

# Development of RPG-Based Mathematics Educational Games with the Waterfall Method on Fraction Material for Elementary School Students

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**Abstract:** Mathematics is one of the subjects that plays an important role in everyday life and in developing logical thinking and problem-solving skills. One of the topics that often poses a challenge for elementary school students is fraction numbers. Fractions are often considered an abstract and difficult concept to understand because they involve numerical representations that differ from whole numbers. This difficulty frequently leads to a lack of interest in learning mathematics, ultimately affecting students' academic performance. The data collection stages applied include interviews, observations, and the distribution of questionnaires. The development of this learning media follows the Waterfall model, which aims to design improvements to the existing system. The results of the User Acceptance Test reveal that this game received a user perception score of 90.5%, categorizing it as "very good," indicating that students find it both enjoyable and effective as a learning tool. This suggests that the game is not only engaging but also effective in helping students understand fraction concepts in a more interactive and enjoyable way. With the presence of story elements, challenges, and engaging game mechanics, students can learn in a more immersive manner compared to conventional methods. Therefore, this game is suitable for use as a mathematics learning tool, particularly in understanding fraction operations such as addition, subtraction, multiplication, and division.

**Keywords:** Development; game; RPG; Mathematic; Fraction Number

## INTRODUCTION

Mathematics is one of the core subjects in the education curriculum in Indonesia, including at the elementary school level (Mubharokh et al., 2021). One of the topics that often poses a challenge for students is fractions. This concept is considered difficult due to its abstract nature and the need for deep understanding (Hartanto et al., 2024). Many students struggle to understand fractions in real-life contexts, which ultimately affects their learning outcomes. A key factor contributing to this problem is the lack of variation in teaching methods and the limited use of interactive media (Anggraeni et al., 2021).

One potential innovation is the development of an RPG-based educational game (Nathanufa & Zailani, 2023). This game can offer interactive, fun learning that is relevant to the needs of students in the digital age. Through this approach, students can learn fractions more effectively through a story and challenges specifically designed for them (Kuwayyis et al., 2023). Moreover, the RPG-based educational game is expected to enhance students' learning motivation and help them deeply understand the concept of fractions. With the development of information and communication technology, opportunities have emerged to create innovations in learning, including in the field of mathematics.

The use of educational games has become a growing focus in mathematics education, especially for elementary school students. A key area of interest is improving students' understanding of fractions, a fundamental concept in mathematics (Nicolò et al., 2023). Researchers have examined the potential benefits of educational games, including those based on role-playing formats, to boost student engagement and enhance their learning outcomes (Ke, 2008; Nicolò et al., 2023; Hardiyanti & Azizah, 2019).

When creating an RPG-based educational game centered around fractions, it is essential to consider how the game's core mechanics align with the learning goals. Games that inherently integrate the concept being taught—

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referred to as intrinsic games—have been found to be more effective in fostering deep learning than extrinsic games, which are typically used for review or general practice. Furthermore, it is important to take students' prior knowledge into account, as research suggests that those with more background knowledge tend to perform better when learning through gameplay (Chen & Ren, 2013). By developing an RPG-based game focused on fractions, educators can utilize the engaging and immersive nature of games to boost students' motivation and interest, ultimately enhancing their understanding of this vital mathematical concept.

Recent research has looked into how educational computer games influence students' academic performance and their attitudes toward mathematics. The results suggest that integrating game-based elements into math instruction can foster greater interest, motivation, and commitment to learning tasks, while also leading to performance that is either on par with or better than traditional, non-game-based teaching methods (Nicolò et al., 2023). Additionally, studies have emphasized the effectiveness of game-based learning environments in deepening students' understanding of mathematical concepts, particularly in number knowledge, including fractions (Nicolò et al., 2023).

In the era of Education 4.0, integrating technology into learning has become an urgent need. According to Miranti et al. et al. (2023), the development of technology-based learning media, such as educational games, provides an effective alternative to overcome the limitations of traditional learning methods (Imtiyaz, 2023). Therefore, this research aims to develop and evaluate the effectiveness of an RPG-based educational mathematics game on fractions to improve the quality of learning, motivation, and student learning outcomes, as well as to help teachers deliver lessons in a more engaging and meaningful way.

