



# Developing an Ethnomathematics Educational Game for Fractions Based on Local Wisdom (Case Study: SD Inpres Laipandak)

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## Abstract

Mathematics learning in elementary schools often faces obstacles, especially in conveying abstract concepts such as fractions. Students' low understanding is caused by the lack of connection between the material and everyday life. An ethnomathematics approach, which connects mathematical concepts with local culture, can be a solution. This study aims to develop an ethnomathematics-based educational game by integrating local wisdom from East Sumba in fraction learning. The method used in this study is Research and Development (R&D) with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) Development model. The game was developed by embracing local culture such as the distribution of meat in traditional ceremonies (kaparakang), ikat weaving patterns, and the division of agricultural land as learning contexts. A trial was conducted on elementary school students to assess the game's effectiveness in improving student understanding

*Keywords: Educational Games, Ethnomathematics, Fractions, Local Wisdom, East Sumba.*

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## 1. Introduction

Mathematics is a subject that plays a crucial role in developing students' logical and analytical thinking skills. However, in practice, many elementary school students struggle to understand mathematical concepts, particularly fractions. One of the main causes of this difficulty is the abstract nature of fractions, which are often taught without connecting them to students' real-world experiences.

Conventional learning approaches, such as the use of numbers and symbols without concrete representations, make it difficult for students to understand that fractions are parts of a whole. Furthermore, the lack of context in everyday life also contributes to students' poor understanding. As a result, many students struggle to compare fractions, perform arithmetic operations, and apply fraction concepts in real-world situations. To address these issues, an ethnomathematics approach can be used in fraction learning. Ethnomathematics is the study of how mathematical concepts relate to a community's culture and traditions. This approach allows students to understand fractions through activities appropriate to their environment and culture.

By leveraging these cultural elements, learning about fractions can become more concrete, relevant, and engaging for students. One innovative method for implementing an ethnomathematics approach is through the development of technology-based educational games.

Android-based educational games can be an interactive learning tool that combines local cultural elements with mathematical concepts. This way, students can learn fractions through a more enjoyable and meaningful gaming experience. The use of technology in learning is also in line with current developments and can increase student motivation and engagement in understanding fraction concepts.

Based on these issues, this study aims to develop an ethnomathematics fraction education game based on local wisdom as an alternative learning medium for elementary school students. This research is expected to help students better understand the concept of fractions and increase their appreciation for the local culture of East Sumba.

## 2. Literary Studies

### 2.1. Educational games

Educational games are games specifically designed to educate, train, and improve students' cognitive abilities through fun and interactive activities. (Al-khayat & Gargash, 2023) Systematic studies have found that game-based learning strengthens motivation and develops cognitive skills through interactive and immersive learning environments. Furthermore, [1] explains the Concrete → Representational → Abstract (CRA) principle, which also supports how educational games work. In developing modern learning media, Android-based

educational games are the right choice because they are easily accessible, interactive, and support various student learning styles, such as visual, auditory, and kinesthetic (VAK).

## 2.2. Ethnomathematics

Ethnomathematics is an approach in mathematics education that links mathematical concepts to the culture, traditions, and practices of local communities. This term was first introduced by Ubiratan [2]. This article introduces the term "ethnomathematics", providing a theoretical basis for how mathematical practices develop in specific cultural contexts. This approach emphasizes that mathematics is not only found in the classroom.

## 2.3. Fraction

A fraction is a number that represents a part of a whole and is mathematically written in the form  $\frac{a}{b}$ , where  $a$  is the numerator and  $b$  is the denominator with the condition  $b \neq 0$  (Purwanto, 2010). According to the Ministry of National Education (2006), fractions are one of the main materials in the basic mathematics curriculum because they form the foundation for advanced topics such as decimals, percentages, and ratios. NCTM (2000) also states that understanding fractions is very important for developing students' mathematical thinking skills from an early age. However, without the right approach, students tend to have difficulty understanding the meaning of fractions as part of a whole. Therefore, the introduction of types of fractions such as ordinary fractions, mixed fractions, and decimals needs to be done gradually and contextually to support meaningful learning.

