

EDUCATIONAL MULTIPLAYER GAME DEVELOPMENT "MATH DUEL" AS A MATHEMATICAL LEARNING MEDIA BASED ON ANDROID

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ABSTRACT

Panembong 1 Public Elementary School is a public elementary school as in general which has a mathematics subject as its main subject. Some things learned in basic mathematical operations include multiplication, addition, subtraction, and division. Understanding and mastering the basic operations of mathematics is not difficult to learn, but it still requires a continuous exercise, not only at school but outside of school as well so that calculations can be done quickly and precisely. The problem that occurs is that students regard mathematics as a difficult and tedious subject, so many students have mathematical values under the minimum completeness criteria (KKM). Based on research conducted by Dora Irsa, Rita Wiryasaputra, and Sri Primaini with the research title Designing Early Childhood Learning Education Game Applications Using Android-based Linear Congruent Method (LCM), the results show that early childhood learning applied to educational games can improve interest in learning children. In this educational game can only be played by one player, but in the Math Duel educational game there are multiplayer features so that it can be played by two players who make the game more interesting for students to learn mathematics outside of school hours and help students practice numeracy skills, also increases the scores of mathematics.

Keywords: Educational games, Mathematics, Google Play Games Service API, Multiplayer.

1. INTRODUCTION

Development technology mobile has become a necessity in various aspects of life that cannot be avoided anymore. Almost all activities, especially in entertainment, apply mobile technology seen from the practical, so that many entertainment applications are embedded in mobile technology. With the growth of the entertainment industry that is so fast, the entertainment products produced are increasingly varied, for example in games mobile that continues to grow and innovate to produce games that can entertain users.

Game holds important functions as entertainment advice or education or training for all groups, especially children. Therefore, the game created should have an education or learning function. Learning in the form of a game usually includes early childhood learning such as learning to read and count. Calculating is closely related to mathematics. Mathematics itself is a lesson that has been given since childhood and is always found in everyday life. Mathematics learning is very important to be learned by a child from the time he knows elementary school. In operation basic mathematics learn some p that is multiplication, division, addition, and subtraction. Understanding and mastering the basic operations of mathematics is not difficult to learn, but it still requires a continuous exercise, not only at school but outside of school as well so that calculations can be done quickly and precisely.

Results interviews that have been conducted with 5th grade guardians in SDN Panembong 1 Cianjur regency that the constraints found are 52.78% of students who have math scores below the Minimum Completion Criteria (KKM). The number of students who think learning mathematics is difficult. Students tend to get bored quickly and lose enthusiasm during math lessons done in the normal way. This is reinforced by the results of the questionnaire that has been distributed to 33 grade 5 elementary school students (SD) showing 96.97% of students prefer playing games rather than learning mathematics, even though 66.67% of students like math, 84.85% of students state still felt difficulties in math lessons, and only 15.15% of students studied mathematics outside school hours.

Based on previous research conducted by Dora Irsa, Rita Wiryasaputra and Sri Primaini with the research title Designing Early Childhood Learning Education Game Applications Using Linear Congruent Method (LCM) Based on Android, the results show that early childhood learning such as reading, writing, and numeracy applied to educational games can increase children's learning interest. With the results of testing and distributing questionnaires that have been distributed to the respondents the results reached a percentage of 78.33% stating that the games built can increase children's learning interest [1]. Based on this research, an educational

game will be made with themes and titles EDUCATIONAL MULTIPLAYER GAME DEVELOPMENT "MATH DUEL" AS A MATHEMATICAL LEARNING MEDIA BASED ON ANDROID that can help children to sharpen their numerical skills quickly and precisely with different nuances, interactive, and competitive

2. LITERATURE REVIEW

2.1 Game

According to Erick Zimmerman, and Katie Salen Game is a system that has certain rules, where players will be involved in a problem so that it can produce a result that can be measured namely win or lose. A game is something that is played with a certain rule that is commonly used for pleasure purposes and can also be used as a means of education [2].

2.2 Game Edukasi

Educational Games is a game created to help users learn something, both about concepts, understanding or practice. Designing a good Education game according to Hurd and Jenuings must meet the following criteria [3]:

- a. Overall Value
- b. Usability
- c. Appropriateness
- d. Relevance
- e. Objectives
- f. Feedback

2.3 Google Play Games Multiplayer API

Google Play real-time multiplayer API games (Application Programming Interface) is one of the services provided by Google Play that can be used to connect several players simultaneously into a game and transfer data between connected players [4]. This service can help with game development efforts because the API can handle several tasks as follows [5].

