DEVELOPMENT OF RESPIRATORY SYSTEM RPG GAME USING UNITY WITH A* (A STAR) ALGORITHM

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Abstract *- This research addresses the need for more engaging and interactive methods to improve elementary students' understanding of complex scientific concepts, particularly the respiratory system. To overcome the limitations of traditional teaching methods, an educational Role-Playing Game (RPG) incorporating the A* (A-Star) algorithm was developed for optimal game navigation. The study followed the ADDIE development model, which involves Analysis, Design, Development, Implementation, and Evaluation. During the analysis phase, learning needs were determined through interviews and classroom observations. The design phase involved creating game scenarios and integrating educational content with interactive elements. The A* algorithm was applied during development to ensure efficient navigation. The game was implemented in a 5th-grade classroom in Kuningan, and its effectiveness was evaluated using pre-tests, post-tests, and student questionnaires. Results demonstrated a significant increase in students' understanding, with average post-test scores rising from 58 to 85. Feedback from both students and teachers was very positive, with the game receiving a 94.2% acceptance rate. The study suggests that RPG-based educational games with intelligent algorithms like A* can greatly enhance science education by offering a more engaging and effective learning experience, contributing to advancements in technology-based learning and setting a standard for future educational game development.*

Keywords*: ADDIE model, A* algorithm, educational game, respiratory system, RPG.*

Abstrak *- Penelitian ini mengatasi kebutuhan akan metode pembelajaran yang lebih menarik dan interaktif untuk meningkatkan pemahaman siswa sekolah dasar tentang konsep ilmiah yang kompleks, khususnya sistem pernapasan. Untuk mengatasi keterbatasan metode tradisional, dikembangkan sebuah permainan edukasi Role-Playing Game (RPG) yang mengintegrasikan algoritma A* (A-Star) untuk navigasi permainan yang optimal. Penelitian ini mengikuti model pengembangan ADDIE, yang mencakup lima tahap: Analisis, Desain, Pengembangan, Implementasi, dan Evaluasi. Pada tahap analisis, kebutuhan pembelajaran diidentifikasi melalui wawancara dan observasi kelas. Tahap desain melibatkan pembuatan skenario permainan dan integrasi konten edukasi dengan elemen interaktif. Algoritma A* diterapkan pada tahap pengembangan untuk memastikan navigasi yang efisien. Permainan ini diimplementasikan di kelas 5 di Kuningan, dan efektivitasnya dievaluasi menggunakan pre-test, post-test, dan kuesioner siswa. Hasil menunjukkan peningkatan signifikan dalam pemahaman siswa, dengan skor rata-rata post-test meningkat dari 58 menjadi 85. Umpan balik dari siswa dan guru sangat positif, dengan tingkat penerimaan permainan mencapai 94,2%. Penelitian ini menunjukkan bahwa permainan edukasi berbasis RPG dengan algoritma cerdas seperti A* dapat meningkatkan pendidikan sains secara signifikan dengan memberikan pengalaman belajar yang lebih menarik dan efektif, serta berkontribusi pada inovasi dalam pembelajaran berbasis teknologi dan menjadi acuan untuk pengembangan permainan edukasi di masa depan.*

Kata Kunci*: model ADDIE, algoritma A*, permainan edukasi, sistem pernapasan, RPG.*

INTRODUCTION

In the modern era of education, innovation in teaching methods is a must in order to improve learning effectiveness and student engagement. Among the approaches that have been proven to increase student interest and understanding is through the use of educational games. Educational

games provide an interactive and exciting learning experience, which can help students understand complex concepts more easily (Sampedro-Martín et al., 2023). In the Science curriculum for grade V elementary school, the respiratory system is one of the important topics that students should be able to understand. However, conventional teaching methods are often ineffective in getting students interested and understanding this material deeply (Goyibnazar & Jorahon, 2024).

To overcome this problem, developing an educational game that utilises the A* algorithm as the basis of the game mechanics can be an innovative solution. The A* algorithm is one of the most popular pathfinding algorithms in game development to determine the shortest and most optimal route(Dong, 2024).

By integrating this algorithm into a Role Playing Game (RPG) educational game design, students can learn about the respiratory system through interesting and challenging play activities. This method not only aims to make students better understand the subject matter, but also to create a more dynamic and engaged learning environment (Yunimuninggar & Fardhani, 2024).

Although conventional learning methods have been widely used in teaching Science, this approach often encounters obstacles in improving students' in-depth understanding. In the case of the respiratory system, many students have difficulty in understanding the concepts and processes involved. This is exacerbated by the lack of interactive and innovative learning tools that can help students to be more involved and motivated in the learning process (Zhao et al., 2022).

Passive and teacher-centred learning makes students less active participants, thus reducing the effectiveness of the learning process. Moreover, in today's digital era, children are more interested in interactive media such as games than traditional teaching methods. Therefore, a solution that integrates technology and learning in an engaging and effective way is needed to overcome this challenge (Adi Badiozaman et al., 2021).

This research aims to design and develop a Role Playing Game (RPG) based educational game that utilises the A* algorithm as the main mechanism in learning the respiratory system for grade V elementary school students. The main objective of this research is to create a learning tool that is not only interactive and fun, but also effective in improving students' understanding of the concepts taught. By using the A* algorithm, this educational game is expected to provide a more dynamic and challenging learning experience, so that students can learn through exploration and problem solving. In addition, this research also aims to measure the extent to which the educational game can increase students' interest in learning compared to conventional learning methods. Through this approach, it is expected to create innovations in science learning that can be widely applied in various basic education institutions (Andriyani et al., 2024).