## 2.4. Local isdom

According to [3], local wisdom is part of a culture passed down through generations and can be used as a medium or learning context to make material more meaningful and relevant to students' lives.

Research conducted by [4] implemented Acehese culture-based learning media in elementary school classes at SDN 33 Banda Aceh using a CAR approach. The results showed an increase in mathematics learning scores from an average of 44.64 to 72.73 after two learning cycles. In her research, Siti developed interactive ethnomathematics-based media that highlighted local culture. As a result, students not only better understood the concept of fractions but also became more engaged in the learning process because the material felt closer to their daily lives. Furthermore, [3] implemented Acehese culture-based learning media in elementary school classes at SDN 33 Banda Aceh using the CAR approach. The results showed an increase in mathematics learning scores from an average of 44.64 to 72.73 after two learning cycles. This approach makes it easier for students to connect mathematical concepts with their social realities, making learning more meaningful. Research [5] found the media valid and practical (Aiken's  $V \sim 0.80$ ; effectiveness  $\sim 81.25\%$ )—demonstrating that cultural contextual games were successfully utilized in early childhood learning. The trial results showed that students who used this game experienced increased learning motivation and a better understanding of fractions, compared to conventional learning methods.

Furthermore, [6] found that ikat woven motifs (horses, chickens, butterflies, flowers, shrimps, mamuli, etc.) contain mathematical elements: points, lines, angles, flat shapes (rectangles, triangles, rhombuses), and geometric transformations (reflection, rotation, translation, dilation). This study also emphasized that a culture-based approach not only strengthens understanding of mathematical concepts but also fosters pride and appreciation for one's own cultural heritage.

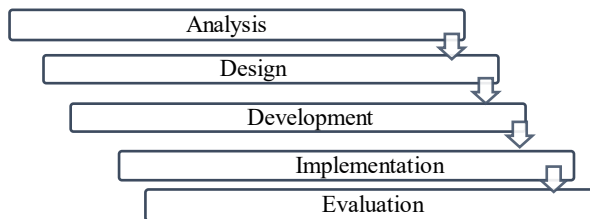
Finally, [7] stated that the goal was to improve students' critical thinking skills in solving mathematical problems. Children who learned through this game showed significant improvements in critical thinking compared to the group without the game. This proves that a local culture-based and technology-based approach can be an effective strategy for improving learning outcomes.

## 2.5. Android

An Android-based educational game developed with Unity has been shown to improve student learning outcomes in mathematics. In the study, Android served not only as a medium for delivering material but also as a game-based assessment tool. [8] This educational game aims to improve students' understanding of the local culture of Flores through an interactive and fun approach.

## 2.6. Game Development with the ADDIE Model

The ADDIE Model is a systematic and step-by-step process for creating learning media, starting with needs analysis, designing, developing, testing, and evaluating the results. In education, developing effective learning media requires a systematic and structured approach. One of the most widely used models in instructional design and learning media development is the ADDIE Model. This model was developed by Florida State University in 1975 for military training and has since been widely adopted in curriculum development, learning software, and interactive media, including educational games. ADDIE is an acronym for the five main stages in the development process: Analysis, Design, Development, Implementation, and Evaluation. This model is iterative and flexible, allowing for revisions at each stage based on testing results or feedback. The following explains each stage in the context of developing a local wisdom-based ethnomathematics fraction educational game:



**2.7. Unity**

Unity is one of the most popular game engines, supporting 2D and 3D game development and enabling easy deployment across platforms such as Android, iOS, Windows, and the web. Unity is also widely used in education, particularly in the development of interactive learning media and educational games. Several studies demonstrate Unity's effectiveness as a learning tool.