The effectiveness of RPG-based educational games is not only measured by improvements in students' motivation and learning outcomes but also by their ability to assist teachers in delivering lessons in a more engaging and meaningful way (Novayanti & Wijaya, 2023). In teaching fractions, this educational game is designed to integrate elements of entertainment, technology, and education, providing a fun learning experience for students while also making it easier for teachers to explain complex concepts (Helsa et al., 2021).

This research focuses on the development of an RPG-based educational mathematics game for elementary school students at SD Negeri Panunggangan 1 Cibodas. The choice of this school is based on the need for learning innovations that can improve students' interest, motivation, and achievement. According to Adrillian et al. (2024), this educational game is designed not only as a learning aid but also as a means to enhance students' critical thinking and problem-solving skills.

## LITERATURE REVIEW

### RPG

Role-Playing Game (RPG) is a game genre that allows players to take on the role of a character in a fictional world and experience a story that develops based on their choices and actions (Khair, 2023). RPGs generally feature elements such as world exploration, character development, leveling systems, and deep storytelling. In these games, players often have the ability to customize their characters with various skills, weapons, and attributes that influence gameplay. Additionally, RPGs can be action-based with real-time combat or turn-based, where players must devise strategies to defeat enemies.

### Mathematics

Mathematics is the science that studies quantities, structures, space, and change through the use of symbols and logical rules (Das, 2020). This discipline encompasses various branches such as arithmetic, algebra, geometry, and statistics, which are used to analyze patterns, solve problems, and understand relationships between numbers and shapes. Mathematics plays a crucial role in various aspects of life, including science, technology, economics, and engineering, as it aids in decision-making and problem-solving in a systematic and rational manner.

### Fraction Number

A fraction is a mathematical concept used to represent a part of a whole. A fraction consists of a numerator, which indicates the number of parts taken, and a denominator, which represents the total number of equal parts (Empson, 2021). There are several types of fractions, including proper fractions, mixed fractions, decimal fractions, and percentages, each used in different contexts. The basic operations on fractions include addition, subtraction, multiplication, and division, which require an understanding of equivalence and common denominators. The concept of fractions is essential in everyday life, particularly in finance, measurement, and scientific calculations.

## METHOD

This study is a research and development (R&D) study using the Waterfall method. In this study, a qualitative research method was used to collect the necessary data. This qualitative approach was carried out through careful data analysis so that the gathered information could be interpreted clearly and reflect the actual reality or situation.

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The data collection stages applied include interviews, observations, and the distribution of questionnaires. The research was conducted at SDN 1 Panunggangan 1 Cibodas, involving 40 students for the application trial and questionnaire filling. Below is an illustration of the waterfall method

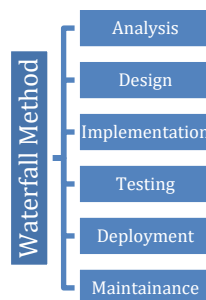


Figure 1. Waterfall Method

### Analysis Stage

In the analysis stage, the focus is on understanding the phenomena and problems that arise, as well as the reasons why creating an application is crucial to addressing these issues or phenomena. This analytical ability is not only the responsibility of programmers but can also be carried out by experts in economics and social-political sciences.

### Design Stage

The next step is to design the system. This stage includes the development of the system's interface design and the overall system flow. It involves creating use cases to design the display, button functions, and the arrangement of system input/output to ensure the system functions properly.

### Coding Stage

Coding is the step that must be carried out by individuals who have a good understanding of programming languages. In this stage, the system design that was created will be implemented through writing code and scripts so that the system can run smoothly and function as expected.

### Testing Stage

After coding is completed, the system will undergo testing before being released to the market for user use. The testing process involves checking whether the system works properly, whether the interface displays as expected, and whether all the system's functions can be used effectively and smoothly. In this study, the Android-based game application was tested at SDN Panunggangan 1 Cibodas, with 40 students involved.

