






Development of Augmented Reality Based Learning Applications in Introducing Types of Animals after the Covid-19 Pandemic

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Abstract: Augmented Reality is a trending topic in the industrial era 4.0, utilized in all areas of society. The existence of Augmented Reality is currently a major requirement for companies, hospitals, and even in the field of education. The COVID-19 pandemic has changed learning methods in Indonesia from face-to-face learning to information technology-based learning. During the COVID-19 pandemic, the learning process was carried out online (online) to break the spread of the COVID-19 virus. This condition causes the education sector to think hard about delivering existing material so students can better understand the material. One way that can be done is to develop game-based learning applications. Researchers develop learning applications based on augmented Reality to introduce animals based on augmented Reality using extreme programming models. The application has been implemented and tested by 54 students with a score of 85.3% based on the usability factor of ISO 9126-3, which means that the application is very useful for Ribath Darut Tauhid madrasah students in studying animal introduction material. Learning applications have been applied to Islamic elementary schools. From the results of the pre-test and post-test, it was found that the application was able to improve students' abilities between 13% and 75%.

1 INTRODUCTION

The development of information and communication technology is currently developing very rapidly (Tanaamah & Indira, 2021). At the same time, people's lives have changed from traditional to digital with the use of information and communication technology in everyday life (Nugroho et al., 2021). Innovation is the key to the digital globalization of information and communication technology (Zhu et al., 2023). Information and communication technology support in people's lives can be found on computers, mobile devices, robots, and even virtual Reality or augmented Reality. Its use can be seen in

industrial education (Grossard et al., 2023). Collaboration between developers and end-users is required in the utilization and development of information and communication technology (Longo et al., 2023).

Augmented Reality is a trending topic in the industrial era 4.0, utilized in all areas of society. Augmented Reality is currently a major requirement for sales companies (Rauschnabel et al., 2022), hospitals, agriculture, and even in education. Caudell and Mizell first introduced the initial concept of Augmented Reality in 1992 (Liao, 2016), for more than 60 years, Augmented Reality (AR) has experienced its journey where AR allows the creation

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of objects that cover physical objects in real-time (De Lima et al., 2022). Augmented Reality allows users to see 3D objects using a smartphone device. Augmented reality technology is one of the innovations in computer vision that can improve user perception and interaction with the real world (Andayani et al., 2020). Augmented Reality is one of the most advanced technologies in the virtual world, which is very effectively used in the learning process. Augmented Reality can be utilized in formal and non-formal education (Rusli et al., 2023).

The COVID-19 virus is a virus that attacks human respiration and spreads very quickly between humans (Rachman, 2021). COVID-19 stands for Coronavirus Disease 2019, which attacked humans for the first time at the end of 2019 in Wuhan, China (Putri et al., 2023). Officially the COVID-19 virus attack was declared a pandemic by the World Health Organization (WHO) in March 2020 (Shobe et al., 2023). The COVID-19 attack caused the Indonesian state to impose Large-Scale Social Restrictions (PSBB) (Anugerah et al., 2021). The implementation of the PSBB has affected all activities by reducing gatherings and maintaining distance between people (Pontoh et al., 2021). One affected is the education sector, where the teaching and learning process cannot be carried out face-to-face (offline) but must be done online (Aziz et al., 2022).

Madrasah Ibtidaiyah (MI) Ribath Darut Tauhid is one of the Islamic schools on Jl. Nambangan Perak 89, Surabaya, East Java. MI is a school equivalent to Elementary School. In its learning process, MI Ribath Darut Tauhid still uses the traditional (face-to-face) learning model. When the implementation of PSBB MI Ribath Darut Tauhid experienced difficulties delivering material online, one of the materials was an animal introduction for class III students. Teachers have difficulty conveying material with online teaching conditions and knowing children's ability to receive the material.

The researcher developed an animal recognition learning application based on augmented reality from the problems above.

2 METHOD

In this study, we focused on developing an augmented reality-based animal recognition application for grade III elementary school children. The research methodology that we have developed is as shown in figure 1, where there are five methods that the researchers carried out, namely Idea Validation using Merapi Analysis Framework (MAF), Pre-Test,

Application Development using Extreme Programming model, Post-Test, and the last step is the Application Feasibility Test using ISO 9126-3 for Usability Factor.

