard and navigation structure are designed. This specification is carried out so that the next stages, such as the material collecting and assembly stages, only need to follow the specifications that have been made.

3) Material Collecting Stage

At the material collecting stage, materials will be used in the application development/assembly process. These materials include pictures of animals that will be used as markers, animal sounds, and 3D animal model assets. This stage can take place simultaneously with the assembly stage to ensure that all the needed materials are available during the assembly stage.

4) Assembly Stage

At the assembly stage, a marker-based augmented reality application was developed to introduce animals to mentally disabled students using Unity3D software through the architecture, storyboard and navigation structure of the application designed at the design stage.

5) Testing Stage

After the development stage (Assembly), black box testing is carried out by running the application and testing all application functionality to ensure that when the application receives input from the user, the application will provide output as expected.

Next, a user validation test is carried out as a questionnaire. The questionnaire was distributed to several users, namely teachers at SLB C YKB, and the questionnaire results can be used as a reference for the success of the application that has been built. Analysis of application success is carried out by comparing the number of scores obtained with the maximum number of scores that have been determined [14], as in formula (1) below

$$P = \frac{f}{N} x 100\% \tag{1}$$

Information :

P = percentage of score sought

F = Score obtained by the examiner

N = Maximum score

Assessment of validation test results is based on degradation indicators, which can be seen in Table 1.

Table 1. Assessment Indicators

No	Value P	Category
1	0% - 20%	Very Bad
2	20.01% - 40%	Bad
3	40.01% - 60%	Enough
4	60.01% - 80%	OK
5	80.01% - 100%	Very good

6) Distribution Stage

At the distribution stage, the application format is changed to .apk so that it can be installed on the user's Android device. Then, it is distributed via the Google Drive link along with animal marker images. This link was shared with teachers and students at the C YKB Special School (SLB).

3. Result and Discussion

3.1 Results

This research follows the stages of the Multimedia Development Life Cycle (MDLC) method, which consists of six stages:

3.1.1 Concept

At this stage, activities are carried out to determine the purpose of the application, namely to introduce animals to mentally disabled students with augmented reality technology to make the learning process more interesting, entertaining and interactive. The user identification process was carried out by interviewing teachers at SLB C YKB, and researchers concluded that the target users for this application were students from grades 1 to 4 and parents. Based on the objectives and results of the interview, the results obtained regarding the application's functional requirements are presented in Table 2 below.

Table 2. Application Concept

No	Description	Specifications
1	Title	Implementation of Augmented Reality in Animal Introduction Learning for Intellectually Disabled Students
2	Target User	Teachers, Students in grades 1 to 4, Parents
3	Objective	Mengenalkan bentuk hewan dan karakteristiknya
4	Feature	Menu, augmented reality, zoom in/out of animal 3D models, quizzes, change animal animation movements, open/close animal characteristics, change background music, exit app
5	Media Type	Text, Audio, Images, 3D Objects in .fbx format, Animation
6	Interactivity	Displays 3D animal objects above the image, Navigate to the main menu, quiz menu, download marker image button, button to change animal animation movements, on/off button and change background music
7	Game Engine	Unity 3D
9	Software Development Kit	Vuforia
10	Minimum Device Specifications	Android 7.0 (Nougat)

3.1.2 Design

At this stage, a storyboard design is carried out to determine the actions of each application page. Designing a navigation structure to provide a flow description for each movement between pages [15]. A description of the storyboard design for the animal recognition application is presented in Table 3, and the navigation structure design is presented in Figure 2.

Table 3. Application Storyboard Design

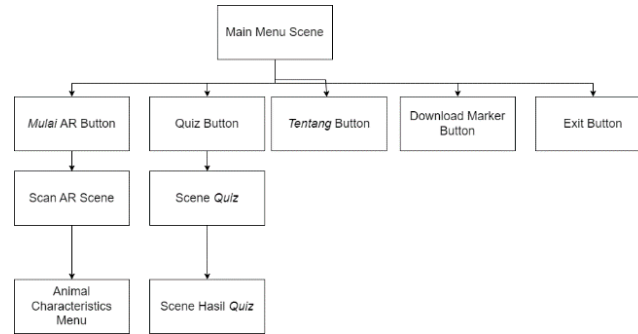| Scene	Scene Description
1	Main Menu Scene
2	Scan AR Scenes
3	Quiz Scene
4	D Scene Description download Marker

Figure.2. Navigation Structure

3.1.3   Material Collecting

The materials needed to build the application are collected at this stage, such as animal images, audio, and 3D animal models. The activities carried out and the materials collected will be explained as follows. The images collected are in .jpg and .png format. Animal images are used for quizzes and as markers that can be scanned via the application. The image material that was collected is presented in Table 4.

