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Design of Augmented Reality-Based Food Chain Learning Media for Grade V Elementary School Students

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ABSTRACT

This study aims to produce a design of science learning media for grade 5 elementary school students regarding the food chain using an application made and based on Augmented Reality (AR). Multimedia Development Life Cycle (MDLC) is the method used in this study which consists of six stages, namely concept, design, material collecting, assembly, testing, and distribution. The subjects of this study were 5th grade elementary school students. Data collection techniques based on literature and literature. The software we use is Unity to create 2D or 3D objects by entering marker images into the vuforia engine database. After the application is built and tested on an android device, blackbox testing is carried out to assess software requirements and specifications. This design produces interactive learning media that is equipped with materials and supported by AR technology. The results of this study indicate that AR technology in grade 5 elementary school science learning media can be designed with more attractive and interactive visuals.

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1. INTRODUCTION

The interdependence between living organisms and their environment is an integral part of life within an ecosystem. In an ecosystem, there are interactions between different communities and their abiotic environment (Winiantari, 2022). For example, plants obtain energy from the sun, animals get their energy from plants, and green plants can produce their own food. This flow or cycle of energy is called a food chain, which represents the process of organisms being eaten and consumed in a specific order and direction. In this energy flow, the biotic components of an ecosystem, specifically producers, consumers, and decomposers, play three fundamental roles. Each level of a food chain is referred to as a trophic level (Retnowati, 2020).

The first or lowest trophic level is occupied by green plants, which are autotrophic organisms capable of producing their own food. The second trophic level is occupied by primary consumers, which are herbivores that feed on green plants. The third trophic level consists of secondary consumers, which are carnivores that feed on other animals, and so on. The organism occupying the highest trophic level is referred to as the apex consumer (Greenman et al., 2019)

In the current digital era, it is essential to transform the learning process from conventional/non-digital methods to digital learning media. The advent of online or distance learning has accelerated the transformation of education towards a digital landscape, where learning can be conducted anywhere, anytime, and in a more flexible manner (Muskania, 2021). However, in some elementary schools, the implementation of digital learning media as a tool to facilitate student understanding is still not well established. Some elementary schools still rely on non-digital learning media due to various reasons such as limited devices, lack of digital technology skills among teachers, and more. Yet, the use of learning media in the classroom plays a crucial role in the success of education. The utilization of learning media in the teaching and learning process can stimulate students' interest and motivation, and even have psychological effects on students (Rahman, 2017).

The current use of non-digital or conventional learning media in some schools leads to students easily getting bored, feeling sleepy, and seeking their own distractions during class (Puspitasari, 2019). Continued reliance on non-digital or conventional learning media may result in suboptimal learning outcomes. Especially when non-digital learning media is presented in a monotonous and simplistic manner, it can hinder students' full comprehension of complex topics like food chains in 5th-grade science class, which require visualizations, abstract concepts, and specific understandings to determine producers, consumers at different trophic levels, and decomposers. Therefore, it is crucial to package learning media in an engaging digital format to prevent student boredom and facilitate their understanding of the subject matter. In this regard, teachers need to be creative and innovative in creating captivating digital learning media that can motivate students to learn, enhance their understanding of the subject, and maximize the intended learning objectives. One of the emerging digital learning media is Augmented Reality (AR)-based learning media.

Augmented Reality is a technology that combines two-dimensional or three-dimensional virtual objects with the real environment, projected in real-time (Muntahanah et al., 2017). Augmented Reality (AR) technology is one of the potential digital technologies that can be developed and applied in education. Its ability to provide detailed visualizations supported by 3D animations makes AR technology suitable for the development of learning media (Hidayat, 2019). Augmented Reality-based applications create interactions between the real and virtual worlds, where all the information can be added, making the information appear interactive

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and real-time. The objective of using Augmented Reality in learning is to make the teaching and learning process, especially in elementary schools, more interactive and enable students to easily understand the subject matter (Usmaedi, 2020). The use of Augmented Reality-based learning applications can be an effective interactive medium to introduce topics related to Natural Sciences (IPA) and stimulate children's imagination, thereby motivating them to learn. Students find it easier to grasp the learning content when they can directly interact with it, rather than just listening to explanations from teachers.