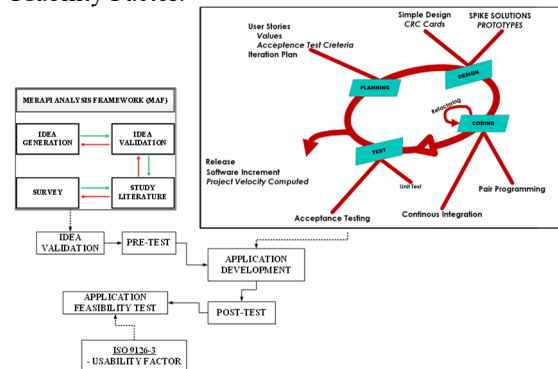


Figure 1: Design research methodology augmented reality.

2.1 Idea Validation Using MAF

Researchers use Idea Validation to determine whether a research idea can be implemented. Researchers carried out idea validation using the Merapi Analysis Framework (MAF). There are four steps taken: Idea Generation, Idea Validation, Literature Study, and Survey. In idea generation activities, researchers put forward ideas that are used in research, namely:

1. During this pandemic, schools had difficulty carrying out the teaching and learning process online.
2. During the COVID-19 era, it is certain that every student has a smartphone that can be used to access learning materials and access the internet.
3. What if we develop a learning application based on augmented reality with the advantage being that the material is delivered in 3D.

After the **idea generation** activity, the researcher proceeded to the second step by carrying out the **idea validation** activity. In this activity, the researcher ascertains whether the research plan can be carried out by looking at the target users or the target users of the research. In this case, the application users are elementary school students. **Literature study** is the next step in MAF. The researcher conducted a literature study on the material discussed in this activity. The study relates to engine literature, programming languages, and game development tools. Besides that, the next literature collected is on application development models in software engineering. The fourth step in MAF is **Survey**. Researchers surveyed according to the available material by visiting several schools that application developers targeted. Researchers surveyed 5

elementary schools or equivalent. Of the five schools targeted, two schools are interested in becoming partners in developing augmented reality applications. From the two schools, it turned out that the one who was pleased with the research topic was Madrasah Ibtidaiyah Ribath Darut Tauhid.

2.2 Pre-Test

The Pre-Test is an activity carried out by researchers to get students' abilities about the material developed by researchers, namely about animal recognition.

Table 1: Instrument pre-test development of educational game.

NO	QUESTION
1	What senses does the Sumatran tiger have?
2	What do iguanas eat?
3	Whale belongs to what class of animal?
4	What cats don't eat is?
5	What are the characteristics of birds?
6	Where is the giraffe's original habitat?
7	How many tusks are there in an elephant?
8	What kind of animal is in the picture beside?
9	What is cowhide usually used for?
10	Goats are animals that produce?

2.3 Application Development

In the application development section, researchers use the extreme programming model. The Extreme Programming model has five major activities: Planning, Design, Coding, Test, and Release. At the Planning stage, the researcher met with the school to discuss the application developed through user stories to get user needs. The researcher carried out the design stage in connection with the prototype of the augmented reality application, which was developed according to its main purpose. The third stage is Coding. This stage aims to realize the application designed as a prototype in the design section. The fourth stage is Testing; in this stage, the researcher tests the software from the smallest parts (units), which produce tests that the customer can accept. These four stages are repeated until the application results meet the user story's needs. When finished, then enter the application release stage.

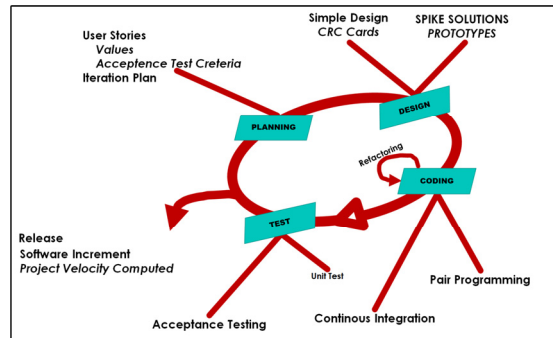


Figure 2: Extreme programming for developing augmented reality.