Table 4. Image Material

Scene	Description	Files
2 & 3	Animal Marker Images and Quiz	zebra.jpg, chicken.jpg, cheetah.jpg, crocodile.jpg, tiger.jpg, sheep.jpg, bear.jpg, dog.jpg, cow.jpg, gorilla.jpg, octopus.jpg, seagull.jpg, deer. jpg, rabbit.jpg, cat.jpg, komodo.jpg, frog.jpg, elephant.jpg, mouse.jpg, goat.jpg, bee.jpg, happyDog.jpg, goose.jpg, wolverine.png, sadDog.png
1	Main Menu Image	MainBg.jpg
1, 2, 3	Button Images	MainBtn.png,Green Btn.png, Exit Btn.png,Blue Btn.png, YellowBtn.png, PurpleBtn.png,star.png, Orange Btn.png
-	Application Logo	Icon.png

Audio is collected in .mp3 format, and the audio music obtained is used as background music to provide a more interesting experience and prevent users from getting bored quickly. A true or false audio signal will play on quizzes to indicate the app's response. The audio material that was collected is presented in Table 5.

Table 5. Material Audio

Scene	Description	File
1	1Scene Main Menu	Flow Of Time Natsukashi(Deebu).mp3
2	Scan AR Scene	BGM 1 Happy Ukulele l.mp3, Backsound Aesthetic Anima.mp3, BGM bee Forest.mp3
3	Quiz Scene	BGM bee Forest.mp3, Backsound Aesthetic Animal.mp3, BGM 1 Happy Ukulele.mp3, Flow Of Time Natsukashi(Deebu).mp3, incorrect soundEffect1.mp3, correct 1.mp3

3D animal models in .fbx format are collected via the internet; the collected 3D models are used to display animals in 3D form, and the animal models are placed on markers scanned by the application. The 3D model that was collected is presented in table 6.

Table 6. Animal 3D Model Materials

Scene	Description	File
2	Scan AR Scene	Goose.fbx, chicken.fbx, bear.fbx, crocodile.fbx, seagull.fbx, dog.fbx, cheetah.fbx, sheep.fbx, elephant.fbx, gorilla.fbx, octopus.fbx, tiger.fbx, goat. fbx, rabbit.fbx, frog.fbx, komodo.fbx, cat.fbx, bee.fbx, mouse.fbx, deer.fbx, cow.fbx, wolf.fbx, zebra.fbx

At this stage, the application development process begins using Unity3D software and integrating it with the Vuforia SDK. All materials that have been collected are imported into the project. There are five buttons on the main menu:

1) The "Start" button will move the page to the AR scan page.
2) The "Quis" button will move the page to the quiz page.
3) The "Download Marker" button will open the browser.
4) Students can download pictures of animals that have been used as markers.

The "About" button displays information about the app developer, and the "Exit" button closes the app. The main menu page display is shown in Figure 3

Figure 3. Main Menu Page

On the quiz page, students select the number of questions they want to answer, as shown (Figure 4.a). All questions are multiple-choice and randomized, as shown (Figure 4.b); after all questions have been successfully answered, the results page will be displayed as shown (Figure 4.c).

(a) Choice of Number of Questions

(b) Example Questions

(c) Quiz Results

Figure 4. View Quiz Page

Students can scan downloadable animal markers via the "Download Marker" button. The 3D animal model will appear above the scanned marker; the user can zoom in/out and rotate the animal model, change the animal movement animation using animation buttons, and mute/unmute background music, as shown (Figure 5.a). Displays the facts and characteristics of the animal being scanned as shown (Figure 5.b).

| (a) Wolf Marker Scanning Application | (b) Animal Characteristics PanelFigure |

Figure 5. View AR Scan Page

3.1.4 Testing

The testing stage was carried out using the black box method. Black box testing is carried out on applications to test and verify whether the application's functionality and features work as the researcher expects by conducting application test cases [16]. For each test case, input is given to the application by the researcher to verify whether the output provided by the application is as expected by the researcher. This trial aims to find errors in the application during the testing stage so that they can be corrected immediately. The results of the trial are presented in.