- a. Manage connection network.
- b. Provide the interface.
- c. Save information.
- d. Send invitation.

3. RESEARCH METHODS

3.1 Method Data Collection

Method data collection carried out that is with way studies literature, share questionnaire, do observation and interviews at Panembong 1 District Elementary School Cianjur.

3.2 Methods of Software Development

In development This application uses the Luther - Sutopo version method. According to Luther multimedia development methodology consists of 6 stages, namely concept, design, material collecting, assembly, testing, and distribution. Sutopo adopted Luther's methodology by modifying the stages. Of the six stages of multimedia development methodology

put forward by Luther, according to Sutopo, the concept must begin and end with the distribution stage [6].

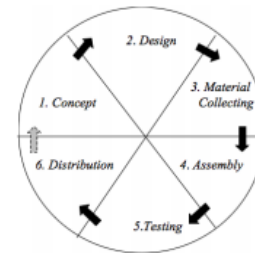


Figure 1. Multimedia Development Methodology Luther – Sutopo

As for the stages of the Luther - Sutopo version as shown in Figure 1 :

a. Concept

The purpose of the development of this Math Duel education game is for the final assignment with the target user is the fifth grade of elementary school. This game is in the form of an educational game that aims to be a companion medium to train math skills outside of school hours.

b. Design

At the design stage, determined the style of the game to be built. The style of play in this educational game is to answer the questions raised to get points and win the game.

c. Material Collecting

At the collecting material stage, materials are collected according to the needs such as pictures to be used in the game, for example button images, characters, trees, and others. Then collect the sound that will be used in the game.

d. Assembly

The assembly stage is made based on the design stage. The manufacturing phase is done by using Unity as a game programming tool and photoshop to make also changing images, characters, and other materials.

e. Testing

Testing is done after the manufacturing phase is complete and all game data has been entered. The testing phase is done in two stages, namely by using blackbox testing as a functional test and questionnaire as an assessment of the game that has been built.

f. Distribution

Distribution that will be done is by uploading games that have been built into the internet, which later students can download the game to be installed on an android smartphone.

4. RESULTS AND DISCUSSION

4.1 Concept

The concept stage is the stage to determine who this application is intended for. In addition to determining what type of application will be made and the purpose of the application development.

4.1.1 User Analysis

User analysis is an analysis of the game users that will be built, so that the level of understanding of the user can be known. User needs in the development of this game are divided into two, namely as follows.

a. User Experience and Knowledge

Table 1 shows the experience and knowledge of users who are expected to run this game.

Table 1 User Experience and Knowledge

User Experience and Knowledge	
Application experience	can run or use an application or play a game.
Android knowledge	Can operate an Android smartphone.
Typing Ability	Does not require high typing skills.
Language skill	Able to speak Indonesian.
Reading Ability	Can be used by various levels of education with moderate reading skills.

b. User Characteristics

Table 2 shows the characteristics of users who are targeted to play this game.

Table 2 User Characteristics

User Characteristics	
Education	Primary school
User	Children
Age	10 to 12 years old
Gender	Male or Female
Disability	No

4.1.2 Game Objective Analysis

The purpose of the development of this game is to make students interested in learning mathematics outside of school hours, while at the same time facilitating students to sharpen their numeracy skills and make mathematics learning more interesting and fun for students, so as to increase the value of student mathematics.

4.1.3 Analysis of Built Games

The game that will be built has the name "Math Duel" which can be interpreted as a mathematical battle between two players. The concept that will be built in this game is an interactive educational game aimed at 5th grade students. This game utilizes multiplayer technology provided by Google Play Games API. This educational game is also built with 2-dimensional (2D) graphics. The description of the application in this educational game is as follows:





- a. This educational game is used as a companion medium for students to hone numeracy skills outside of school hours.
- b. This educational game is playing while learning.

- c. The game is played by touching and pressing (tapping). Tapping is used instead of the mouse function that players use to interact by touching the screen on the smartphone.
- d. Each question applied to this game has various levels of difficulty based on 5th grade elementary school mathematics learning material with the 2013 curriculum.