**2.8. Fisher-Yates algorithm Shuffle**

The Fisher-Yates algorithm (named after Ronald Fisher and Frank Yates), also known as the Knuth Shuffle (named after Donald Knuth), is an algorithm that generates random permutations of a finite set, in other words, to randomize the set. If implemented correctly, the results of this algorithm will be unbiased, so each permutation has an equal probability. The Fisher-Yates Shuffle algorithm is one algorithm used to randomize elements in a set or array. This algorithm was first introduced by Ronald Fisher and Frank Yates in 1938 in their book, Statistical Tables for Biological, Agricultural, and Medical Research. Initially, this method was used for data randomization in statistical research, but with the advancement of technology, this algorithm has been widely implemented in computer science, particularly in data randomization processes, games, simulations, and learning applications. The basic principle of the Fisher-Yates algorithm is to randomly swap elements in an array with equal probability. The randomization process begins at the last index of the array, then swaps elements at random positions between the first and current indexes

**Table 1:** Example of FYS Algorithm Calculation

Iteration (i)	Array before swapping	Random index (j)	Swapped elements (i ↔ j)	Array after swapping
i = 4	[1, 2, 3, 4, 5]	j = 2	5 ↔ 3	[1, 2, 5, 4, 3]
i = 3	[1, 2, 5, 4, 3]	j = 1	4 ↔ 2	[1, 4, 5, 2, 3]
i = 2	[1, 4, 5, 2, 3]	j = 0	5 ↔ 1	[5, 4, 1, 2, 3]
i = 1	[5, 4, 1, 2, 3]	j = 1	4 ↔ 4 (tidak berubah)	[5, 4, 1, 2, 3]

**2.9. System Testing**

**2.9.1. System Usability Scale (SUS) Testing**

SUS (System Usability Scale). The SUS was developed (Brooke, 1996) as a "quick and dirty" usability measurement. The survey consists of 10 questions, each with a 5-point Likert scale for responses. The SUS output is a seemingly easy-to-understand score ranging from 0 to 100, with higher scores indicating better usability. The System Usability Scale (SUS) is a standard instrument used to measure the usability of a system, application, or digital product. The SUS was first introduced by John Brooke in 1986 and remains a simple yet effective method for evaluating user perceptions of a system (Brooke, 1996). According to ISO 9241-11, usability is defined as the extent to which a product can be used by users to achieve specified goals effectively, efficiently, and satisfactorily within a specified usage context. Thus, the SUS serves as a subjective measure of how easy and comfortable a system is to use.

**Table 2 :** System Usability Scale (SUS) Testing

No	SUS Statement	Skala (1-5)				
		1	2	3	4	5
1	I feel like I'll be using this game a lot.					
2	I feel like this game doesn't need to be this complicated.					
3	I found this game easy to use.					
4	I feel like I need some technical help to be able to use this game application.					
5	I feel the features in this app are well integrated.					
6	I feel there are a lot of inconsistencies in this app.					
7	I feel like other people will quickly learn to use this app.					
8	I find this app confusing.					
9	I feel confident when using this application.					
10	I need to learn a lot before I can use this app.					

**2.9.2. Pretest and Posttest Testing**

Testing was conducted by comparing students' pre-test and post-test results before and after using the educational game to measure improvements in their understanding of fractions. This formula was used in the evaluation process to determine students' level of understanding of the material, both during the pre-test and post-test.

### 3. Research Methods

#### 3.1. Research Subjects

The subjects of this study were fourth and fifth grade students of SD Inpres Waingapu 3, users of the developed educational game. In addition to the students, the mathematics teacher was also involved as a resource person in the validation of the material and as a user in the learning trial process. The direct involvement of the students and teachers enabled the researchers to obtain authentic and relevant data on the effectiveness of the designed learning media.

#### 3.2. Research Object

The object of this research is the fraction value data owned by fifth-grade students. This data is used to assess students' understanding of fraction material, both before and after the use of educational games. The main focus of this research object is the change in student learning outcomes after the implementation of ethnomathematics-based learning media.

#### 3.3. Research Location

This research was conducted at SD Inpres Laipandak, located in East Sumba Regency, East Nusa Tenggara. This location was chosen because it has strong local cultural potential and is relevant to the ethnomathematics approach that underpins the development of the educational game in this study.

#### 3.4. Research Flow

In this research flow, several stages were used, namely: problem analysis, data collection, system needs analysis, educational game design, game implementation, testing and evaluation.

#### 3.5. Software Development Methods

Game development is conducted using the ADDIE model. This stage begins with an analysis of student needs and the curriculum, followed by storyboard and gameplay design, product development using specific software, implementation through school trials, and evaluation and revision based on test results and user feedback.

