

Android-Based Math Build Space Educational Game for Elementary School Students: A Case Study at SD Inpres Palindi Mburung

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Abstract

Technology, as a product of scientific advancement, has significantly influenced various sectors, including education. In the educational field, progress in information and communication technology (ICT) has enhanced learning effectiveness through digital media such as computers, the internet, and Android-based devices. One notable innovation is educational games, which offer students an engaging, interactive, and enjoyable learning experience. These games are particularly effective in helping students grasp abstract concepts through visual and animated methods. At the elementary level, mathematics is a critical subject for developing foundational understanding; however, many students struggle with spatial concepts due to their abstract nature. Observations and questionnaires conducted with grade V students at SD Inpres Palindi Mburung revealed a low average understanding score of 2.0, with an average ability score of 2.92 in calculating area and volume. Limited use of engaging learning media contributes to student boredom and declining performance. Interestingly, the survey indicated high student interest in game-based learning, with an average score of 3.46. This study, therefore, aims to design and develop an Android-based math educational game utilizing the Fisher-Yates Shuffle algorithm and the Multimedia Development Life Cycle (MDLC) approach as an innovative and effective solution for teaching spatial concepts.

Keywords: Education, Educational Games Build Space, Fisher Yates Shuffle, MDLC, SD Inpres Palindi Mburung

1. Introduction

In the world of education, technology has brought about major changes in learning methods. The use of digital media such as computers, the internet and android-based devices gives students wider access to various learning resources. One of the innovations born from technological developments in the field of education is educational games, which are designed to provide a more interesting and interactive learning experience for students [1]

Educational games are games made with techniques and the use of animations that can make students learn in a fun way [2]. Elementary school (SD) is an early level of education that is very important in building students' basic understanding, especially in mathematics subjects. However, many students have difficulty in understanding the building material of the space because they have to imagine the shape, size, and relationships between buildings in the abstract [3].

In several schools, including SD Inpres Palindi Mburung, learning to build a space still faces various difficulties. Based on the results of the initial observations and questionnaires distributed, the average level of student understanding was at a score of 2 on an assessment scale of 1-4, where a score of 4 means very understanding, 3 understanding, 2 not understanding, and 1 not understanding. This can also be seen from the teacher's explanation, where some students still find it difficult to follow the material because it is considered quite difficult. In addition, the average score of the use of learning media is also at 2, indicating that visual media or teaching aids are rarely used in the learning process. This condition causes students to feel bored easily, which has an impact on decreasing their understanding. As a result, some students experienced a decrease in scores, especially in calculating the area and volume of building space, which can be seen from the average score of 2.92.

2. Literature Review

2.1. Learning Media In Mathematics

Learning media refers to any form of support utilized by teachers to facilitate the delivery of material during student learning activities, making it easier to understand and more engaging. Examples include images, audio, videos, teaching aids, and technology such as laptops and projectors. The purpose of learning media extends beyond merely conveying information; it also aims to enhance student interest, comprehension, and enthusiasm for learning. [4]

Mathematics is a subject that must be studied at every level of education, from elementary school to college, because it is closely related to numbers and operational techniques used to solve various problems. Understanding mathematical concepts is an important basis in developing students' cognitive abilities, especially in relating concrete concepts to more abstract concepts [3].

2.2. Innovation in Learning Methods

In today's world of education, various challenges arise in the teaching and learning process, especially in delivering materials such as building space, and innovations in learning methods. Teachers need to present new ways that are more interesting and relevant so that students can more easily understand the subject matter. This innovation can be in the form of the use of technology, digital applications and educational games that are interactive [5].

Games are a form of entertainment media that can help reduce a person's boredom due to daily work routines. In addition, games can also increase an individual's intelligence, especially when the game demands a level of dexterity from the player [2][6]. Educational games are games designed with techniques and the use of animation to provide a fun learning experience.

2.3. Android

According to [7] Android is a linux-based operating system that helps manage hardware resources on various devices, such as smartphones, mobile phones and tablet PCs. In general, android is an open platform that allows developers to create their own apps that can be used on a variety of platforms. Mobile devices, in addition, android is also a complete and ready-to-use operating system for consumers.

2.4. Algoritma Fisher Yates Shuffle

Algoritma Fisher-Yates, yang diberi nama sesuai dengan Ronal Fisher dan Frank Yates, juga dikenal sebagai Knuth Shuffle, berdasarkan nama Donald Knuth. Algoritma ini digunakan untuk menghasilkan permutasi acak dari suatu himpunan terbatas, atau dengan kata lain, untuk mengacak himpunan tersebut [8].