2.4 Post-Test

The Post-Test stage is the stage where the end-users of the target users are tested concerning the existing material. The Post-Test Mater is the same as the material in the Pre-Test. Still, the difference is that the Post-Test Activities are carried out after the end user uses the application. In contrast, the pre-test students do not use the application because the application has not been developed. A good result is whether the value obtained is better results or the same as the pre-test.

2.5 Application Feasibility Test

The Application Feasibility Test was carried out by researchers using the Usability Factor from ISO 9126-3, where there are five sub-factors assessed: understandability, learnability, operability, attractiveness, and usability compliance. The feasibility test process is carried out by sending questionnaires to application users. Applications are rated for each sub-factor by users from 1 to 5 on a Likert scale.

3 RESULT AND DISCUSSION

3.1 Result

This research uses the MAF framework and the Extreme Programming application development model to develop an augmented reality-based animal recognition learning application.

3.2 Target User

Based on the MAF stages, the target users of the animal recognition learning application are class III students from Madrasah Ibtidaiyah Ribath Daruth

Tauhid. There are two classes III which are the target users, namely Class 3A and Class 3B. This study's total number of users was 54, with details: of 27 students in Class 3A and 27 students in Class 3B.

3.3 Educational Game Application

The educational game application developed by researchers uses the Extreme Programming model.

3.3.1 Stage 1 – Planning

At the planning stage, the researcher carried out four actions, namely carrying out four activities, namely, user stories, values, acceptance test criteria, and iteration plan.

3.3.2 User Stories

In the user stories section, the researcher interviewed third-grade students regarding the expectations of students as users. From the results of these interviews, it was found that there were 9 wishes of class III students regarding the animal introduction augmented reality educational game, as shown in Table 2.

Table 2: User stories educational game introduction to animals.

CODE	USER STORIES
US1	As a student, I want to enjoy an interesting look at augmented reality games
US2	As a student, I can see the diversity of animals in augmented reality games
US3	As a student, I can learn by playing augmented reality games
US4	As a student, I can interact and control animal characters in augmented reality games
US5	As a student, I want augmented reality games to be able to display interesting gameplay
US6	As a student, I want an augmented reality game to be able to distinguish between different types of animals
US7	As a student, I want an augmented reality game to be able to replace Indonesian or English
US8	As a student, I want an augmented reality game to be able to clearly display animal descriptions
US9	As a student, I want augmented reality games to make it easier for players to answer quiz questions.

3.3.3 Value

In this section, the researcher communicates with the teacher as a team of material experts regarding the application features developed by the researcher. Application features prioritized in application development according to user stories are in the order CODE US3, US6, and US8 get the highest priority. Namely, a value of 5 means the most priority. CODE US1, US2, and US5 get high priority, which is worth 4, meaning it takes precedence. For CODE US4, US7, and US9, they get a fairly high priority, namely a value of 3 means that it must be considered.

3.3.4 Acceptance Test Criteria

Acceptance Test Criteria are the criteria used for test acceptance concerning existing user stories. The Acceptance Test Criteria referred to are in table 3.

Table 3. Acceptance test criteria in animal introduction educational game user stories.

CODE	ACCPTANCE TEST CRITERIA
US1	Games must be able to provide an attractive and colorful display
US2	Games must contain a variety of animals that can be played and introduced to students
US3	Games must be able to contain a wide variety of animals, food, sounds, and pictures of animals
US4	Games can move animals or control animals
US5	Games can display animal images, text information about animals, and animal audio
US6	Game gives players choose the type of animal
US7	The game has a language switching feature
US8	Games can provide information about animals
US9	Games provide guides, information, tutorials about quizzes.

3.3.5 Iteration Plan

The researcher divides application development activities into two iteration plans in this section. The first iteration focuses on system development for developers and teachers, and the second iteration is

on system development for students, as shown in figure 3.

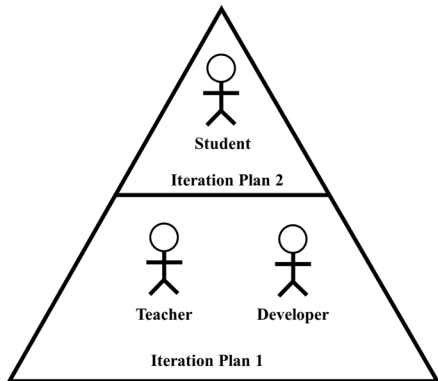


Figure 3: Iteration plan development of educational game.