4.1.4 Character Analysis

In a game, character is one of the most important factors to keep the game interesting and players don't get bored quickly when the game takes place [7]. Table 3 explains the analysis of characters in the game that was built.

Table 3 Character Analysis

No	Gambar	Deskripsi	Sumber
1		<ol style="list-style-type: none"> 1. Karakter <i>player</i> 1. Karakter ini akan digunakan untuk <i>player</i> 1 pada permainan tanding (<i>Multiplayer</i>). 2. Karakter berupa siswa sekolah dasar yang memakai baju olah raga dan topi berwarna biru. 	Adobe Photosbop
2		<ol style="list-style-type: none"> 1. Karakter <i>player</i> 2. Karakter ini akan digunakan untuk <i>player</i> 2 pada permainan tanding (<i>Multiplayer</i>). 2. Karakter berupa siswa sekolah dasar yang memakai baju olah raga dan topi berwarna merah. 	Adobe Photosbop
3		<ol style="list-style-type: none"> 1. Karakter <i>player</i> ini digunakan pada permainan mode latihan (<i>Single Player</i>). 2. Karakter berupa seorang pria dengan baju seperti para petualang. 	finalbossblues.itch.io
4		<ol style="list-style-type: none"> 1. Karakter ini digunakan untuk mengganggu <i>player</i> pada permainan mode latihan (<i>Single Player</i>). 2. Karakter berupa seskor monster yang berwarna hijau dan memiliki tubuh bulat. 	finalbossblues.itch.io

4.1.5 Material analysis

Mathematics lesson material to be used in the Math Duel educational game can be seen in Table 4.

Table 4 Material Analysis

Chapter 1	Addition and Reduction of Fractions
Basic Competencies	a. Menyamakan Penyebut Pecahan Berpenyebut Berbeda
	b. Penjumlahan Pecahan Dengan Penyebut Berbeda
	c. Pengurangan Pecahan Dengan Penyebut Berbeda
	d. Penjumlahan dan Pengurangan Desimal
	e. Penjumlahan dan Pengurangan Persen
Chapter 2	Multiplication and Fraction Distribution
Basic Competencies	a. Perkalian Pecahan Biasa
	b. Perkalian Pecahan Campuran
	c. Perkalian Bilangan Persen
	d. Pembagian Pecahan Biasa
	e. Pembagian Pecahan Campuran
Chapter 3	Comparison
Basic Competencies	a. Perbandingan Dua Besaran Berbeda

Chapter 4	Scale
Basic Competencies	a. Penggunaan Perbandingan Pada Skala
	b. Perhitungan Skala
	c. Aplikasi Skala Dalam Luas Bangun Datar
Chapter 5	Space Build Volume
Basic Competencies	a. Volume Balok
	b. Volume Kubus
Chapter 6	Space Build Nets
Basic Competencies	a. Mengingat Kembali Unsur-Unsur Bangun Ruang Sederhana (Balok Dan Kubus)
	b. Jaring-Jaring Bangun Ruang Sederhana (Balok Dan Kubus)
	c. Luas Permukaan Bangun Ruang Balok Dan Kubus

4.1.6 Question Analysis

Question analysis is done to find out how the process of making questions will be applied to the game. For example in the Math Duel educational game it has several types of questions as in Table 5.

Table 5 Question Analysis

No	Persamaan	Keterangan
1	$\frac{a}{b} + \frac{c}{d}; \frac{a}{b} - \frac{c}{d};$ $\frac{a}{b} : \frac{c}{d}; \frac{a}{b} \times \frac{c}{d}$	Operasi pecahan dengan penyebut berbeda. Dengan ketentuan sebagai berikut: $0 < a \leq b; a < c; b < d$
2	$a \times b$	Perkalian Desimal. Dengan ketentuan sebagai berikut: $0 < a < b;$
3	Jika sebuah kendaraan menempuh jarak a km dalam waktu b jam. Berapa kecepatan kendaraan tersebut?	Perbandingan dua besaran berbeda. Dengan ketentuan sebagai berikut: $10 \leq a < b;$
4	Sebuah miniatur gedung dibuat dengan skala 1: a. Jika tinggi gedung tersebut adalah b cm, tentukan tinggi sebenarnya!	Perhitungan skala. Dengan ketentuan sebagai berikut: $100 \leq a > b;$
5	Permukaan sebuah kolam berbentuk persegi panjang, diFigure dengan skala 1: 100. Panjang pada Figure a cm dan lebar b cm, tentukan luas kolam sebenarnya!	Aplikasi skala dalam luas bangun datar. Dengan ketentuan sebagai berikut: $0 < a, b;$
6	Tentukan volume balok yang memiliki panjang p cm dan lebar l cm dan tinggi t cm.	Volume balok. Dengan ketentuan sebagai berikut: $0 < p, l, t;$