#### 3.6. Functional Requirements Analysis

Functional requirements analysis is a very important initial stage in the system development process, where the main activity is to identify and design the main functions that must be performed by the system to meet its intended use. Functional requirements describe the behavior of the system in response to certain inputs and describe how the system should behave in certain situations. The requirements analysis process is carried out using the ADDIE approach as a tool to visualize the system design. The UML used is a use case diagram, activity diagram.

#### 3.7. Design of the system offered

The system developed is an Android-based educational game with a child-friendly interface and incorporates local cultural elements. The language used is simple and can be supplemented with regional language narration. The game consists of five modules: an introduction to fractions, fractions in kaparakang (a traditional Indonesian word), fractions in ikat weaving, fractions in land division, and evaluation and scoring.

## 4. Game Implementation

This ethnomathematics fraction education game based on local wisdom was implemented using the Unity game engine due to its flexibility in creating 2D and 3D games and its distribution support across multiple platforms, including Android. Unity was chosen for its interactive interface, asset store support, and ease of integration with the C# programming language.

The programming language used to develop the game logic is C#. This language is used to manage various in-game mechanisms, such as page navigation, user interaction, answer validation, score calculation, and determining win/loss conditions. The use of C# in Unity allows the game logic to run in real time, responding quickly to player input.

```
void AcakSoal()
{
    for (int i = daftarSoal.Length - 1; i > 0; i--)
    {
        int j = Random.Range(0, i + 1);
        Soal temp = daftarSoal[i];
        daftarSoal[i] = daftarSoal[j];
        daftarSoal[j] = temp;
    }
}
```

Fig. 1: Pseudocode of the FYS algorithm

Fig. 1 : shows the code in Unity for randomizing questions using the Fisher-Yates shuffle algorithm. Based on the Fisher-Yates shuffle algorithm formula for randomization, the results can be seen below:

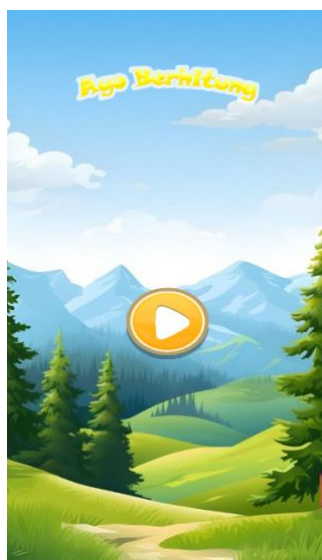
Additionally, the Fisher-Yates Shuffle algorithm is used for the question randomization system. This algorithm randomly and evenly shuffles the question sequence, resulting in a different set of questions each game session. This ensures players won't encounter the same question sequence every time, increasing variety and challenge, and reducing the likelihood of simply memorizing answers.

**Table 3 :** Fisher Yates Shuffle algorithm calculation

Device	Enter a question	Question output
L	1-2-3-4-5-6-7-8-9-10	5-6-8-3-1-4-2-9-10-7
L1	1-2-3-4-5-6-7-8-9-10	10-4-5-7-6-3-1-2-8-9
L2	1-2-3-4-5-6-7-8-9-10	5-4-8-10-2-3-1-9-7-6

The Fisher Yates Shuffle algorithm randomization input is done by taking all the questions in the game, then randomizing from a value of 0 to the last question, which will repeat until all the questions have been randomized.

#### 4.1. Start View



**Fig 2 :** Game Start Screen

Figure 3 shows the initial screen (start screen) when the game is first launched. This screen serves as the opening page before players enter the game's main menu. The game title "Let's Count" is displayed at the top of the screen against a backdrop of mountains and trees, creating an engaging, child-friendly experience that aligns with the educational theme.

In the center of the screen is a yellow play icon, which serves as the start button for the game. Pressing this button will direct players to the main menu or directly to the next stage, depending on the gameplay.

The start screen is designed to be simple, clear, and interactive, ensuring that students, as the primary users, can easily understand the functions of the available buttons without requiring additional instructions. This aligns with the user-friendly principle in developing game-based learning media.