Table 7. Test Results

Feature	Test Case	Expected Results	Results
Scan AR	Click the "Start" button	Switch pages to AR Scan	Succeed
Quiz	Click the "Quiz" button	Switch page to Quiz	Succeed
Download Markers	Click the "Download Marker" button	Open a browser	Succeed
About	Click "About" Button	Displays Information About the Application Developer	Succeed
Show 3D animals	Scan Markers	Displays a 3D animal model above the marker	Succeed
Change animal animation	Touching animation button	Animal Changing Animation	Succeed
Show Animal Characteristics	Click the "Facts" button	Display Animal Characteristics Panel	Succeed
Mute/Unmute and Change Music	Click the audio button	Background music changes and mutes/unmutes	Succeed
Reset rotation and model size	Click "Reset rotasi" button	Animal size and rotation reset to default	Succeed

After testing the functionality and features of the application, a validation trial is carried out to find out how good the application is from the user's point of view. The trial was conducted on several users who are experts in technology and education. In this validation process, the application is tested in terms of content, content quality and comfort level in using the application. There are seven examiners with the composition: 1 Informatics lecturer from Yogyakarta Technology University, one expert teacher in the field of technology and five expert teachers in the field of SLB C YKB education; user validation results are shown in Figure 6.
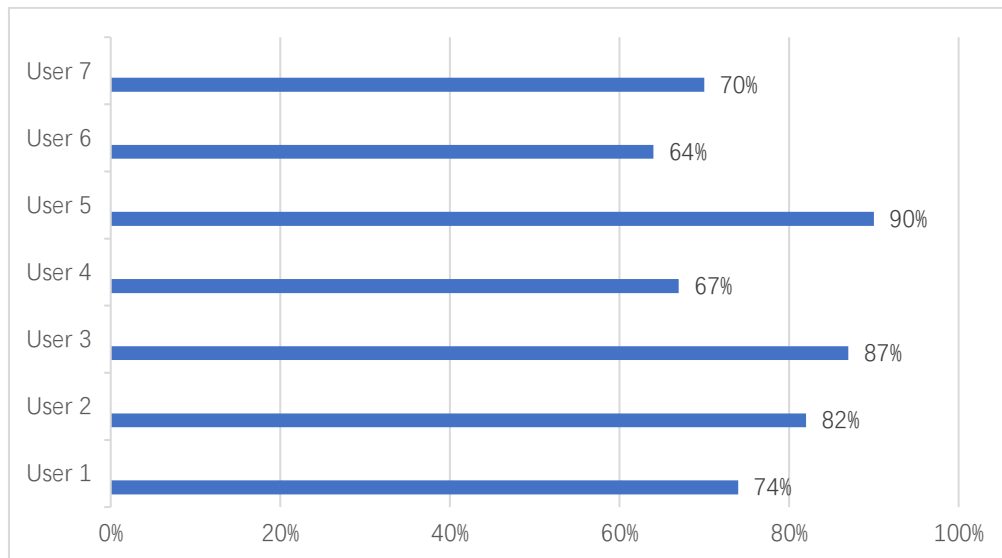
Figure 6. User Validation Results

Using equation (1), the average result from user validation is 76%. Based on the assessment indicators from Table 1, user responses to the AR application for animal recognition are included in the "Good" category; some users, especially SLB C YKB teachers, felt confused because they were not used to using the AR application and were a little uncomfortable because there were too many buttons at the time. scan markers.

3.1.5   Distribution

After the testing process and the application is deemed ready, the application will go through the distribution stage, where the application format will be changed to a .apk file. Then, the application and marker images will be distributed via a Google Drive link, which can be accessed and downloaded by teachers, students and parents at SLB C YKB Garut.