Augmented Reality (AR) has several advantages and disadvantages. Some of the advantages include being more interactive, effective in usage, widely implementable across various media, having simple object modeling as it displays only a few objects, being cost-effective, and easy to operate. On the other hand, the disadvantages of Augmented Reality include sensitivity to changes in the viewing angle, a limited number of creators, and the requirement of substantial memory on the installed devices (Mustaqim, 2017). Despite these limitations, the use of AR media can make learning more engaging and provide an effective solution to enhance learning efficiency (Golonka et al, 2014).

Previous research on Augmented Reality-based learning media has been conducted, covering various educational levels and perspectives. For instance, a study by (Putra et al., 2022) titled "The Implementation of Augmented Reality Technology-Based Android Application for Food Chain Learning in Animals" demonstrated that AR-based technology can be used in teaching food chain concepts, with an Android application serving as a helpful tool in the learning process. Similarly, a study by (Wardana, 2016) concluded that Augmented Reality-based learning media for food chains can attract students' interest in learning biology. Development of learning media is necessary to facilitate students in understanding abstract concepts related to food chains. Furthermore, a study by (Qorimah et al., 2022) indicated that teachers and students are interested in using Augmented Reality (AR) media as a solution to enhance learning, particularly in the context of food chain topics. The use of such media can facilitate students' understanding of abstract concepts related to food chains.

Based on the above information, the researcher is interested in conducting a study titled "Designing Augmented Reality-Based Learning Media for Food Chains in 5th Grade Elementary School Students." The objective of this research is to develop AR-based learning media for 5th-grade elementary school students in the subject of Science, specifically focusing on the topic of food chains. This research is important as it can assist teachers in preparing the younger generation to compete in the midst of globalization and serve as an innovative technology-based learning approach for elementary school students. Additionally, this study can contribute to the reference material for the development of digital learning media in elementary schools.

2. METHODS

The method used in our research is the Multimedia Development Life Cycle (MDLC) method. According to Soetopo in (Borman & Purwanto 2019), there are six stages in the MDLC method: concept, design, material collecting, assembly, testing, and distribution. These are the stages of MDLC **Figure 1**.

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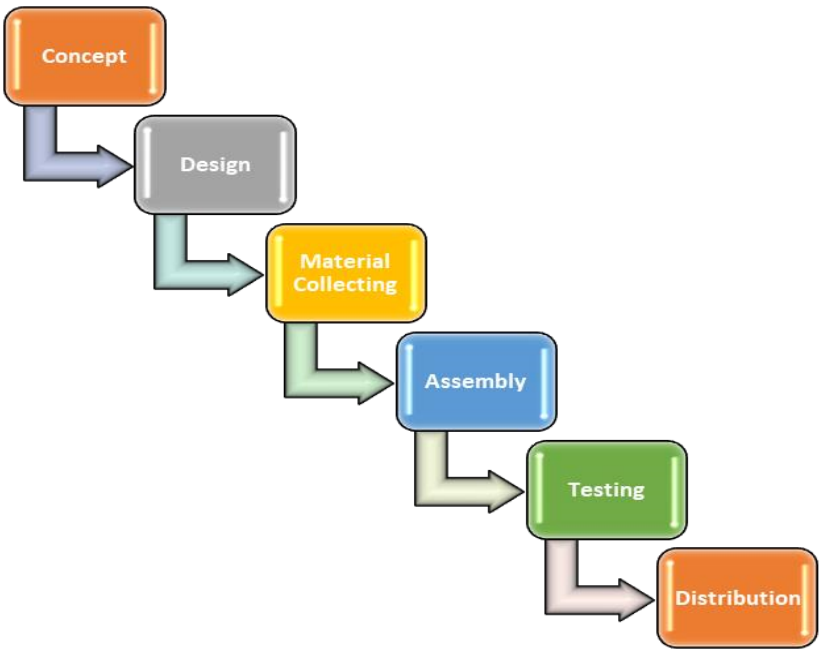

Figure 1. MDLC stages.