#### 4.2. Home/Menu Display



**Fig 3 :** Home/Menu Display

**Fig. 3:** Shows the main menu of the Fractions Math educational game. On this page, users are presented with several menu options that can be accessed as needed. The "Learn" menu allows users to access fraction learning materials presented in a visual and interactive format,

while the "Play" menu directs users to a game mode or fraction quiz designed to test understanding. Additionally, there's an "About" menu that displays information about the game, including the developer's identity and the purpose of the application, and an "Exit" menu that closes the application. Furthermore, in the upper right corner, there's a background sound on/off button to turn off and reactivate the background sound.

#### 4.3. Home/Menu Display



Fig. 4 : Material Menu Display

**Fig. 4 :** Above displays the material menu page, which serves as the central learning access point for the Fractions Math educational game. This page provides three main options: "Fractions," "Fraction Comparison," and "Fraction Arithmetic Operations." This menu is designed to facilitate students' gradual learning of fraction concepts, starting from basic concepts and moving on to more complex forms, ensuring a structured and systematic learning process.

The background of this display retains the natural illustration of mountains and trees, consistent with the previous page, maintaining a friendly and enjoyable feel. The menu buttons are designed simply with a bright green color that contrasts with the background, making them easily recognizable by students.

#### 4.4. Fraction Material Display

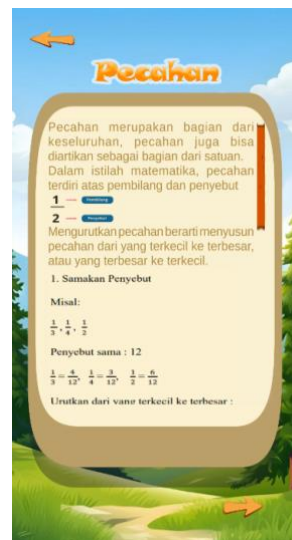


Fig 5 : Fraction Material Display

**Fig. 5 :** Above shows a material page explaining the basic concept of fractions. This page explains that fractions are parts of a whole, consisting of a numerator and a denominator. The material is written in simple language for easy understanding by elementary school students, and is accompanied by example problems demonstrating how to make denominators the same and order fractions from smallest to largest. The material display is designed to resemble a book page with a cream-colored background to highlight the text and keep students focused on the learning content. At the top is the title "Fractions" in a bold color, while in the upper left corner there is an arrow button to return to the previous menu, and in the lower right corner there is an arrow button to advance to the next page of the material.

#### 4.5. Display of Fraction Comparison Material



Fig. 6 : Comparison of Fractions Material Display

Fig. 6 : displays a learning page about comparing fractions. This section explains that comparing fractions means determining which fraction is greater or less. The method used in this material is to have the denominators the same or to convert the fractions to decimal form. The explanation is clarified through example problems, such as comparing the fractions three-fifths and four-fifths. Because both fractions have the same denominator, the comparison can be made directly by looking at the numerators: three is less than four, so the result is  $3/5 < 4/5$ . This page uses a book-like design with a cream background for easy reading.

#### 4.6. Display of Fraction Arithmetic Operation Material

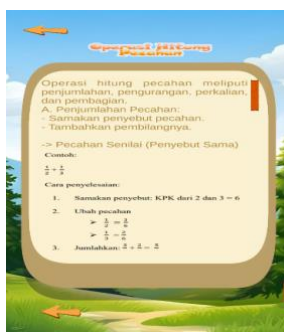


Fig. 7 : Fraction Arithmetic Operations Material Display

Fig. 7 : Above displays a learning page about comparing fractions. This section explains that comparing fractions means determining which fraction is greater or less. The method used in this material is to have the denominators the same or to convert the fractions to decimal form. The explanation is clarified through example problems, such as comparing the fractions three-fifths and four-fifths. Because both fractions have the same denominator, the comparison can be made directly by looking at the numerators: three is less than four, so the result is  $3/5 < 4/5$ .