3.2. Discussion

This research shows that using AR technology in the education sector as an alternative learning media provides many benefits for students, teachers and parents. This application can increase students' interest in animals and reduce students' boredom in class by making students more active and involved in the learning process. In addition, students can test their knowledge of animals and their characteristics by playing quizzes. During the development process, the Unity 3D application was used to build the application; the programming language used C# and the Vuforia SDK to implement Augmented Reality technology into the application and turn 2D images into animal markers. The application has several main menus, such as Scan AR to scan markers and display 3D animals and explain their characteristics, a quiz menu to test students' knowledge about animals and their characteristics, and a download menu to download animal markers. The successful implementation of AR technology at the SLB C YKB school shows its potential to increase student interest in learning and student activity during the teaching and learning process.

4. Related Work

This research includes various previous studies on the implementation of Augmented Reality technology. For example, research by [10] utilized Augmented Reality technology to convey folklore in Indonesian language subjects for deaf students with sign language animation. Research by Rahayu & Setya (2021) built an animal recognition application for toddlers 4 – 6, using marker-based AR technology to display animals [17]. Another study from Sudarmayana *et al*, (2021) used marker-based AR technology to display animations of animals during breeding, animal growth from birth, and explanations via audio [8]. Then Sobarudin & Ary (2021) utilized markerless AR technology to introduce the names and shapes of objects, animals and letters in English to elementary school students [13]. Kamiana *et al.*, (2019) created an application system that implements marker-based AR technology to use books as markers to display various forms of viruses in 3D [6]. This related research shows the versatility of AR technology in education in increasing student interest and engagement in the learning process. This shows a growing trend of utilizing AR technology in the education sector.

5. Conclusion

This research succeeded in building a marker-based Augmented Reality application that can visualize animals in 3D form. Apart from Augmented Reality, this application also offers a quiz feature that can be used to test their knowledge about animals and their characteristics. From the results of user validation trials included in the "Good" category, it can be concluded that this application is suitable as an alternative media for learning about animals and their characteristics at SLB C YKB. However, in this research, there are still areas for improvement, such as the application, which can cause some users to feel uncomfortable and quickly overwhelmed due to unfamiliarity with augmented reality technology and too many buttons on the screen. In future research, a user guide feature in text form should be added to the application, images, or videos to guide users who are still unfamiliar with augmented reality technology and implement a better User Interface (UI) to overcome the problem of inconvenience and prevent users from being quickly overwhelmed.

References

[1]   Alisyafiq, S., Hardiyana, B., & Dhaniawaty, R. P. (2021). Implementasi Multimedia Development Life Cycle Pada Aplikasi Pembelajaran Multimedia Interaktif Algoritma dan Pemrograman Dasar Untuk Mahasiswa Berkebutuhan Khusus Berbasis Android. *Jurnal Pendidikan Kebutuhan Khusus, 5*(2), 135–143. https://doi.org/10.24036/jpkk.v5i2.594

[2]   Ananda Widhiyantoro, A., & Sumarno, A. (2020). Pengembangan Modul Cerita Rakyat Berbasis Augmented Reality Materi Teks Cerita Sederhana Mata Pelajaran Bahasa Indonesia Pada Siswa Tunarungu Di Slb Ab Kemala Bhayangkari 2 Gresik. *Jurnal Mahasiswa Teknologi Pendidikan*. Retrieved February 20, 2023, from https://virtual-class.unesa.ac.id/index.php/jmtp/article/view/36205/32180

[3]   Burghate, M. (2018, November). Work Breakdown Structure: Simplifying Project Management.

[4]   Dalim, C. S. C., Kolivand, H., Kadhim, H., Sunar, M. S., & Billinghurst, M. (2017). Factors Influencing the Acceptance of Augmented Reality in Education: A Review of the Literature. *Journal of Computer Science, 13*(11), 581–589. https://doi.org/10.3844/jcssp.2017.581.589

[5]   Fitriani, L., Destiani, D., & Muhtadillah, H. (2022, June). A Tourism Introduction Application Using Augmented Reality. *Jurnal Online Informatika, 7*(1), 56. https://doi.org/10.15575/join.v7i1.817

[6]   Kamiana, A., Kesiman, M. W. A., & Pradnyana, G. A. (2019). Pengembangan Augmented Reality Book Sebagai Media Pembelajaran Virus Berbasis Android. *Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika (KARMAPATI), 8*(2), 165. https://doi.org/10.23887/karmapati.v8i2.18351

[7]   Kiswati, S., & Chasanah, U. (2021). Perencanaan Manajemen Proyek Dalam Meningkatkan Efektifitas Kinerja Sumber Daya Manusia Di Semarang Jawa Tengah. *Jurnal Bina Sarana Informatika*, 1–7.