The six stages of the Multimedia Development Life Cycle (MDLC) are as follows: 1) Concept stage: This involves developing a concept for the application. The concept includes determining the objectives of the Augmented Reality (AR) based learning media application and the target users. The purpose of creating this application is to make it easier for users to understand the subject matter and to enhance their creativity. The target users for the application are fifth-grade elementary school students, and the media developed is based on the Android platform. 2) Design stage: This stage involves designing the application, including the visual style and the materials required for the development process. The application design utilizes a navigation structure that shows the relationship between menus within the application. 3) Material collecting stage: In this stage, the necessary materials are collected for the application development, such as 2D images, 3D images for creating AR markers, audio files to make it more engaging, and other supporting materials. 4) Assembly stage: This stage involves the actual development of the application using tools like Unity, Vuforia engine, and Lean Touch. The Vuforia engine contains a database of images used to create AR markers, while Lean Touch is used to add effects to 3D objects, such as zooming and rotation. The commands for buttons or interactive elements are implemented using C#. In this stage, the materials collected earlier are assembled to create the application. 5) Testing stage: This stage involves testing the developed application to ensure its proper functioning. The goal of testing is to determine whether the application works correctly. Blackbox testing, which focuses on the input and output of the software system without knowledge of its internal structure, is used during this stage. The testing is conducted by the system developer. 6) Distribution stage: This stage involves storing the application in a suitable media format that can accommodate the application.

Blackbox testing, mentioned in stage 5 (testing), refers to a testing approach where the system requirements and specifications are evaluated by examining inputs and outputs without knowledge of the internal workings of the program. From the tester's perspective, blackbox testing is represented by **Figure 2**.

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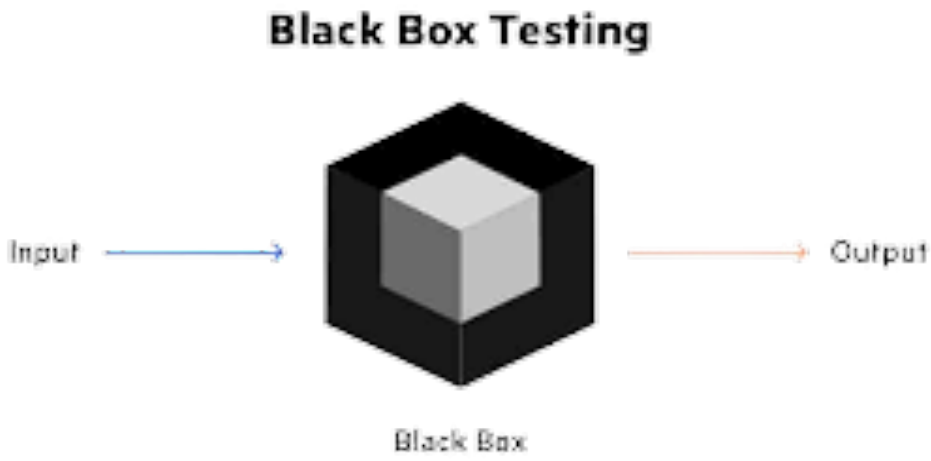

Figure 2. Blackbox testing.

3. RESULTS AND DISCUSSION

The initial stage of research begins with modeling the system in the form of Unified Modeling Language (UML). The UML used is Use Case Diagram and Activity Diagram.

3.1. Use Case Diagram

The use case diagram is a modeling technique used to design an information system. It represents the interactions between users and the system (Hendrastuti, 2021). In this case, the use case diagram is used to depict the interaction between the user and the application designed for fifth-grade elementary school students, with a simple menu layout for easy understanding. The application provides a single "Play" button, which leads to the information page. The information page contains several buttons, each accompanied by a description of its function or purpose. After pressing the "Next" button, the user is directed to the main menu page, which offers five menus: "Food Chain Definition," "Producers," "Consumers," "Decomposers," and "Food Chain Examples." Additionally, there is a "Developer Profile" menu. The use case diagram as shown in **Figure 3** represents these interactions and components of the system.

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Figure 3. *Use Case* diagram.

3.2. Activity Diagram

The activity diagram is a diagram that depicts the flow of activities in a designed system. It illustrates various activity flows within the software system being designed (Ismai, 2020). There are two activity flows depicted in the diagram. The activity flow specifically related to Augmented Reality (AR) **Figure 4**.