#### 4.7. Select Level View



Fig 8 : Tamoilan Select Level

The image above displays the level selection page, which determines the game's difficulty. This page offers three difficulty levels: easy, medium, and hard. These difficulty levels offer players varying challenges based on their abilities, allowing students to adjust their level of play to their current understanding of the material. Selecting levels also aims to make the game more interactive and less boring, as users can attempt higher levels after completing the previous one. This interface maintains a consistent design with a natural illustration of

mountains and trees as the background, and prominently placed green navigation buttons in the center of the screen. In the upper left corner, there is an arrow icon to return to the previous menu, allowing users to easily reset their options. The simplicity of this interface is expected to help students focus on the core gameplay without being distracted by excessive visual elements.

#### 4.8. Game or Quiz Display



Fig 9 : Game or Quiz Display

The image above displays a game or quiz page containing interactive fraction problems. In the example shown, players are asked to simplify the fraction  $6/8$  by selecting the correct answer from four available options. The problem is displayed in the center of the screen in text format, while the answer choices are presented as easily recognizable and selectable green buttons. This format allows students to directly interact with the problem by selecting an answer, thus enhancing the learning process.

#### 4.9. Final Score Display



Fig 10 Final Score Display

The image above shows the final score display that appears after a player completes a level. This display displays the player's score and the time taken to complete the level. This information serves as immediate feedback, allowing players to understand their results and evaluate their speed and accuracy in answering questions. In addition to displaying the score and time, this display also provides several navigation buttons. The list button returns to the main menu, the circular arrow button repeats the same level, and the right arrow button advances to the next stage. This navigation allows players the flexibility to choose whether to repeat, return, or continue the game.

#### 4.10. Testing

System testing was conducted to ensure that the developed Fraction Math educational game ran smoothly, met functional requirements, and was effective as a learning tool. Testing was conducted in three stages: blackbox testing, System Usability Scale (SUS), and pretesting and posttesting.

#### 4.11. Testing

Blackbox testing is performed to ensure that every function in the game works as expected. This testing focuses on input and output without directly viewing the program code. The test results are shown in Table 4.2 below.

**Table 4 : BlackBox Test Results**

Tested Feature	Test Scenario	Expected Result	Test Result	Status
Start Button	Press the Start button	Enter the main menu	As expected	Valid
Learning Menu	Select the Learning menu	Display fraction learning materials	As expected	Valid
Playing Menu	Select the Playing menu	Display level selection	As expected	Valid
Level Selection	Select Easy/Medium/Hard level	Display questions based on difficulty level	As expected	Valid
Answering Questions	Select one of the answer options	Provide correct/incorrect score	As expected	Valid
Final Score	Complete the game	Display total score and completion time	As expected	Valid

**4.12. SUS Testing**

The System Usability Scale (SUS) test was conducted to determine the level of feasibility, ease of use, and user satisfaction with the Fraction Math educational game. The SUS method, developed by John Brooke in 1986, has become the standard for usability measurement due to its simplicity, reliability, and applicability to various types of interactive systems.

**Table 5 : SUS Testing Score**

Jawaban	Skor
Strongly agree (SS)	5
Agree (S)	4
Disagree (KS)	3
Disagree (TS)	2
Strongly disagree (STS)	1

Table 5 presents the SUS test statements, each with answers that determine the score obtained for the respondent's analysis.

The SUS statements are shown in Table 7 below.

**Table 6 : SUS Testing Questions**

No	Statement	Answer				
		1	2	3	4	5
1	I feel like I'll be using this game a lot.					
2	I find this game too complicated to use.					
3	I found this game easy to use.					
4	I need someone else's help to use this game.					
5	I feel like the features in this game work well.					
6	I feel like there are a lot of inconsistencies in this game.					
7	I'm sure most people will quickly understand how to use this game.					
8	I found this game confusing to use.					
9	I feel confident when using this game.					
10	I have to learn a lot first before using this game.					

Table 6 shows the questions given to seven respondents: five students as primary users and two teachers as instructors. The respondents' scores will be entered into the SUS testing table.

The following is the calculation formula for the respondents' answers:

**Table 7 : SUS Test Results**

Responden	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	X	X*2,5	
Siswa-siswi	R1	4	3	3	4	4	4	4	4	4	38	95	
	R2	4	4	3	4	3	3	3	4	3	34	85	
	R3	3	4	4	4	4	3	4	4	3	4	37	92,5
	R4	4	4	3	4	4	4	4	4	4	4	39	97,5
	R5	4	3	4	4	4	4	4	4	3	4	38	95
Guru	R6	4	4	4	4	4	4	4	4	4	40	100	
	R7	4	4	4	4	4	4	4	4	4	40	100	
<b>Total</b>												<b>95</b>	

Table 7 shows the calculation results obtained from the interview questions in Table 4.3 with the test scores in Table 4.2.