### Implementation and Maintenance Stage

The implementation and maintenance stage focuses on system updates that may be necessary, repairs to address system malfunctions and corruption, as well as the addition of new features to the system. This process heavily depends on user needs, and if carried out well, the system will be able to evolve successfully. SD Negeri Panunggangan 1 Cibodas is a public elementary school located in the Cibodas sub-district, Tangerang City, Banten. It was established on January 1, 1970, under the Ministry of Education and Culture. The school, which has 253 students, is guided by 11 professional teachers in their respective fields. In the user requirement section, the final draft elicitation, which will later be tested, is the result of the final process of elicitation stages that can be used as a guide and foundation for development. Based on the third elicitation stage, the result is the final draft of the requirements, which is expected to help the author design the system.

## RESULT

The author has developed a mobile application-based learning media with the principle of "Belajar Sambil Berpetualang" which combines the material of fractional numbers in mathematics with entertainment elements. This learning media is equipped with interactive elements that allow students to interact with the multimedia content presented. The content in this learning media is designed in an engaging way, using animations, narration, and entertaining background music. The aim is to make learning more engaging and interactive for users. It is hoped that this learning system will provide significant benefits for both teachers and students during classroom activities. The main success expected from the developed learning media is to provide a more accessible and

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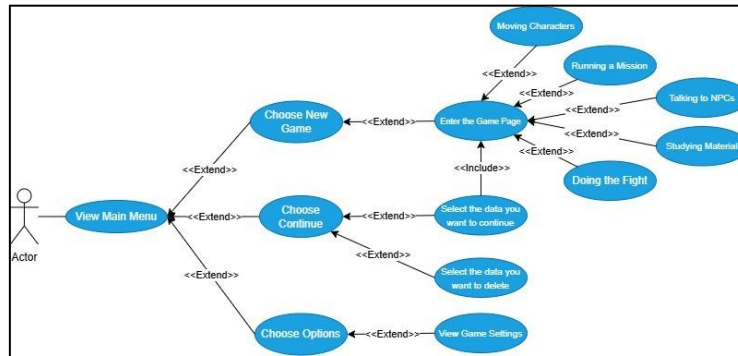


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engaging learning experience. The system design aims to structure it in a way that allows data flow within the program to be smoother, with the goal of facilitating the creation of the system so that it can be developed more easily.

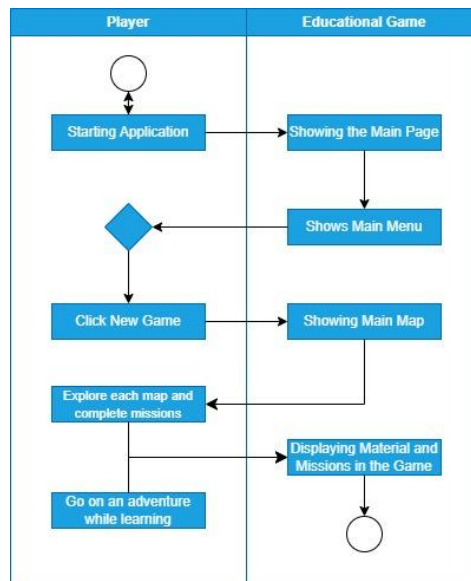
**Use Case Diagram, Activity Diagram, and Sequence Diagram**

In this stage of the research, the author uses an activity diagram as part of the Unified Modeling Language (UML) design, which includes the use case diagram, activity diagram, and sequence diagram for the running system. Below is an overview of the diagrams in the system design:



**Figure 2.** Proposed Use Case Diagram

The image above depicts the scenario in the use case diagram, which includes the sequence of events or flow of occurrences from start to finish in the interaction between the actor and the main use case.