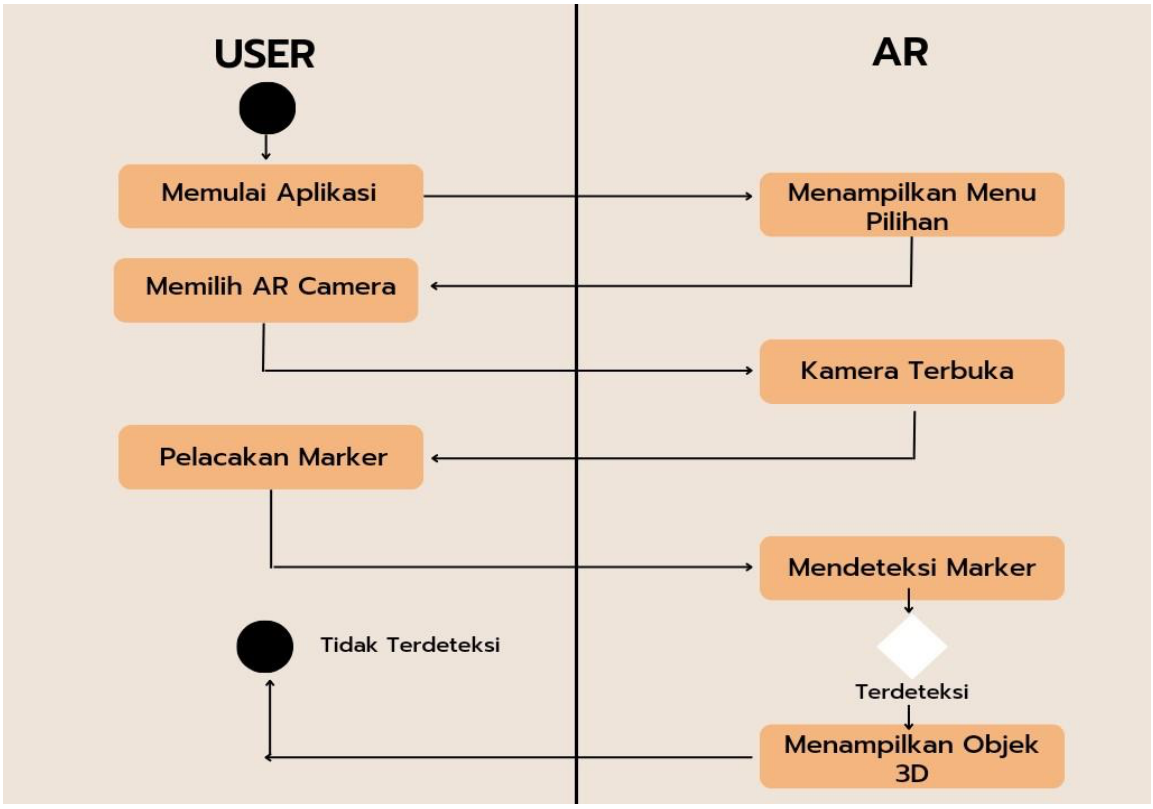

Figure 4. *Activity* diagram.

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3.3. Design Phase

The concept phase is the stage where the objectives and users of the application are determined. The target users for this food chain application are 5th-grade elementary school students. The goal of this food chain application is to enable students to utilize AR technology as a learning media by utilizing the camera on their Android devices.

The next phase is the design phase. The food chain learning application for 5th-grade elementary school students has been successfully designed. First, the design process starts by creating the system interface, which begins with pressing the play button on the opening page **Figure 5.**

Figure 5. Front page.

Second, the design includes the information page of the food chain learning application. On this information page, there are several explanations of the functions of the buttons that will be used in the application. These buttons include the play button, next button, back button, home button, developer profile button, food chain definition button, consumer button, producer button, decomposer button, and example of food chain button **Figure 6.**

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Figure 6. Information page interface.

Third, the design includes the main menu page that contains 5 menu options: food chain definition, producer, consumer, decomposer, and example of food chain. In this main menu page, there are also back and developer profile buttons. The back button is used to go back to the previous page. Meanwhile, the developer profile button contains the identity of the team who developed this application **Figure 7**.

Gambar 7. Main menu interface

Fourth, the design includes the developer profile page that contains the identity of the team who developed this application. This page is equipped with a home button that functions to go back to the main menu page **Figure 8**.

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Gambar 8. Developer porfile page interface.

Fifth, the design includes the food chain definition page. This page will appear when the student presses the "pengertian rantai makanan" button on the main menu page. The food chain definition page is also equipped with a home button and a back button as shown in **Figure 9**.

Gambar 9. Food chain definition page.

Sixth, the design includes the food chain classification page. This page will appear when the student presses the "next" button on the food chain definition page. The food chain classification page includes a back button and a home button as shown in **Figure 10**.