No	Persamaan	Keterangan
7	Tentukan volume kubus yang memiliki sisi S cm.	Volume kubus. Dengan ketentuan sebagai berikut: $0 < S;$
8	Berapa luas balok dengan panjang p cm dan lebar l cm dan tinggi t cm?	Luas balok. Dengan ketentuan sebagai berikut: $0 < p, l, t;$
9	Tentukan luas kubus yang memiliki sisi S cm.	Luas kubus. Dengan ketentuan sebagai berikut: $0 < S;$

Then the variables a, b, c, d, p, l, t, and S will be filled with a number that matches the predetermined criteria. Then the system will automatically calculate to get the correct result or answer from the question formula. The results of these calculations will be placed randomly on the answer buttons available in the game.

4.2 Analysis of Non-Functional Requirements

Analysis of non-functional requirements is the analysis needed to determine the specifications of requirements outside the system. This specification includes the devices or elements needed by the system to be built until the system can be implemented. Analysis of non-functional requirements in this educational game includes, hardware analysis, software analysis, and user analysis.

4.2.1 Hardware Requirements Analysis

Analysis of hardware requirements that can be used to run the Math Duel educational game can be seen in Table 6.

Table 6 User Hardware Requirement Minimum Analysis

No	Perangkat Keras	Keterangan
1	Processor	ARMv7 CPU dengan NEON support atau Atom CPU
2	Layar	Touchscreen
3	RAM	512 MB
4	Graphic Card	OpenGL ES 2.0
5	Storage	512 MB

4.2.2 Software Requirements Analysis

Analysis of software requirements that can be used to run the Math Duel educational game can be seen in Table 7.

Table 7 User Software Requirement Minimum Analysis

No	Perangkat Lunak	Keterangan
1	Operating System	Android: OS 4.1
2	Support App.	Google Play Game 5.13

4.3 Functional Needs Analysis

Functional needs analysis is carried out to describe the process that will be applied to a system and explain the requirements needed by the system so that it can run properly in accordance with predetermined requirements.

4.3.1 Use Case Diagram

Use case diagram is a way to describe the interaction between actors and the functionality expected in a system [8]. Figure 2 shows the Use Case Diagram in the game that will be built.

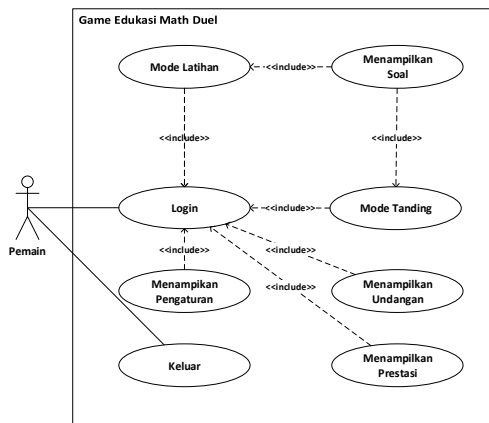


Figure 2 Use Case Diagram

4.3.2 Class Diagram

Class Diagrams explain the relationships between classes that contain the names of classes, attributes, methods and relations between classes. Each class describes the type and nature of the method itself [8]. Figure 3 shows the Class Diagram in the game that will be built.