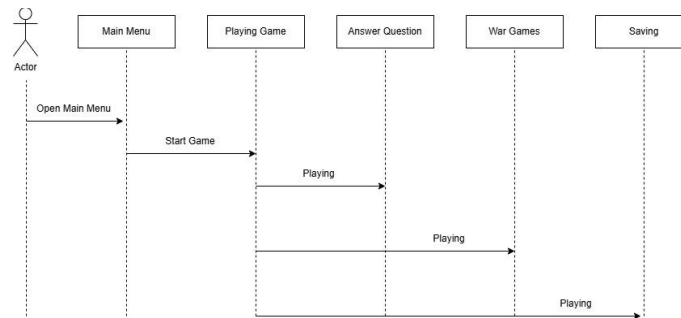


**Figure 3.** Activity Diagram

The Activity Diagram is a visual representation of the flow of activities or processes that will be executed within a system. In the image above, there is a party acting as a single user, who controls the system by starting the application. The system will respond by displaying the initial page of the application after it is launched. After that, the user will select the "Start Application" option, and the system will display the page selected by the user.

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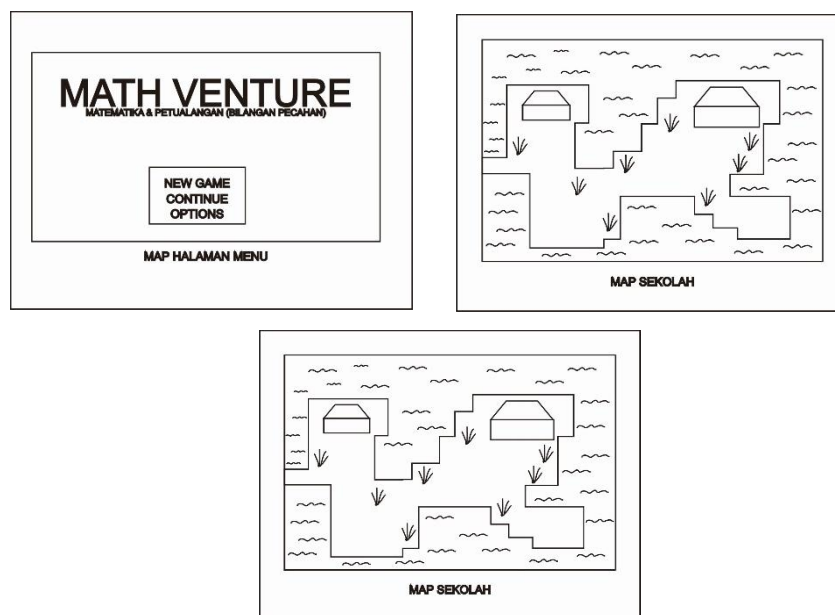


**Figure 4.** Sequence Diagram

In the image above, the Sequence Diagram shows that when the user opens the application, they will be directed to the Main Page first. On the main page, there are "Start" and "Instructions" menus. The user clicks the "Play" menu, which directs them to a menu page containing the "New Game," "Continue," and "Options" menus.

**Storyboard Main Page Display**

Storyboard is a tool used to simplify the process of developing educational media applications. This tool combines narration with visual elements on a single sheet, ensuring the integration of text and visuals. Its function is similar to an initial sketch created to design an object before it is produced. The final result of this application design is the development of educational media for teaching fractions to fifth-grade students at SD Negeri Panungangan 1 Cibodas, with the following design:



**Figure 5.** Storyboard of the Main Page Display in the Game Application

In Figure 5, the process of creating the storyboard for the main page display of the game application is shown, which will later become the Main Menu in the Math Venture game. The main map display in the game application will serve as the starting point for the player's adventure in Math Venture. The school map display in the game application will later become the first mission in the player's Math Venture adventure. The park map display in the game application will later become the second mission in the player's Math Venture adventure.