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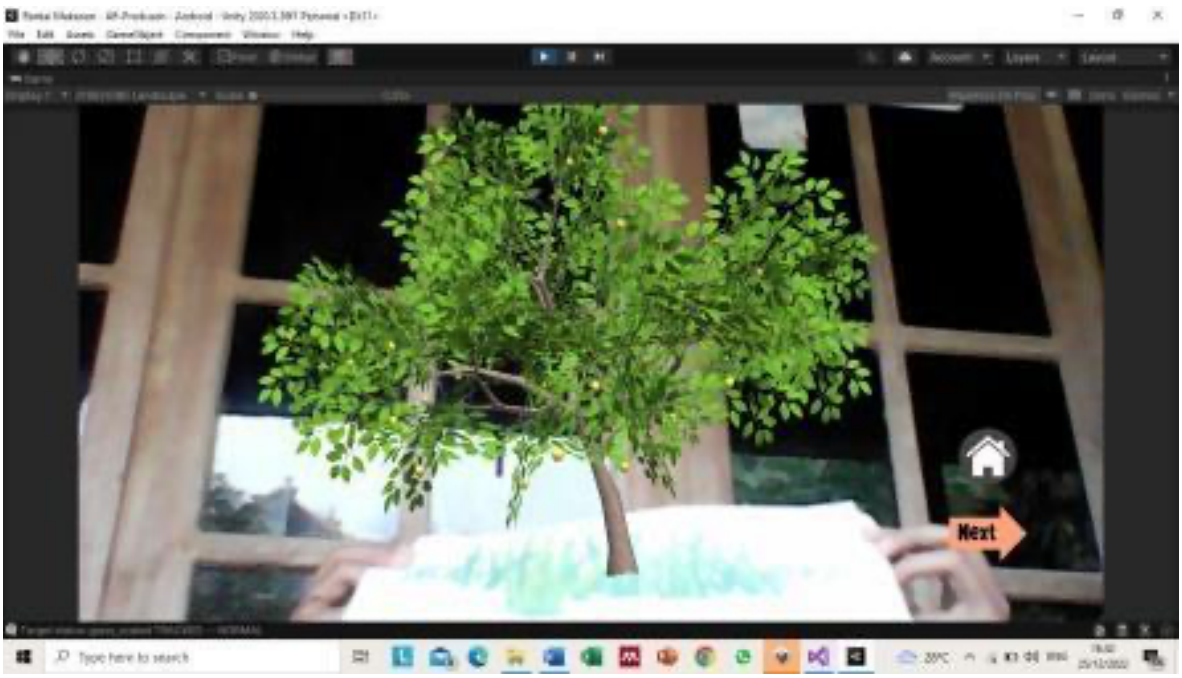
Gambar 10. Food chain classification page view.

Seventh, the design includes 3D objects in the application for the topics of producers, consumers, and decomposers. These 3D objects will appear when the student presses one of the buttons for producers, consumers, or decomposers. The 3D objects will be triggered by scanning marker images of plants and animals, specifically a tree marker for producers, an eagle marker for consumers, and a mushroom marker for decomposers. The scanned result will display the objects visually in 3D, creating a realistic experience as shown in **Figure 11-13**.



Gambar 11. Augmented reality 3D objects: trees.