2.5. Multimedia Development Life Cycle (MDLC)

The Multimedia Development Life Cycle (MDLC) development model is a method that is often used in the creation of multimedia-based applications, including educational games. MDLC consists of six main stages, namely Concept, Design, Material Collecting, Assembly, Testing and Distribution [9].

2.6. Unity 3D

According to [5] Unity 3D is one of the popular game engines used to develop games. Unity is a game engine that is widely used by developers.

2.7. Black Box

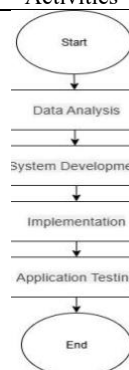
Black Box testing focuses on testing each functional specification of the software. A tester can define a set of input conditions and perform tests on software functionality (Mustaqbal, 2015). The Black Box testing method consists of several methods, including Equivalence Partitioning, Boundary Value Analysis, State Transition Testing, and Decision Table Testing Black Box [10].

3. Research Methodology

Research Flow

Table 1: Research Flow

Yes	Research Flow	Activities
1	The research began, conducting a literature study related to android-based mathematics educational games and the needs of grade V students.	Start
2	Analysis and needs, identifying subject matter, appropriate curriculum, and user needs.	Data Analysis
3	The stages of designing, designing the <i>game's</i> interface, key features, and learning mechanisms.	System Development
4	The implementation stage, developing <i>games</i> using android and integrating educational materials.	Implementation
5	The testing stage, conducting application trials on grade V students to measure effectiveness.	Application Testing
6	Finish <i>the game</i> that has been created, analyze the test results and distribute the application to the end user.	End



4. Result

4.1. Game Design

Planning Flow

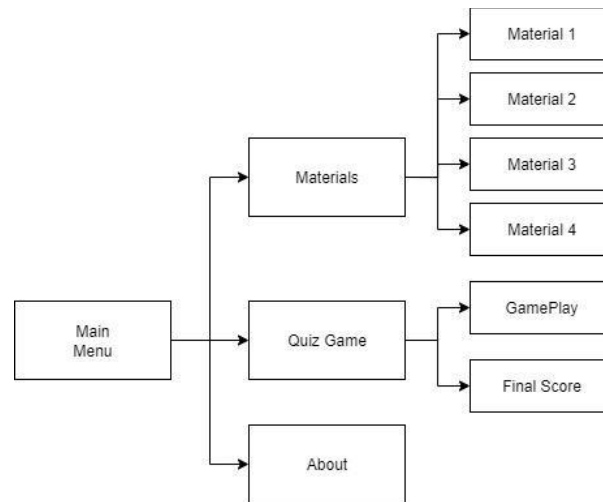


Fig. 1: Planning Flow

This Design flow shows a flow in the spatial building educational game application where there is a main menu containing materials, quiz games, and about. Where in this material menu there are materials for building space, and in the quiz game menu there are quiz and final score.

Implementation of the Fisher Yates Shuffle Algorithm

In developing this educational game, the Fisher-Yates Shuffle algorithm was implemented to randomize the order of quiz questions. The purpose of using this algorithm is to ensure that each student receives a different set of questions every time they play, encouraging them to focus on understanding the material rather than memorizing the question sequence. Generally, the algorithm operates by iteratively selecting elements from the list of questions and randomly swapping them with other elements. This process begins with the last element in the list and proceeds backward to the first element, ensuring that each question has an equal probability of appearing in any position. In this study, the algorithm was implemented in Unity using the C# programming language. A simplified code snippet of the implementation is presented below:

```

void FisherYatesShuffle(List<Soal> list)
{
    for (int i = list.Count - 1; i > 0; i--)
    {
        int j = Random.Range(0, i + 1);
        Soal temp = list[i];
        list[i] = list[j];
        list[j] = temp;
    }
}

void Start()
{
    // Salin semua soal dari database
    soalTeracak = new List<Soal>(database.daftarSoal);
    // Acak soal menggunakan Fisher-Yates
    FisherYatesShuffle(soalTeracak);
    // Ambil hanya sejumlah soal yang kita mau dari soalTeracak (misal 10)
    if (soalTeracak.Count > jumlahSoalDipakai)
    {
        soalTeracak = soalTeracak.GetRange(0, jumlahSoalDipakai);
    }
    TampilkanSoal();
    MulaiTimer();
    // Sembunyikan tombol Play Again dan Home di awal
    if (tombolPlayAgain != null)
        tombolPlayAgain.gameObject.SetActive(false);
    if (tombolHome != null)
        tombolHome.gameObject.SetActive(false);
    // Sembunyikan animasi benar/salah saat mulai
    if (animasiBenar != null)
        animasiBenar.SetActive(false);
    if (animasiSalah != null)
        animasiSalah.SetActive(false);
    // Pasang listener tombol
    if (tombolPlayAgain != null)
        tombolPlayAgain.onClick.AddListener(ResetKuis);
    if (tombolHome != null)
        tombolHome.onClick.AddListener(KembaliKeHome);
}
  