The following is the average SUS calculation formula:

$$\bar{x} = (x_1 + x_2 + x_3 + \dots + x_n) / n$$

$$\bar{x} = (95 + 85 + 92.5 + 97.5 + 95 + 100 + 100) / 7$$

$$\bar{x} = 665 / 7$$

$$\bar{x} = 95$$

$\bar{x}$  = Average score  
 x = Score per respondent

n = Number of respondents

#### 4.13. Pretest and Posttest Testing

Pretest and posttest testing were conducted to measure the effectiveness of the Fractions Math educational game on improving student understanding. The primary objective of this testing was to determine the extent to which the game helped students better understand fractions after learning using this interactive medium. The game consisted of three levels, each with 10 questions of gradually increasing difficulty.

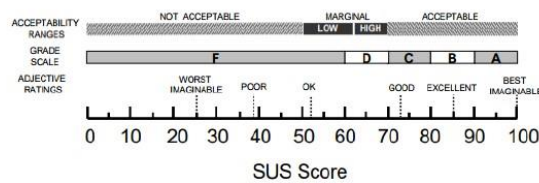
**Table 8 : Pretest and Posttest Testing**

Responden	Pretest Value	Posttest Value	Increase Difference
S1	60	85	+25
S2	55	80	+25
S3	65	85	+20
S4	70	90	+20
S5	60	80	+20
S6	75	95	+20
S7	65	85	+20
S8	50	75	+25
S9	60	80	+20
S10	70	90	+20
Rata-rata	63,0	84,5	+21,5

Based on the table above, the average pretest score was 63.0, while the average posttest score was 84.5. This indicates an average increase of 21.5 points after students used the Fractions Math educational game. This improvement indicates that the game developed is effective in helping students better understand the concept of fractions. The learning process, presented in a game format, makes students more motivated, focused, and active in answering each question. Through direct interaction with visuals, sounds, and an engaging scoring system, students can learn while playing in a fun way. Thus, it can be concluded that the use of the Fractions Math educational game, with three levels and ten questions at each level, has proven effective in improving elementary school students' learning outcomes, making this game suitable for use as an interactive learning medium for fractions.

#### 4.14. Analysis of Test Results

Test results were analyzed to assess the success of the development of the Fraction Mathematics educational game based on three types of testing: blackbox testing, System Usability Scale (SUS), and pretest-posttest. Each test contributed significantly to ensuring that the game not only functioned technically but was also effective and suitable for use as a learning tool. Based on the blackbox testing results, all features implemented in the game performed according to functional requirements. The navigation buttons, learning menu, playing menu, and final score display were functional and error-free. This indicates that the system is technically stable and can be run smoothly on user devices.



**Fig. 11 : SUS Test Scale**

The results of the Fractions Math educational game showed an average SUS score of 95, within the 85–100 range and falling into the “Best Imaginable” category. Based on this interpretation, it can be concluded that the game's usability level is very high. Users found the game easy to use, had an attractive interface, and its features worked well without causing significant difficulties.

#### 4.15. Discussion

Based on the results of testing the Fractions Math educational game, it can be concluded that the developed system functions well and meets the eligibility criteria for interactive learning media. Blackbox testing demonstrated that all application functions functioned smoothly without any errors. Every button, navigation, and game logic functioned as designed, including the level selection mechanism, question presentation, score calculation, and final result display. This demonstrates that, functionally, the game is suitable for use by users. Furthermore, the usability test using the System Usability Scale (SUS) obtained an average score of 95, which falls into the "Best Imaginable" category based on the SUS interpretation scale. This score indicates that users were highly satisfied with the ease of use, interface appearance, and comfort when interacting with the game. In other words, this game has a very high level of usability and is capable of providing an enjoyable learning experience for elementary school students. Furthermore, pretests and posttests conducted on 10 students showed an increase in their understanding of fractions after using the game. The posttest results showed a higher average student score compared to the pretest, indicating that the game was effective in supporting the learning process. This improvement demonstrates that game-based learning methods can increase students' motivation and retention of the material taught.