[8]   Kurniawan, Y. I., & Kusuma, A. F. S. (2021). Aplikasi Augmented Reality untuk Pembelajaran Salat bagi Siswa Sekolah Dasar. *Jurnal Teknologi Informasi dan Ilmu Komputer, 8*(1), 7. https://doi.org/10.25126/jtiik.0812182

[9]   Lubis, R., et al. (2023). Pendekatan Behavioristik untuk Anak Disabilitas Intelektual Sedang. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini, 7*(2), 1626–1638. https://doi.org/10.31004/obsesi.v7i2.4161

[10]   Mayasari, N. (2019). Layanan Pendidikan Bagi Anak Tunagrahita Dengan Tipe Down Syndrome. *Yinyang: Jurnal Studi Islam Gender dan Anak, 14*(1), 111–134. https://doi.org/10.24090/yinyang.v14i1.2847

[11]   Naba, C., Akbar, M. A., & Supianto, A. A. (2022). Pengembangan Permainan Edukasi Berbasis Augmented Reality untuk Pembelajaran Senyawa Hidrokarbon bagi Siswa Sekolah Menengan Atas (SMA). *Jurnal Teknologi Informasi dan Ilmu Komputer, 9*(3), 631–638. https://doi.org/10.25126/jtiik.2022935743

[12]   Rahayu, S., & Setya, A. P. P. (2021). Aplikasi Pengenalan Hewan untuk Anak Berbasis Android Menggunakan Teknologi Augmented Reality. *Jurnal Algoritma, 18*(1), 106–112. https://doi.org/10.33364/algoritma/v.18-1.848

[13]   Sobarudin, S., & Ary, M. (2021). Aplikasi Augmented Reality sebagai Media Pembelajaran Pengenalan Bahasa Inggris Berbasis Android untuk Anak Sekolah Dasar (Studi Kasus SDN 2 Kutanagara). *Infomatek, 32*(2), 107–114. https://doi.org/10.23969/infomatek.v23i2.4581

[14]   Sudana, A. A. (2015). Konsep Dasar Pendidikan Anak Berkebutuhan Khusus. Yogyakarta: Familia.

[15]   Sudarmilah, E., Supriyono, H., Fadlilah, U., Al Irsyadi, F. Y., & Fatmawati, A. (2018). Prototyping AR EduGame for children: learning Indonesian culture. *MATEC Web of Conferences, 197*, 03012. https://doi.org/10.1051/matecconf/201819703012

[16]   Sumarni, T., & Saputra, H. (2021). Implementasi Metode Marker Based Tracking Pada Augmented Reality Sebagai Media Pembelajaran Rumah Adat Tradisional (Studi Kasus : Sd Negeri Sindangjaya Cianjur). *Naratif Jurnal Nasional Riset Aplikasi dan Teknik Informatika, 3*(02), 25–29. https://doi.org/10.53580/naratif.v3i02.130.

[17]   Rahayu, S., & Setya, A. P. P. (2021). Aplikasi pengenalan hewan untuk anak berbasis Android menggunakan teknologi augmented reality. *Jurnal Algoritma, 18*(1), 106–112. https://doi.org/10.33364/algoritma/v.18-1.848

[18]   Sobarudin, ., & Ary, M. (2021). Aplikasi augmented reality sebagai media pembelajaran pengenalan bahasa Inggris berbasis Android untuk anak sekolah dasar (Studi kasus SDN 2 Kutanagara). *Infomatek, 32*(2), 107–114. https://doi.org/10.23969/infomatek.v23i2.4581

[19]   Kamiana, A., Kesiman, M. W. A., & Pradnyana, G. A. (2019). Pengembangan augmented reality book sebagai media pembelajaran virus berbasis Android. *Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika (KARMAPATI), 8*(2), 165. https://doi.org/10.23887/karmapati.v8i2.18351.