```

Fig. 2: Implementation of the Fisher Yates Shuffle Algorithm

The implementation of the Fisher-Yates Shuffle also helps maintain the objectivity of assessments by ensuring that the sequence of questions varies with each session. This approach encourages students to demonstrate genuine mastery of the material rather than relying on memorization. Such a strategy aligns with the primary goal of educational games: to foster a deeper understanding of mathematical concepts through engaging and interactive learning experiences.

Application Implementation

1. Home



Fig. 3: Home

When you first open the application, the university logo appears. Users launch the educational game application, they are presented with the initial interface of the Math Building educational game. This main page displays the game title and several menus, each with specific functions, accompanied by background music. The main page contains four buttons: Material, Quiz, About, and Exit. Selecting the Material button directs users to a menu with four different learning topics. The Quiz button takes users to the quiz menu, which offers two types of quizzes aligned with the selected material. The About button provides information about the developer, while the Exit button allows users to close the application.

2. Learning Materials Menu

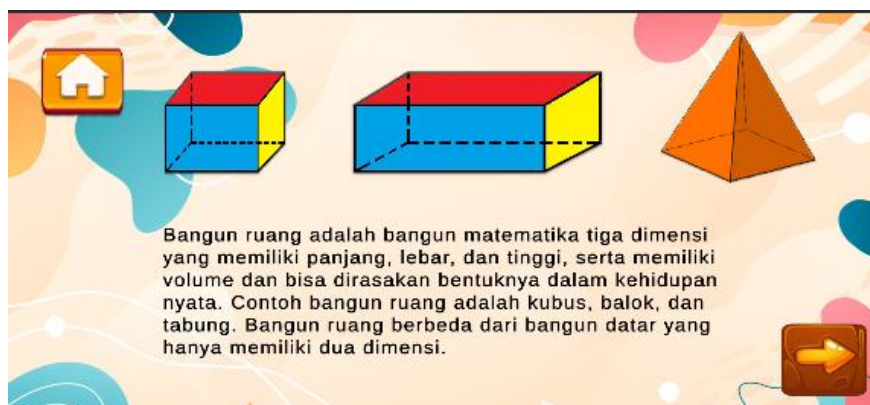


Fig. 4: Learning Materials Menu

The material menu page is a menu page that can be used to learn space building materials and is equipped with images of space building objects.

3. Quiz Menu Page



Fig. 5: Multiple Choice Quiz Menu Page

The quiz menu page is a page consisting of two quizzes, namely multiple choice and drag and drop that is adjusted to the selected quiz. At the top there is a score indicator and a home icon.



Fig. 6: Drag and Drop Quiz Menu Page

On this page, a multiple-choice quiz is presented based on the selected material and quiz type. The questions are displayed along with four answer options, allowing students to select the correct answer. A score indicator is also provided to track performance. On the drag-and-drop page, the content is adjusted according to the user's selection and includes an image of a three-dimensional shape, a score indicator, and a home button for navigation. This section represents Quiz 2 with a drag-and-drop model, which maintains a similar interface to Quiz 1. However, the points awarded in Quiz 2 are set at 20 for each correct answer, reflecting the level of material covered.

4. Score Page



Fig. 7: Score Page

The score page will appear when the user finishes answering all the questions. This page will appear "Congratulations You Have Solved the Question" and the final score of the user who answered 10 questions. At the bottom of the page is a button to return to the main page.

5. About Page

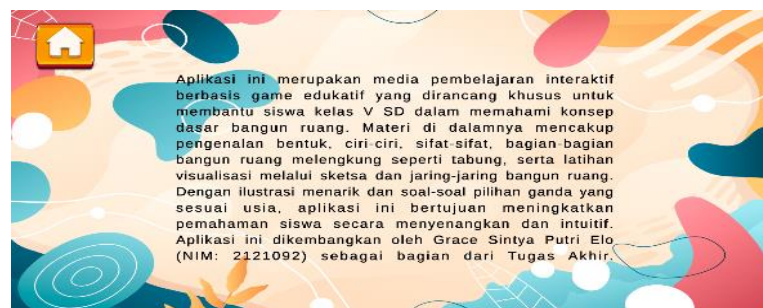


Fig. 8: About Menu Page

The about page contains information about the app with a brief description of the developer. The page design is simple and the home button is available.