3.3.6 Stage 2 – Design

At the design stage the researcher carried out two main activities namely Simple Design and CRC Cards, and Spike Solution and Prototypes.

3.3.7 Simple Design and CRC Cards

Researchers carry out the application design process in the simple design section by developing application features. For this reason, the researcher used a case diagram to develop an augmented reality-based animal recognition educational game application.

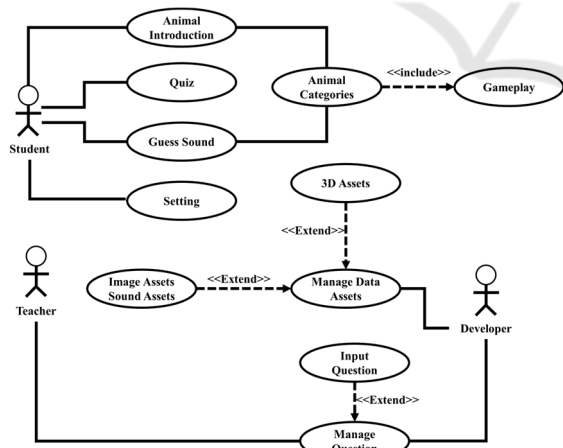


Figure 4: Use Case Diagram Educational Game Introducing Types of Animals.

Figure 4 shows that the teacher and developer features become one level of importance before researchers develop features for students. The student feature is the biggest part of existing user stories—armed with user stories that have been evaluated,

interesting learning features formed for third-grade students.

Researchers assign responsibilities to each team in the CRC Card (Class, Responsibilities, and Collaboration) section. There are ten researchers with a division of responsibilities, as shown in Table 4. There are four job functions in the research, namely game design and development (CRC1), application system design (CRC2), game tester (CRC3), and quality control (CRC4). The highest number of teams and game testers are in game design and development (figure 5)

Table 4: CRC card educational game introducing of types of animals.

ID	NAME	CODE CRC	JOB DESCRIPTION
TI1	Andy Rachman	CRC1	Game Design and Development
TI2	Sulistyowati	CRC2	Application System Design
TI3	Rachman Arief	CRC3	Game Tester
TI4	Nanang Fakhur Rozi	CRC4	Quality Control
TI5	Zakky Fatahilih Hasan	CRC1	Game Design and Development
TI6	Ach. Khafid Salim	CRC2	Application System Design
TI7	Mohadi	CRC1	Game Design and Development
TI8	Yusuf Effendi	CRC4	Quality Control
TI9	Marsetya Aditia Arifiandi	CRC3	Game Tester
TI10	Ahmad Hafid Holy Saputra	CRC3	Game Tester

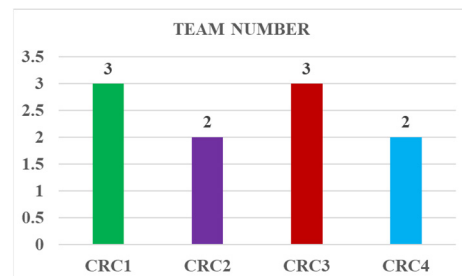

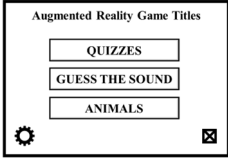
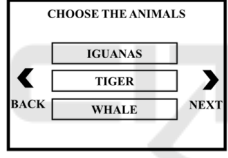
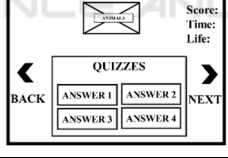
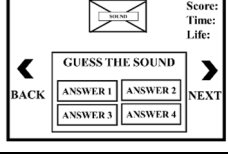
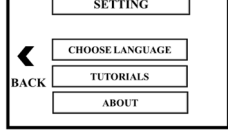


Figure 5: Team number of development educational game introducing of animal types.