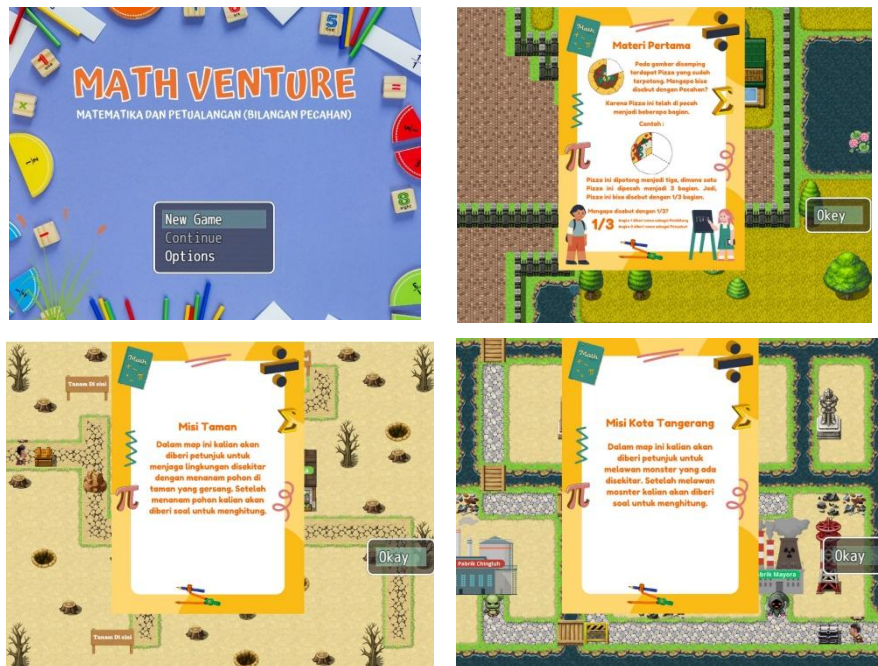
**RPG Maker MV Application**

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Next, the application was developed using RPG Maker MV and converted to Android, resulting in the game application with the following display:



**Figure 6.** Display in the Game Application

The process of designing the main page display for the game application, which will later become the Main Menu or Main Page in the Math Venture player's adventure. The Main Map display in the game application will later become the main map at the start of the Math Venture player's adventure. The School Map display in the game application will later serve as the first mission in the Math Venture adventure, where the player will adventure and learn Mathematics within this map. The Park Map display in the game application will later become the second mission in the Math Venture adventure. The player will continue the second mission in this map by cleaning up trash and counting how much trash is in this map. The process of designing the Tangerang City map display for the game application, which will later become the final mission in the Math Venture player's adventure. The player will be guided to complete the final map, where they will adventure within the Tangerang City map.

**Blackbox Testing**

Blackbox Testing is used to test the specific functions of the designed software. The validity of the test is determined by the output produced from the input data or conditions provided for the existing functions, without considering how the process generates that output. From the generated output, the program's ability to meet the user's needs can be measured, and any errors can be identified. The results of the Blackbox Testing can be shown in Table 1.

**Table 1.** Results of Blackbox Testing

Menu/Features	Testing	Input	Expected Output	Results
Main page	New game button	Press the new game button	Switch to the main city page	Valid
Main city page	Direction controls	Press up, down, right, and left keypad	Move according to the pressed direction	Valid
Main city page	Read material	Press the enter button	Display the material	Valid
School map page	Direction controls	Press up, down, right, and left keypad	Move according to the pressed direction	Valid

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School map page	Answer quiz	Select an answer in the provided column	Multiple-choice display	Valid
Park map page	Direction controls	Press up, down, right, and left keypad	Move according to the pressed direction	Valid
Park map page	Answer quiz	Select an answer in the provided column	Multiple-choice display	Valid
Tangerang city map page	Direction controls	Press up, down, right, and left keypad	Move according to the pressed direction.	Valid
Tangerang city map page	Battle/fight	Press up, down, right, left keypad, and press enter	Fight against available monsters	Valid
Tangerang city map page	Answer quiz	Select an answer in the provided column	Multiple-choice display.	Valid

Based on the Blackbox Testing that has been conducted, it can be seen that the test results show a "valid" value for all, meaning that the game application is in accordance with the output expected by the application developers.

### Results of the User Acceptance Test (UAT)

User Acceptance Test (UAT) is a testing process conducted by users, with the output being a test result document that can serve as evidence that the software has been accepted and meets the required needs. In the UAT, this game will involve 40 elementary school students as respondents. To conduct the User Acceptance Testing, the respondents will answer 4 questions related to the game. Each question has 4 response scales, as shown in Table 2.

