IMPLEMENTATION OF AUGMENTED REALITY AND LINEAR CONGRUENTIAL GENERATOR ALGORITHM ON ANDROID-BASED ENERGY INTRODUCTION APPLICATION FOR ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

Introduction to Energy is very important and needs to be known since childhood. Learning Energy Recognition by applying today's technology, namely Augmented Reality (AR) is a digital innovation that can help improve understanding and a more interactive experience. AR is an interactive technology that can display 2D objects into 3D or look like real. This research aims to develop an AR-based Android Mobile Learning application, especially "Introduction to Energy" for elementary school students, with a case study at SD N Jipang 05. The application development process follows the Waterfall method which includes planning, analysis, design, implementation, testing, and maintenance stages. The result of the research is an application called "Malgi - Let's Get to Know Energy," which utilizes AR and quizzes with the Linear Congruential Generator (LCG) algorithm to create random questions. Thi s application has been tested with various methods including using Black box testing with a percentage of achievement of 100%, White Box testing with a percentage of achievement of 100% and testing (UAT) based on the design aspect has a percentage result of 93%, based on the material aspect 100% and based on the use aspect has a result with a percentage of 100%, so the results can be categorized as feasible to use. With this application, it is expected that the introduction of energy will be more interesting and effective for elementary school students. The use of AR allows for a more interactive learning experience, while quizzes and the LCG algorithm ensure understanding of energy concepts. This application is expected to be an effective educational tool and support the developmen t of students' understanding from an early age.

Keywords *: Energy, Augmented Reality, Linear Congruential Generator, Android, Technology.*

1. INTRODUCTION

The development of information technology, especially in the software industry, has drastically changed the landscape of education. These technological advancements have eased access and overcome distance and time constraints in education. Education that was previously limited to textbooks and conventional teaching now has access to innovative technology-based learning tools. The Central Bureau of Statistics (BPS) is a government agency whose role is to provide statistical data needs for the government and society, in providing valid data results, of course this must be accompanied by good and optimal performance of partners. Every year the Central Bureau of Statistics receives new partners and also old partners. However, BPS does not have records of partner data and assessments of each partner. Does the partner follow the training well or not. In addition, the Central Bureau of Statistics has difficulty when determining the selection of the best partners to be eligible for employment after the training.

Learning is an activity that involves teachers and students in a learning environment. This learning environment requires several learning components such as learning objectives, subject matter, educators, learners, learning methods, learning media, and environment. One of the important learning materials is "Introduction to Energy." According to the Big Indonesian Dictionary, energy can be defined as the ability to do work or power used in various activity processes. Knowledge about energy is very important because energy is a key element that affects human life. In the context of education, the concept of energy is one of the learning materials included in Natural Sciences (IPA),

and is usually taught to elementary school students, especially in grade.

However, in today's modern era, children are already familiar with technology. Many elementary school children have their own cell phones, and this significantly affects their learning process. Teachers are required to be more innovative in their teaching and learning activities, one of which is by utilizing technology as learning media that can make learning more interactive and interesting for students. Learning media is a tool used by educators to convey messages in the learning process to students so that students can be motivated to learn so that learning becomes fun and not monotonous and efficient.(Novitasari, Djahir, and Fatimah 2015).. Learning media has an influence on the world of education and the learning process.(Yuanta 2019).

Seeing this situation, researchers tried to create a learning media called "MALGI - Let's Get to Know Energy". This media is equipped with questions that can hone students' knowledge about energy, as well as Augmented Reality (AR) technology to make learning more interactive. This learning application is based on Android Mobile Learning and will be implemented on mobile phones.

2. METHODS

A. Waterfall Method

The process of making this application uses the waterfall system development method. This stage describes in detail the methods used in making this application. The waterfall method consists of 5 main stages that are carried out sequentially, namely:

1) Requirement Analysis

At this stage, an analysis of the research needs that will utilize the software to be created is carried out by collecting information about functional and non-functional needs, and ensuring that these needs are in accordance with the research objectives. The results are data requirements, functional and non-functional requirements.

2) Design

The second stage is the design stage, creating an architecture design based on the needs that have been analyzed in the previous stage. The results of this stage are User Interface or application interface design and UML (Unified Modeling Language).