4.2. Black Box Testing

Testing of functions in the application of mathematical educational games building space using black box testing.

Table. 2: Black Box Testing

Test name	Forms of testing	Expected results	Result	
			Succeed	Fail
Main Menu	Open the app	Main menu display appears	√	
Study Menu	Pressing the learn button	Display of space building materials	√	
Quiz Menu	Pressing the quiz button	Appears a quiz display	√	
The following button	Selecting the next button	Appears a quiz display	√	
Back Button	Selecting the back button	A previous material view appears	√	
Algoritma Fisher Yates Shuffle	Play the game	There is no recurrence of the question in the same session	√	
Answering True	Answer the correct answer	The score increases and the next feedback and questions appear	√	
Answering Wrong	Answering an incorrect answer	The score does not increase and feedback appears	√	
Score Page	Finish playing the game or time ends	An interface displays the earned score	√	

From the test table above, it can be seen that the results of the test of educational game applications using the black box method show successful results or successfully executed according to the expected function

4.3. Pre-Test And Post-Test

Table. 3: Pre-Test And Post-Test

Number	Name	Pre-test	Post-test
1.	Devan	70	90
2.	Nindita	70	90
3.	Yoklin	30	70
4.	Mikael	30	60
5.	Wyliam	50	70
6.	Griselda	40	60
7.	Sesilia	60	80
8.	Brayan	60	80
9.	Boas	50	70
10.	Alena	60	80
11.	Meme	70	90
12.	Iva	30	60
13.	Tri	50	70
	Total	670	1010

The test in this study used pre-tests and post-tests conducted on class V students consisting of 13 students. Pre-test and post-test are given to students with the scores obtained.

The table above shows the results of the pre-test and post-test that have been carried out, the number of pre-tests is 620 and the number of post-tests is 1490 as outlined in table 4.2. After knowing the total number of pre-test and post-test results, the summed score is searched for the average score. Calculation of the average score of the pre-test:

$$X_{pre} = \frac{\sum X}{N}$$

$$X_{pre} = \frac{670}{13}$$

$$= 51,53$$

Calculation of the post-test average score:

$$X_{post} = \frac{\sum X}{N}$$

$$X_{post} = \frac{1.010}{13}$$

$$= 77,69$$

Information:

X_{pre} = Average score from *the pre-test*

X_{post} = Average score of *post-test*

$\sum X$ = Total Score

N = Number of Students

From the results of the calculation, the average score of students was obtained as 51.53 and *the post-test* score was 77.69. Then from the calculation of the average score obtained, a percentage increase in student scores was calculated.

$$\text{Percentage} = x 100\% \frac{X_{post} - X_{pre}}{X_{pre}}$$

$$\text{Presentation numbers} = \frac{77,69 - 51,53}{51,53} \times 100\%$$

$$\text{Presentation numbers} = \frac{26,16}{51,53} \times 100\%$$

$$\begin{aligned} \text{Presentation numbers} &= 0.5077 \times 100\% \\ &= 50,77 \%. \end{aligned}$$

This improvement shows that students' understanding has improved after using the educational game. This is strengthened by the results of the calculation of a percentage increase of 50.77%. Thus, it can be concluded that the use of educational game-based learning media has a positive impact on improving student learning outcomes in understanding space building materials.

5. Conclusion

This research succeeded in designing an Android-based spatial building mathematics education game focused on building space materials for grade V students of SD Inpres Palindi Mburung. The app is designed using Unity as a game engine and implements the Fisher Yates Shuffle algorithm. Features such as material menus, interactive quiz in the form of multiple choice and drag and drop, as evidenced by black box testing. Overall, this educational game is able to provide an interactive and fun learning experience, and is proven to increase students' interest and understanding of the concept of building a space, as shown by the increase in average scores by a certain amount after using the game.

The results of the trial using the black box method show that all features in the application run according to their function. In terms of learning, this game is proven to provide an interactive, fun, and effective learning experience, shown by the increase in students' average score from 51.53 during the pre-test to 77.69 in the post-test. With an average increase in score of 50.77%, it can be concluded that this educational game has a positive effect on increasing students' understanding in learning the concept of building space.

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