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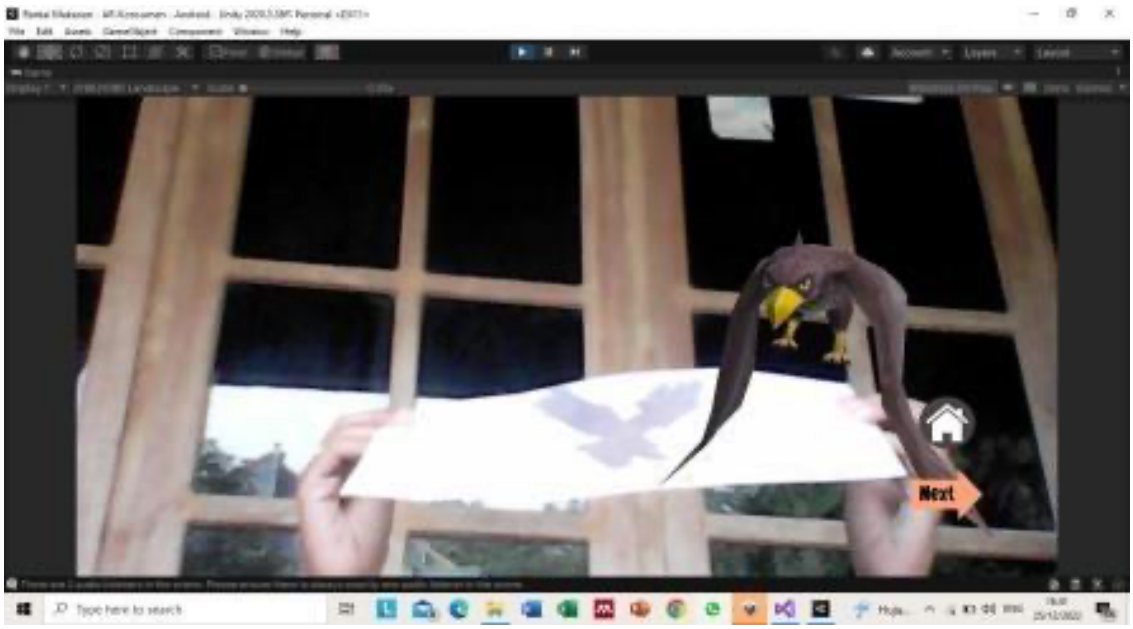
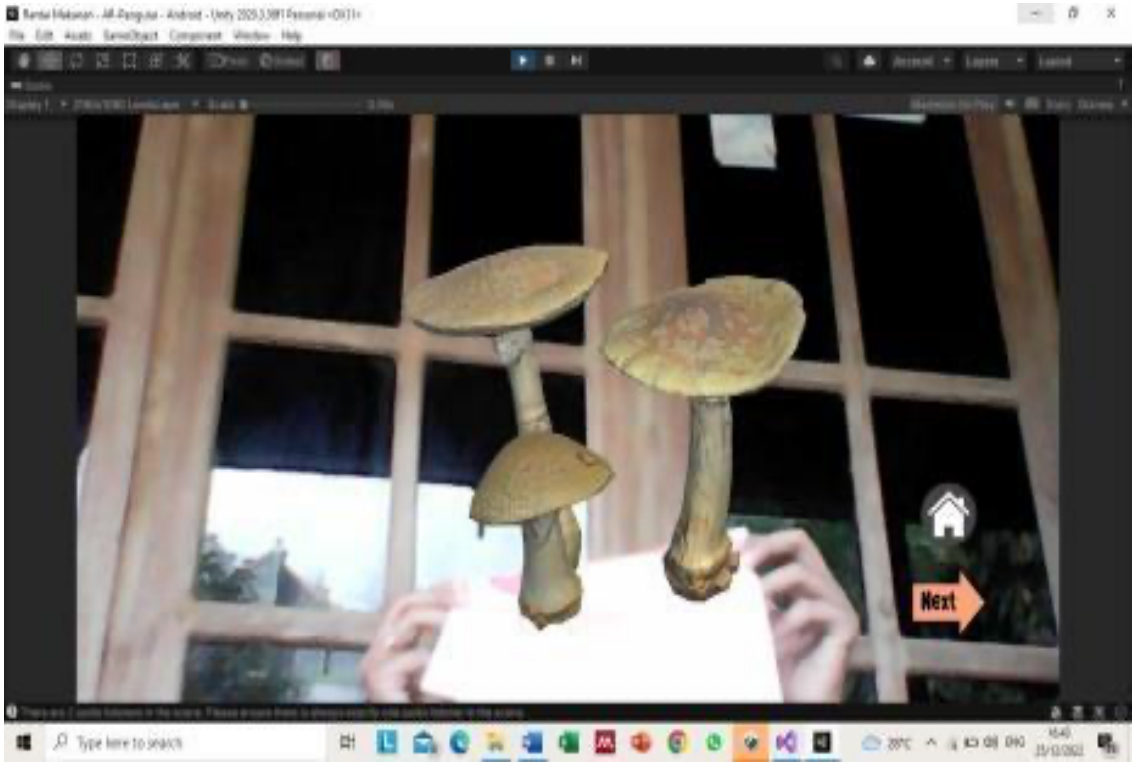


Gambar 12. Augmented reality 3D objects: eagle



Gambar 13. Augmented reality 3D objects: mushroom.