3) Implementation

The third stage is the implementation stage, creating program code based on the design that has been made in the previous stage. At this stage, the team also conducted an initial trial to ensure that the application made was running well. The results of this stage are Implementation in Blender in the form of making 3D objects, implementation in Unity of interface design design results, implementation of Augmented Reality from Vuforia in the form of AR results that have been programmed, and implementation of the Linear Congruential Generator Algorithm in the form of programmer code or Script that can randomize the question data displayed in the application.

4) Testing

The fourth stage is the testing stage, testing the application that has been made to ensure that the application is running properly. If errors or bugs are found, improvements will be made at the next stage. The results of this stage are application testing documents such as Blackbox, Whitebox, and User Acceptance Testing sheets.

5) Maintenance and operation of the system

The last stage is the maintenance stage, researchers perform application maintenance after the application is applied to the production environment. At this stage, researchers will fix any errors or bugs found, make minor changes, or add new features if needed. The result of this stage is an application that is ready to be used by users.

B. Linear Congruential Generator Algorithm Method

Linear Congruential Generator (LCG) is an algorithm or method used to generate random or pseudorandom numbers by combining previous values with certain constants and moduli. This method works by generating a sequence of random numbers, where each number in the sequence is generated from simple mathematical operations such as multiplication, addition, and modulus on the previous number. LCG is widely used in computer applications to generate random numbers, such as in games, simulations, and statistical analysis. Here is the LCG formula:

$$X_i = (aX_{i-1} + c) \bmod m$$

Description:

Xi = The I-th random number of the sequence.

Xi-1 = The previous random number.

a = Multiplier factor.

b = Enhancement factor.

M = Modulus.

The generating key is X which is called the seed (secret seed). LCG has a period no greater than m, and in the case that the period is less than that(Wahyudi, Handoko, and Pasaribu
2015). LCG has full period (m-1) if it fulfills the following conditions:

1. b is relatively prime to m.

2. a-1 is divisible by all prime factors of m.

3. m > max(a, b, X0).

4. a>0, b>0.

This LCG method is applied to the application quiz menu with the aim of generating random or random questions.

C. Literature Review

1. Energy

According to the Big Indonesian Dictionary (KBBI), energy is the ability to do work (for example for electrical and mechanical energy) or power (strength) that can be used to carry out various activity processes.

2. Renewable Energy

Renewable energy or alternative energy is a source of energy that comes from natural resources that are not limited and can be renewed.

3. Augmented Reality (AR)

According to (Azuma 1997; P 1994)Augmented Reality is an interactive technology
that can display 2D objects into 3D or look like real. Augmented Reality is a variation of Virtual Environments (VE) or also called Virtual Reality, which is a combination of the real world with the virtual world or virtual objects that are interactive in real time in 3D.

4. Android

According to (Nadia Firly 2018)Android is a mobile operating system on Linux- based cell phones that is open source or open source. Android is a very popular operating system today and is widely used by almost everyone.

3. RESULTS AND DISCUSSION

1. Needs Analysis

According to (Marha1 et al. 2022)The needs analysis stage aims to define the needs of the application to be developed. In the process of analyzing the needs of learning media to be developed, the authors use UML (Unified Modeling Language) modeling to describe the needs that exist in the application.

1) Data Requirements Analysis a. Interview

At this stage, direct communication interviews were conducted using a
questionnaire that had been made with the aim of obtaining the data and information needed about the research. The resource persons of the interview are elementary school teachers, especially teachers who teach about energy recognition material.

b. Observation

At the observation stage, observations were made at the place that was the target of the research. The results of the observation are in the form of a Theme 6 LKS book about energy and its changes.

c. Literature Study

By searching for data and collecting data that can be used related to research such as previous research results, journals, papers, and books.

2) Hardware Requirements Analysis

a. Laptop with at least 2GB RAM, with 64-bit operating system.

b. Android phone, for app usage.

3) Software Requirements Analysis

a. Window 11 Operating System, as a support in making the system. b. Draw IO, to design the design in the system.

c. Adobe Illustrator, to create system user interface assets.

d. Unity, to build the energy recognition app system or Malgi app. e. Vuforia, to support augmented reality creation.

f. Blender, for creating 3D assets.

g. Visual Studio Code, for creating coding scripts.