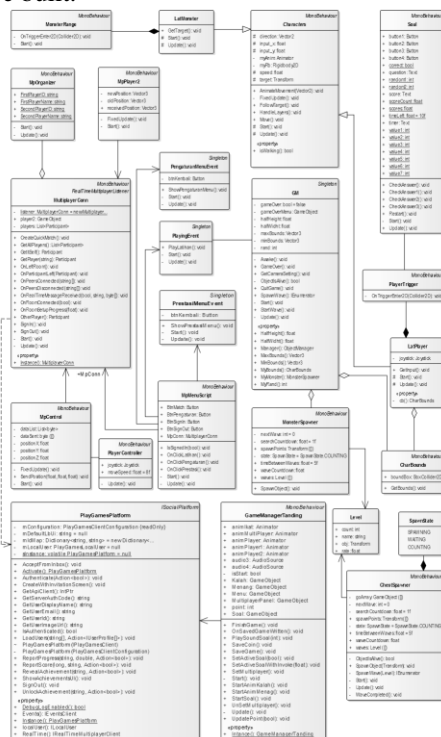


Figure 3 Class Diagram

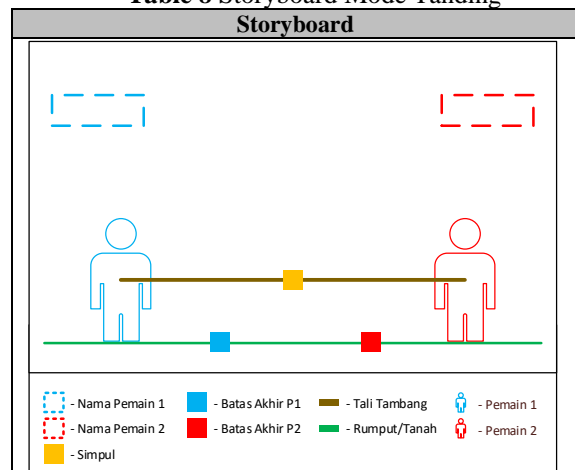
4.4 Design

The design stage is the stage of making specifications regarding the style of the game (storyboard), appearance and material requirements based on the concepts that have been made.

4.4.1 Storyboard

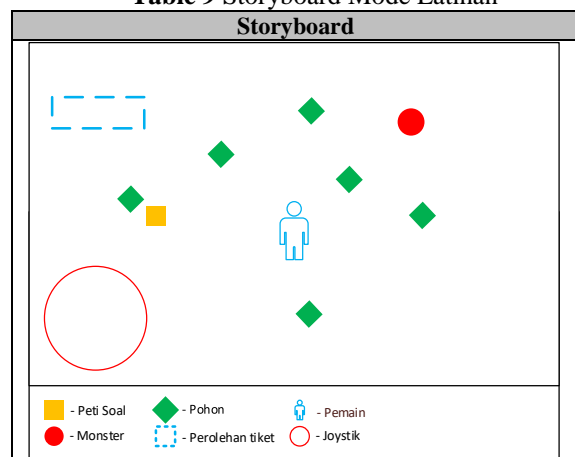
Table 8, 9, and 10 show the storyboard in the Math Duel educational game.

Table 8 Storyboard Mode Tanding



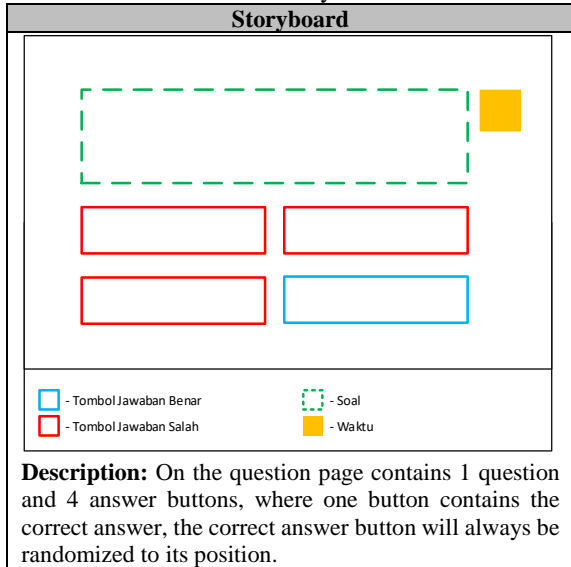
Description: At this stage is a match mode game where players will face each other 1 to 1 to win the tug of war game, the player must answer questions faster than the opponent to be able to draw the knot to close to his deadline, the game is complete when the node is at the end of one player, the player who is declared winning when the node is at the end of his possession.

Table 9 Storyboard Mode Latihan



Description: At this stage is a training mode game where the player has to look for a chest containing questions that must be answered, the player gets 1 ticket each answer the question correctly, the game ends when the player is caught by roaming monsters.

Table 10 Storyboard Soal
Storyboard



4.5 System Design

At this stage it will be explained about the system design in the educational game that will be built such as the design of game material, menu structure design, interface design, message design and semantic network.