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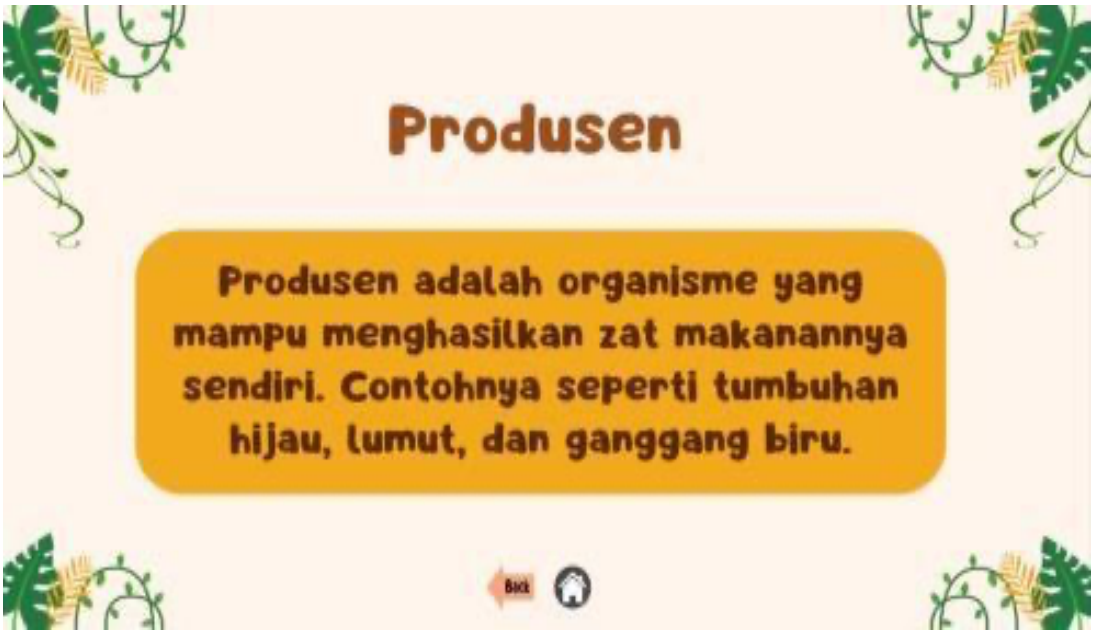
Eighth, the design of the producer, consumer, and decomposer material page. This material page will appear when students press the next button after scanning an object image from one of the producer, consumer, or decomposer materials. This material page is also equipped with a back button and home button as shown in **Figure 14-16**.

Gambar 14. Producer material.



Gambar 15. Consumen material

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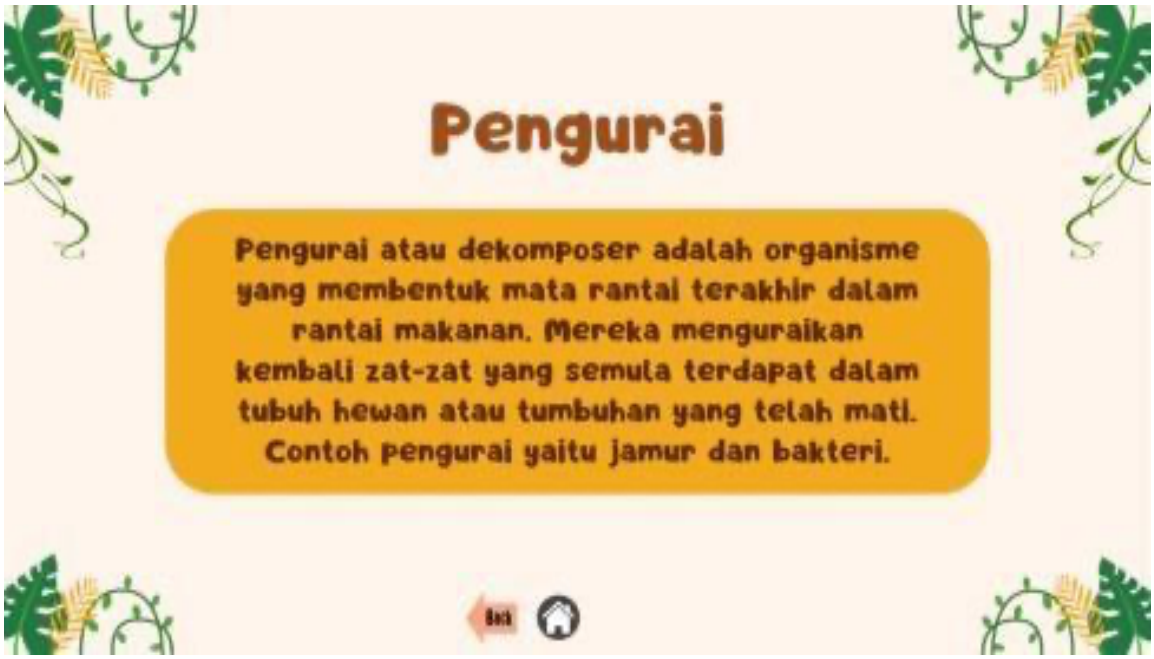