2. Design

1) UML

a. Use Case Diagram

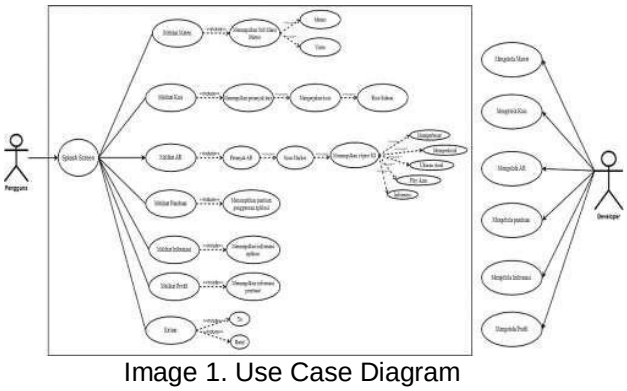

Image 1. Use Case Diagram

In the Use Case Diagram Figure 1 above, the system has 2 actors, namely users and developers or application developers. The system has 7 menus or main pages to interact with actors.

b. Activity Diagram

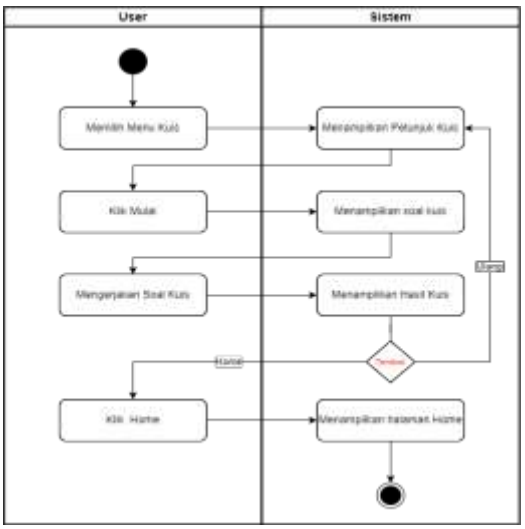

Image 2. Activity Diagram of the Application

Figure 2 describes the system flow to display the Quiz Menu. The process to display the Quiz menu is that the user selects the Quiz menu, then the system will display the Quiz page. The user clicks start the system displays the quiz question page. Users work on quiz questions until completion, the system displays quiz results or scores. If the user clicks the repeat button, the system will return to display the quiz page. If the user clicks the Home button, the system will display the main menu or Home page.

c. Sequence Diagram

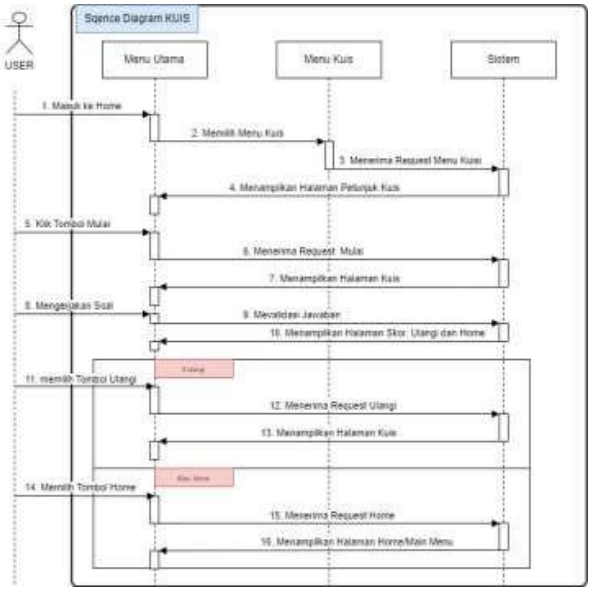

Image 3. Application Sequence Diagram

Figure 3 explains the logic of the process of displaying the Quiz page. The process is that the user enters the main menu then selects the quiz menu, the system will receive a request and display the quiz instructions page. The user clicks start, the

system will display the quiz page. The user works on the questions on the quiz page until it is finished, if it is finished the system will display the score page or quiz results. On the score page there are two buttons, namely the Home and repeat buttons. If the user clicks the Home button, the system will display the main menu page, and if the user clicks the repeat button, the system will return to display the quiz page.