## 5. Closing

### 5.1. Discussion

Based on the research and testing conducted on the Unity-based Fraction Math Education Game, the following conclusions can be drawn:

This educational game has been successfully developed as an interactive learning medium that can help students understand the concept of fractions in a fun way. Based on black-box testing, all system functions functioned as designed, and no errors were found in any test scenario, indicating that the application meets the functional requirements.

The usability test results using the System Usability Scale (SUS) obtained an average score of 95, which falls into the "Best Imaginable" category. This indicates that the game is easy to use, has an attractive interface, and provides user comfort during the learning process.

Meanwhile, the results of the pretest and posttest on 10 students showed a significant improvement in learning outcomes after using the game. This demonstrates that the Fractions Math Educational Game is effective in helping students understand fractions, while also increasing learning motivation through game-based interactions. Overall, it can be concluded that this educational game is suitable for use as a learning support tool in elementary schools because it meets the criteria of functionality, usability, and learning effectiveness.

### 5.2. Discussion

For further development, some suggestions that can be considered include the following:

1. Adding more question variations and difficulty levels to make the game more challenging and broaden the scope of fractions.
2. Developing more interactive audio or animation feedback features to strengthen students' understanding of correct and incorrect answers.
3. Integrating an online database-based scoring or learning progress system so that teachers can monitor student progress directly.
4. Conducting trials on larger groups of students to obtain more representative evaluation results. With further development and refinement, it is hoped that this game can become an innovative, engaging, and effective digital learning medium to support the teaching and learning process in elementary schools, particularly in mathematics.

## References

- [1] N. Newton, "Fluency Doesn't Just Happen with Addition and Subtraction," (*Issue Oct. 2019*). <https://doi.org/10.4324/9780429055553>, 2021.
- [2] G. Tosho., "Belajar bersama temanmu: Matematika untuk Sekolah Dasar Kelas V," (*Nila Mareta Murdiyani, Penerjemah*). *Pus. Perbukuan, Kementeri. Pendidikan, Kebudayaan, Riset, dan Teknol. Republik Indones.*, vol. 1, 2021.
- [3] S. Syahrul, S., Arifin, A., Datuk, A., Almu, F. F., & Ramlah, "Pengembangan Bahan Ajar Berorientasi Literasi Kearifan Lokal di Mas Al-Hikmah Soe Nusa Tenggara Timur.," *JPM (Jurnal Pemberdaya. Masyarakat)*, 4(2), 371–379. <https://doi.org/10.21067/jpm.v4i2.3628>, 2019.
- [4] C. Y. Hadijah, S., Aulia, L., & Eviyanti, "Integrasi Budaya Aceh Kedalam Media Pembelajaran," . 04(02), 1143–1152., 2020.
- [5] N. D. Hariyani, I. T., & Fitri, "Pengembangan Game Edukasi 3D untuk Menumbuhkan Cinta Tanah Air Sejak Dini. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*," 7(2), 1354–1367. <https://doi.org/10.31004/obsesi.v7i2.3378>, 2023.
- [6] M. R. Wulandari, "Eksplorasi Tenun Ikat Sumba Timur Ditinjau Dari Etnomatematika. *Satya Widya*," 36(2), 105–115. <https://doi.org/10.24246/j.sw.2020.v36.i2.p105-115>, 2021.
- [7] A. Asmaarobiyah, R., & Arisetyawan, "Efektivitas Permainan Congklak Berbantuan Etnomatematika terhadap Kemampuan Berpikir Kritis Matematis Kelas II Sekolah Dasar," 8(2), 283–300. <https://doi.org/10.29240/jpd.>, 2024.
- [8] C. R. Rahma, G., Asiqin, F., Sumaryana, Y., & Hidayat, "(". GAME EDUKASI PEMBELAJARAN BUDAYA FLORES ANDROID MENGGUNAKAN METODE GAME DEVELOPMENT LIFE CYLCE ( GDLC )," 13(1), 2025.