**Table 2.** Scale Used

No.	Scale	Test Results
1	Strongly Agree	4
2	Agree	3
3	Disagree	2
4	Strongly Disagree	1

The answers to each question in the user acceptance testing conducted with 40 students can be shown in Table 3.

**Table 3.** UAT Scale

No.	Question	Test Results			
		SA	A	D	SD
Q1	Is this game easy to use and easy to understand?	25	15	0	0
Q2	Do you need someone's help when playing this game?	24	16	0	0
Q3	Is the material in this game easy to understand?	30	9	1	0
Q4	Does this game help you learn mathematics?	24	11	5	0
Q5	Can this game be used as a new learning medium?	29	9	2	0

Based on the answers to each question, the results of the user acceptance testing were obtained, as shown in Table 4.

**Table 4.** Results UAT

No	Total Score	Percentage	Indicator Category
Q1	145	90,63%	Very good

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Q2	144	90%	Very good
Q3	149	93,13%	Very good
Q4	139	86,88%	Very good
Q5	147	91,88%	Very good
Average	144,8	90,5%	Very good

Based on the results of the User Acceptance Test, a user perception score of 90,5% was obtained, which falls into the "very good" category indicator. Therefore, this game is suitable for use in mathematics learning.

### DISCUSSIONS

A Role-Playing Game (RPG)-based game in fraction learning provides an innovative approach to teaching mathematical concepts by offering an interactive and immersive experience. Through a story-driven narrative, students embark on various missions and challenges that require them to apply fraction operations such as addition, subtraction, multiplication, and division (Saputra et al., 2024). Unlike traditional learning methods, this game enables students to engage actively with fractions in a meaningful way, reinforcing their understanding through practical application in a simulated game world. The results of the User Acceptance Test reveal that this game received a user perception score of 90.5%, categorizing it as "very good," which suggests that students find it enjoyable and effective as a learning tool.

The high level of user acceptance highlights the effectiveness of this RPG game in making fraction learning more engaging and accessible. The combination of dynamic interactions, diverse challenges, and captivating game elements ensures that students remain interested and motivated throughout the learning process (Damayanti, 2023). By integrating gamification aspects such as point systems, level progression, and rewards, the game encourages students to persist in their learning journey (Viorika, 2023). This structured yet enjoyable approach makes learning fractions more appealing compared to conventional teaching methods, where abstract concepts can often feel overwhelming for students.

Furthermore, the RPG-based game fosters critical thinking, problem-solving skills, and a deeper conceptual understanding of fractions. As students navigate through the game world, they must strategize and make decisions based on their mathematical knowledge, reinforcing their ability to apply fractions in real-world scenarios. The immersive nature of the game also promotes independent learning, allowing students to explore and experiment with different fraction operations at their own pace. Given its effectiveness in engaging students and improving their comprehension, this RPG game stands as a promising alternative to traditional fraction-learning methods, making mathematics both fun and educational (Bulan et al., 2023).

As a suggestion, further development can be carried out to enhance the variety of challenges and difficulty levels in the game, allowing it to adapt to students of different skill levels. Additionally, extra features such as multiplayer mode or student competitions can be introduced to boost learning motivation through social interaction. Regular evaluations and updates are also necessary to ensure the game remains relevant and aligned with learning needs. With continuous development, this RPG game can become an even more effective tool in improving students' understanding of fractions while making mathematics learning more engaging and enjoyable.

### CONCLUSION

Based on the results of the User Acceptance Test, the Role-Playing Game (RPG)-based game on fraction material received a user perception score of 90.5%, which falls into the "very good" category. This indicates that the game is not only engaging but also effective in helping students understand fraction concepts in a more interactive and enjoyable way. With the presence of story elements, challenges, and engaging game mechanics, students can learn in a more immersive manner compared to conventional methods. Therefore, this game is suitable for use as a mathematics learning tool, particularly in understanding fraction operations such as addition, subtraction, multiplication, and division.

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