d. Class Diagram

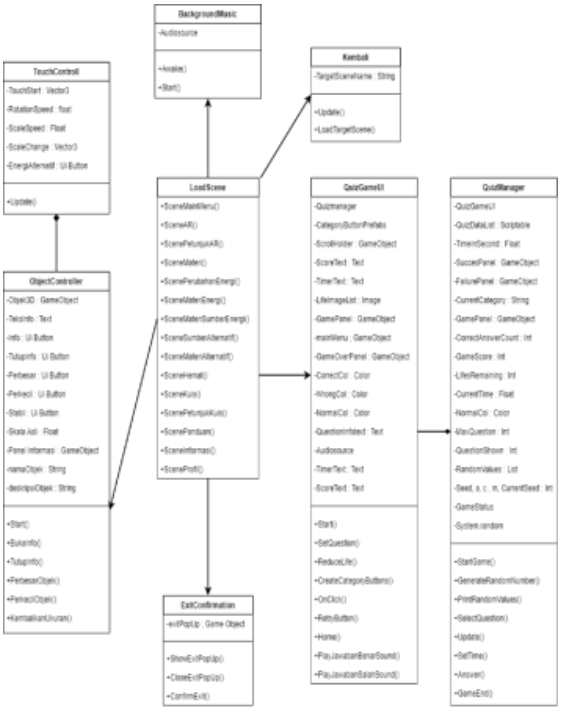

Image 4. Application Class Diagram

In Figure 4. 16 describes the class diagram that describes the classes involved in the application. There are 8 classes involved, namely the LoadScene class, ExitConfirmation class, ObjectController class, TouchControll class, BackgroundMusic class, Back class, QuizManager class, and QuizgameUI class.

2) Interface Design

a. Main Menu Design

The design of the Main Menu page is the Main Menu display which contains the material menu, quiz menu, ar menu, exit button, guide menu, information button and profile button. The following is the design of the main menu page interface, can be seen in Figure 5.

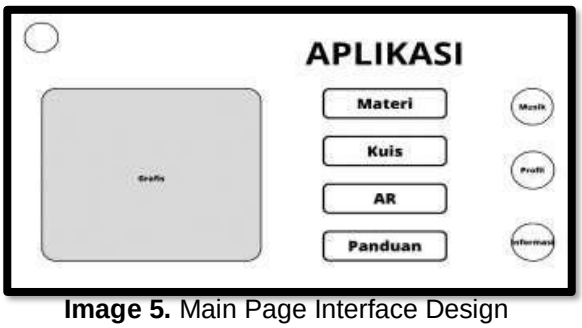

Image 5. Main Page Interface Design

b. Quiz Design

Image 6. Main Page Interface Design

The quiz page design is a quiz page display that contains time panels, lives, values, questions, and answer buttons. The following is the design of the quiz page
interface, which can be seen in Figure 6.

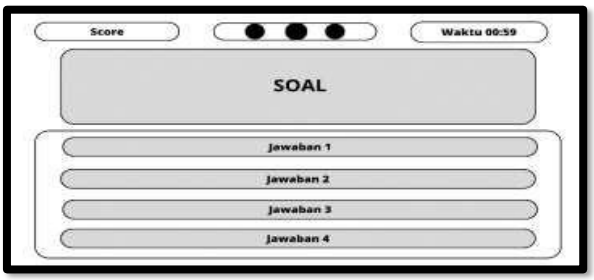

Image 8. Quiz Interface Design

c. AR Design

Image 8. Quiz Interface Design

The AR camera page design is an AR page display that contains an AR camera and AR object control buttons such as the button to enlarge the 3d object, reduce the 3d object, stabilize the size of the 3d object and 3d object information. Here is the design of the AR page interface design, can be seen in Figure 7.

Image 8. AR Interface Design

3. Implementation

1. Main Menu

Image 10. Main Page

Based on Figure 10, it can be obtained that the main menu page can be displayed in accordance with the design of the main menu interface design. Its function is as a quick access to all features and content in the application.

2. Quiz

Image 11. Quiz Page

Based on Figure 11, it can be obtained that the quiz page can be displayed in accordance with the design of the quiz interface design. This page is specifically designed to display questions and collect user answers. On this page there is a score feature, which displays the answer value, a reduce life feature, which is a life, and a timer feature, which is the time to do it. There are also question components and answer buttons.