3.3.8 Spike Solution and Prototypes

In the spike solution and prototypes section, the researcher developed an augmented reality prototype. In the development of augmented reality games, researchers divide it into seven main sections: the splash screen, main menu, choose the animal menu, quizzes menu, guess the sound, types of animals, and setting menu

Table 5. Spike Solution and Prototypes of Educational Game Introducing of Types Animals.

BOARD	PROTOTYPE	FUNCTION
Splash Screen		Splash Screen Game
Main Menu		Main Menu Game Augmented Reality
Choose The Animal		Menu Choose The Animal
Quizzes		Menu Quizzes Game Augmented Reality
Guess The Sound		Guess The Sound Game Augmented Reality
Setting		Setting Game Augmented Reality

3.3.9 Stage 3 – Coding

In this section, the researcher is coding an educational game application using the C# language. The game engine used is UNITY. In application development, the markers used by researchers are of the Marker Based Tracking type. The tool used to map markers

are the Vuforia SDK. TI1, TI5, and TI7 in pair programming generated the program code.

3.3.10 Stage 4 – Test

At this stage, the researcher conducted the software testing process using black box testing. In general, five components are tested, and 22 test scenarios are in the testing phase.

Table 6. Black Box Testing Educational Game Introducing of Types Animals.

No	Component	Test Scenario	Succeed	Failed
1	Main Menu	4	4	0
2	Choose Animal Menu	4	4	0
3	Quizzes	6	6	0
4	Sound	4	4	0
5	Introducing of Animals	4	4	0

3.3.11 Stage 5 – Release

At this stage, the researcher carried out the application release process that had been developed. The researcher carried out the release process after obtaining approval from the Madrasah Ibtidaiyah Ribathh Darut Tauhid. At this stage, the researcher also carried out the implementation process for Class III students. The results of application development are shown in figure 6.



Figure 6: Main menu of educational game augmented reality.



Figure 7: Educational game augmented reality introducing types of animals.

3.4 Post-Test

Researchers carried out the post-test process by surveying 54 third-grade students. The purpose of the Post-Test is to discover students' abilities regarding animal introduction material where students have played augmented reality games. After playing the game for one week, students are given the same exam questions as during the pre-test, from the post-test results obtained as shown in Figure 8.

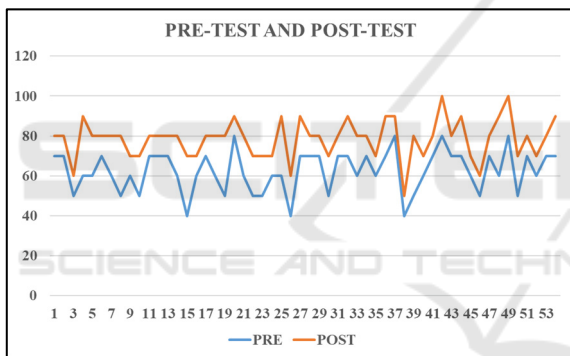


Figure 8. Ability Test Results for Class III Students (Pre-Test and Post-Test).

From the results of the Post-Test, which were compared with the results of the Pre-Test, it was found that the understanding of material about animals increased between 13% and 75%

3.5 Analysis

The researcher analyzes the applications developed using ISO 9126-3 for Usability Factors in this section. There are five sub-factors in the usability factor: understandability, learnability, operability, attractiveness, and usability compliance. The total number of respondents who rated the animal introduction augmented reality educational game application was 54 respondents. From the results of the application feasibility test for the ISO 9126-3 usability factor, 85.30% was obtained. This

application is useful for third-grade students of Ribath Darut Tauhid. The total results can be seen in the table.

Table 7: The result of application feasibility assessment test using iso 9126 usability factors.

USABILITY FACTORS	VALUE
Understandability	83.85%
Learnability	85.18%
Operability	84.99%
Attractiveness	86.47%
Usability Compliance	86.04%
Average =	85.31%

4 CONCLUSIONS

From the research results, it can be concluded that researchers have succeeded in developing an animal recognition learning game application based on augmented reality by implementing an extreme programming model. The application developed received an assessment of 85.31%, which means that the application is very useful for third-grade students of Ribath Darut Tauhid Surabaya. The application has increased students' abilities by between 13% - 75% in animal recognition.

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