Gambar 16. Decomposer material

Ninth, the design includes the page for the example of a food chain, which appears when the student presses the "Contoh Rantai Makanan" button on the main menu. The food chain page consists of two sections: an example of a food chain in a rice field ecosystem and an example of a food chain in a marine ecosystem. The page is equipped with buttons for navigation, including "Back," "Next," and "Home," as shown in **Figure 13**.

Gambar 13a. Food chain in rice field ecosystems

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Gambar 13b. Food chain in marine ecosystems

Lastly, the design includes the closing page. The closing page is equipped with a "Home" button that allows the user to return to the main menu as shown in **Figure 14**.

Gambar 14. Closing page interface.

3.4. Blackbox Testing

Blackbox testing is a testing technique that focuses on the functional specifications of the software without knowledge of its internal structure (Jaya, 2018). The results of blackbox testing on **Table 1** shows the input and output of the designed system, which operates normally and meets the requirements. This testing was conducted on all the designed application menus, and the results were based on the perspective of the system developer. The application testing process was performed using an Android device with Android version 11, MIUI 12.5.4, and a screen resolution of 1080 x 2400 pixels.

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Table 1. Blackbox Testing.

Testing Scenario	Test Case	Expected Results	Test Result	Conclusion
Open app info	Displaying info, click play button	The info page is successfully displayed	Match	Normal
Open main menu	Display the main menu, click the next button	The main menu page is successfully displayed	Match	Normal
Open developer profile	Featuring profile developer. Click the profile buttin developer	Developer profile page successfully displayed	Match	Normal
Open the meaning of food chain page	Featuring understanding of food chains, click the food chain button, button on the main menu page	Understanding page food chain page successfully displayed	Match	Normal
Open food chain classification	Displaying food chain classification, click *next* on the meaning of food chain page	Page classification food chain page successfully displayed	Match	Normal
Unlock and detect AR cameras from producer materials	Pointing the AR camera to an available marker, click the producer button	3D Object successfully displayed	Match	Normal
Open producer materials	Displaying the manufacturer material, click the next button on the page AR manufacturer page.	The producer material page is successfully displayed	Match	Normal
Opens and detects AR cameras from consumer materials	AR camera to available marker, click consumer button	3D Object successfully detected	Match	Normal
Open decomposer material	Displaying decomposer material, click the next button	Decomposer material page Successfully displayed	Match	Normal

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Testing Scenario	Test Case	Expected Results	Test Result	Conclusion
	on the page AR decomposer page			
Opens food chain example	Display examples of food chains food chain in the ecosystem rice field ecosystem, click the example button on the main menu page	The food chain example page in the rice field ecosystem was successfully displayed	Match	Normal
Opening example of a food chain in marine ecosystems	Display an example of a food chain food chain in marine ecosystem, click the next button on the food chain example page food chain in the marine ecosystem	Food chain example page in marine ecosystem ecosystem was successfully displayed	Match	Normal
Opens the closing page	Display the page page, click the next button button on the example of a marine ecosystem food chain	Closing page Successfully displayed	Match	Normal
Returns to main menu page	Displays main menu page click next	Main menu page Successfully opened	Match	Normal

4. CONCLUSION

Based on the results of the blackbox testing conducted, it has been shown that the design of the 5th-grade elementary school Science multimedia learning media in the form of a food chain application with Augmented Reality (AR) technology is proven to be usable and functioning normally. This food chain application can be accessed through an Android device. The availability of this application is expected to make learning more engaging and interactive for students, as it incorporates animations and visualizations of the subject matter using AR technology.

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5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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