4.5.1 Designing Menu Structure

Figure 4 shows the design of the menu architecture of the system to be built.

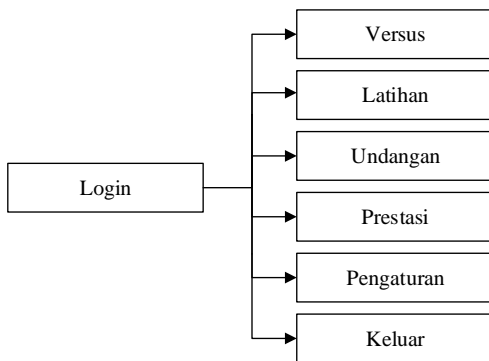


Figure 4 Menu Structure

4.6 Interface Implementation

Interface implementation is carried out according to the interface design stage. Following is the interface implementation in the Math Duel educational game.

4.6.1 Login Interface Implementation

Figure 5 shows Interface Implementation login in Math Duel educational game.

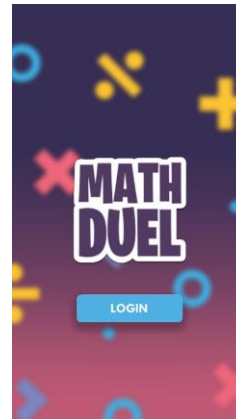


Figure 5 Login Interface Implementation

4.6.2 Main Menu Interface Implementation

Figure 6 shows the main menu interface implementation in the Math Duel educational game.

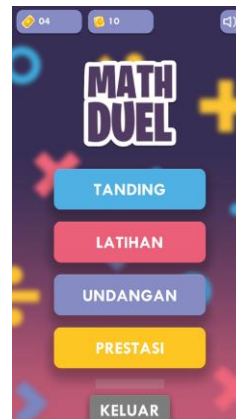


Figure 6 Main Menu Interface Implementation

4.6.3 Tanding Interface Implementation

Figure 7 shows the Interface Implementation of the match mode in the Math Duel educational game.

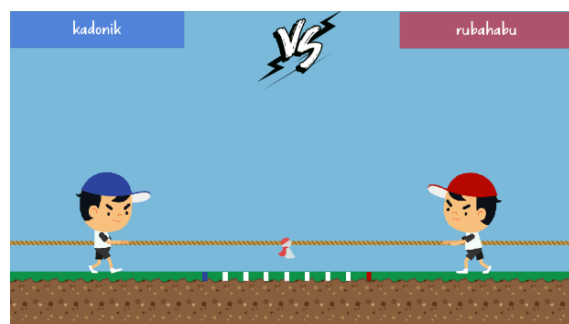


Figure 7 Interface Implementation Mode Tanding

4.6.4 Latihan Interface Implementation

Figure 8 shows the Interface Implementation training mode in the Math Duel educational game.

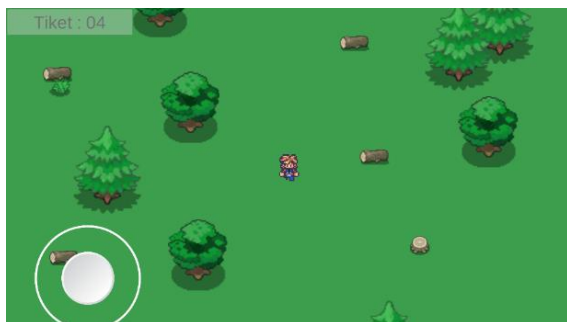


Figure 8 Interface Implementation Mode Latihan

4.6.5 Questions Interface Implementation

Figure 9 shows the Interface Implementation questions in the Math Duel educational game.

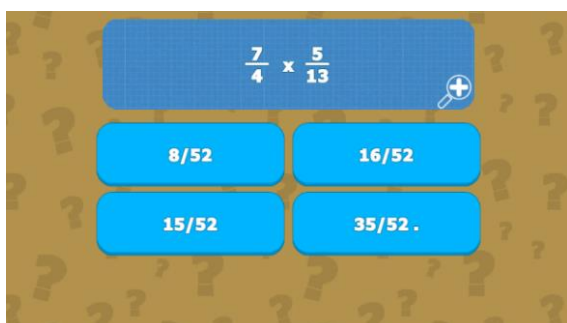


Figure 9 Interface Implementation Soal

4.6.6 Invitations Interface Implementation

Figure 10 shows the Interface Implementation invitation to the Math Duel educational game.