3. Augmented Reality (AR)

Image 12. AR page

Based on Figure 12, it can be obtained that the AR camera page can be displayed in accordance with the design of the AR camera interface design. The AR Camera page allows users to interact with learning materials in augmented reality format. They can use their cell phone camera to view 3D objects related to the material. On this page there are buttons such as back button, zoom in button, zoom out button, stable button, play button and information button.

4. Linear Congruential Generator Algorithm

The implementation of the LCG algorithm on quizzes in apps is one way to generate pseudo-random or random number sequences used in quiz questions. In this context, the LCG algorithm is used to generate random numbers that will be used as question indices. Here is the calculation of the LCG algorithm.

Table 1. Calculation of Linear Congruential Generator Algorithm

Question Index	Xi = (aXi-1 + c) mod m	Xi
0	X(0) = (1(0)+19) mod 31	19
1	X(1) = (1(19)+19) mod 31	7
2	X(2) = (1(7)+19) mod 31	26
3	X(3) = (1(26)+19) mod 31	14
4	X(4) = (1(14)+19) mod 31	2
5	X(5) = (1(2)+19) mod 31	21
6	X(6) = (1(21)+19) mod 31	9
7	X(7) = (1(9)+19) mod 31	28
8	X(8) = (1(28)+19) mod 31	16
9	X(9) = (1(16)+19) mod 31	4
10	X(10) = (1(4)+19) mod 31	23

5. Application Testing

a. Blackbox

Blackbox testing focuses on the functionality and behavior of the application without paying attention to the implementation details. This test performs checks based on the suitability of the expected functions and meets the functional requirements without paying attention to how the code in it is implemented.

Based on blackbox testing, it can be seen that the application black box testing was carried out by 3 respondents, namely R1, R2, and R3. The results of the R1 respondent are 18 accepted and 0 rejected. The results of the R2 respondents were 18 accepted and 0 rejected. And the last is the result of respondent R3, which is 18 accepted and 0 rejected.

b. Whitebox

White Box testing is testing that involves knowledge of how the program source code works and how the control flow is designed. This test involves making flowcharts, flowgraphs, linear path sets, and calculating Cyclomatic Complexity to analyze the logic flow and complexity of the program code that has been created.(Budianto, Sutabri, and Kurniawan 2022). Here are the results of Cyclomatic Complexity.

V(G) = E - N +2
V(G) = 11 - 11+2
V(G) = 2

Description:
E = Number of Arrows/Links
N = Number of Nodes/Conditions
The result of Cyclomatic Complexity is 2 which will reflect the number of basic paths that can be formed.

c. User Acceptance Testing (UAT)
UAT testing is carried out to ensure that the application has met the requirements and needs of users before being introduced to the environment used by end users. The testing carried out consists of three aspects, namely design aspects, material aspects and usage aspects with information disagree, agree, strongly agree.

Table 3. UAT Testing Results

No.	Aspects	Results			Total	Maximum
		R1	R2	R3		Results
1.	Design	15	15	13	43	45
2.	Material	15	15	15	45	45
3.	Usage	15	15	15	45	45
	Total	45	45	43	132	135

Feasibility Percentage = 132/135 x100% = 98%

Based on the calculations, the percentage results of UAT testing obtained from 3 respondents show that the application has a percentage value of 98%. So it can be concluded that the application strongly agrees to be feasible to use.

4. CONCLUSIONS

Based on the results and discussion obtained from the research, the following conclusions can be drawn:

a. The application, which aims to introduce energy, was designed using the Waterfall development process which involves the stages of needs analysis, design, implementation, testing, and maintenance.
b. The use of Augmented Reality (AR) and Linear Congruential Generator (LCG) technology in the application runs smoothly. The algorithm used is effective in randomizing questions without producing repetition of questions at certain iterations.
c. The application testing results show that the application performance is as expected and feasible to use. Black box testing achieved 100% success and 0% failure.
d. White box testing resulted in a score of 100% with a complexity of 2, meeting software engineering standards.
e. User Acceptance Testing (UAT) shows the design, material, and use aspects of the application with a value of 100%, while the use aspect gets 98.7%, showing the results strongly agree and feasible to use.

5. ADVICE

a. Interface design can be updated accordingly considering human and application interaction.
b. Multiplatform development so that it can be used in various OS not only android.

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