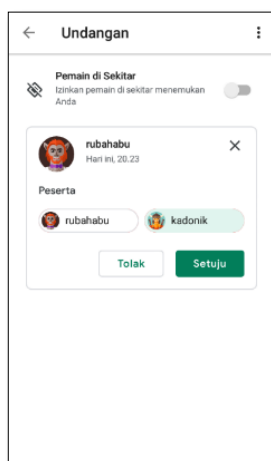


Figure 10 Invitation Interface Implementation

4.7 System Testing

Testing the Math Duel educational game consists of blackbox testing and beta testing in the form of questionnaires.

4.7.1 Blackbox Test Results

The case and test results move the characters in the Math Duel educational game can be seen in Table 10

Table 11 Testing Moves Character

Kasus dan Hasil Uji (Data Benar)			
Data Masukan	Hasil yang Diharapkan	Pengamatan	Kesimpulan
Masukan: direction: x = 3, y = 0	Karakter bergerak sesuai arah masukan	Karakter dapat bergerak sesuai dengan arah masukan	Sesuai
Kasus dan Hasil Uji (Data Salah)			
Data Masukan	Hasil yang Diharapkan	Pengamatan	Kesimpulan
Masukan: direction: x = a, y = b	Karakter tidak bergerak	Karakter tidak bisa bergerak	Sesuai
Kasus dan Hasil Uji (Data Kosong)			
Data Masukan	Hasil yang Diharapkan	Pengamatan	Kesimpulan
Masukan:	Karakter tidak bergerak	Karakter tidak bisa bergerak	Sesuai

4.7.2 Conclusion of Blackbox Testing

Based on the results of the blackbox testing that has been done on the Math Duel Educational Game there are no process errors and functionally it has been running in accordance with the expected results. Then the conclusion is that testing has met the needs of the system in accordance with the needs of the software designed.

4.7.3 Beta Testing Questionnaire

The questionnaire was given to 34 class V students of Panembong 1 Public Elementary School, Cianjur Regency. Table 11 shows the criteria for the Likert scale score in the beta testing questionnaire.

Table 12 Likert Scale Score Criteria

Answer	Description	Score	Percentage
SS	Strongly Agree	5	> 80% - 100%
S	Agree	4	> 60% - 80%
N	Neutral	3	> 40% - 60%
TS	Disagree	2	> 20% - 40%
STS	Strongly Disagree	1	0% - 20%

4.7.4 Questionnaire Results

The following are the results of beta testing which can be seen in Table 12

Table 13 Hasil Kuisisioner

No	Questions	Score Percentage
1	Does the Math Duel educational game make you interested in learning mathematics outside of school hours?	81,18%
2	Is this Math Duel educational game easier for you to hone your numeracy skills?	80,59%
3	Does this Math Duel educational game make math learning more interesting and fun?	82,94%
4	Does this Math Duel education game help you in increasing the value of math subjects?	79,41%

No	Questions	Score Percentage
5	Is the multiplayer feature in the Math Duel educational game, adding to the fun of learning mathematics?	79,41%
6	Does this Math Duel educational game have attractive and easy-to-use appearance and images?	84,12%

4.7.5 Conclusion of Beta Test Results

Based on the results of beta testing on the Math Duel Educational Game, the overall attitude of the respondents can be concluded that this game makes students interested in learning mathematics outside of school hours, while facilitating students to sharpen their numeracy skills and make mathematics learning more interesting by adding multiplayer features. increase fun while playing while learning, so that it can increase the value of students' mathematics.

5. CLOSING

5.1 Conclusion

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

- The Math Duel educational game can make 81.18% of students interested in learning mathematics by making this game as a companion media for students to study mathematics outside of school hours.
- Math Duel educational game makes it easy for students to sharpen their numeracy skills by making mathematics learning more interesting and fun.
- The Math Duel educational game can increase 79.41% of the value of student mathematics.

5.2 Suggetion

Based on the results that have been achieved, suggestions for the development of the Math Duel educational game are better in the future, among others:

- Development to be used in all devices (multiplatform).
- Can be used for math subjects in all classes by adjusting the content.
- Add features to manage questions that make the presentation of questions more dynamic and varied, so that students can be more familiar with various kinds of mathematical questions.

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