Previous research has shown that the use of educational games can increase student engagement and understanding in various subjects. However, there are still limitations in the application of educational games in learning Natural Sciences (IPA), especially on the material of the respiratory system for grade V elementary school students. In addition, although the A* algorithm has been widely used in game development for entertainment purposes, its application in an educational context is still rare (Tan et al., 2023). This gap indicates the need for research that combines the interactive elements of educational games with the A* algorithm to create a more effective and engaging learning experience. Therefore, this research aims to fill the gap in the existing literature by developing an RPG educational game specifically designed to help students understand the respiratory system, while evaluating its effectiveness compared to traditional learning methods (López-Jiménez et al., 2022).

This research offers a significant innovation in the field of education by developing a Role Playing Game (RPG)-based educational game that utilises the A* algorithm to teach the respiratory system to grade V elementary school students (Zuhdi et al., 2023). This approach not only combines technology and learning in one interactive and engaging platform, but also introduces the use of efficient pathfinding algorithms in an educational context. The uniqueness of this research lies in the integration of the A* algorithm to create a dynamic and challenging learning experience, which is expected to increase students' understanding and interest in the subject matter (Mylonas et al., 2023). In addition, the justification for the importance of this research can be seen from the need for more effective and adaptive learning methods in the digital era, which are able to overcome the limitations of conventional methods. Therefore, this research not only helps develop new learning aids, but also offers practical solutions for basic education (Udeozor et al., 2023).

MATERIALS AND METHODS

The method used in this research is Research and Development (R&D) to design, develop, and evaluate Role Playing Game (RPG)-based educational games that utilise the A* algorithm in learning the respiratory system. The game

development process follows the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to ensure that the final product meets the learning needs of students and achieves the research objectives (Hung et al., 2023).

Population and Sample

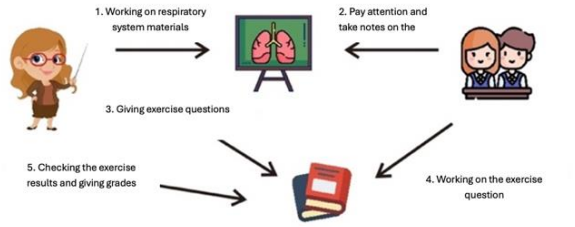
The population of this study were all elementary school students in Kuningan Regency. The sample selected was grade V students at SD X, who were purposively selected to ensure active and representative involvement in the trial of the developed educational game.

Game Development Research Method

The research method used follows the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Hidayatullah et al., 2024).

Analysis

The analysis stage in the development of the Respiratory System RPG educational game for grade V SD begins with identifying learning needs and learning objectives to be achieved. In the context of the Natural Science curriculum in grade V, understanding the respiratory system is one of the basic competencies that students must master. Based on observations and interviews with teachers, it was found that conventional learning methods are less able to make students actively involved and understand the basic concepts of the respiratory system well. Based on the test results on respiratory system material, the average score is 65.38 with 12 students scoring above average and 14 students scoring below average.

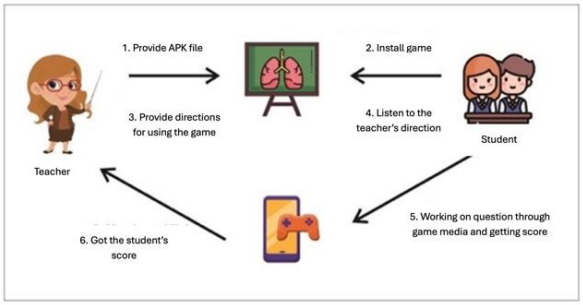


Source: (Research Result, 2024)

Figure 1. Running System

This analysis aims to provide a true picture of the learning process of respiratory system material at SDN 1 Rajadanu. In Figure 1, the Running System above is analysis of the current system, First, the teacher teaches material about the respiratory system to students, second, students pay attention to what the teacher explains and take notes on the material presented, third, the teacher gives exercise questions from the material that has been taught, fourth, students work on exercise questions, fifth, the teacher checks the results of the exercise and gives a score. In addition, the literature shows that the use of interactive media such as educational games can increase student motivation and understanding. Therefore, this study aims to develop an RPG game that is not only interesting and interactive, but also effective in delivering respiratory system material.

The needs analysis also includes the identification of user characteristics, namely grade V students, who have different learning preferences and tend to be more responsive to technology-based learning. To ensure that the game developed is in accordance with the needs and characteristics of students, a literature study related to educational games, the A* algorithm, and game-based learning pedagogy was conducted. The results of this analysis will be the basis for the design and development of games designed to increase students' understanding and engagement in science learning, especially on the material of the respiratory system. The proposed system analysis is a description of the system to be built. This analysis aims to provide an overview of the use of learning media using the SDN 1 Rajadanu Respiratory System RPG Educational game application. The following is the analysis of the proposed system



Source: (Research Result, 2024)

Figure 2. Proposed System

In Figure 2 above are First, the teacher teaches the material about the respiratory system to students, second, students pay attention to what the teacher explains and take notes on the material presented, third, students work on questions through game media and get scores, fourth, the teacher records all student scores. Problem solving analysis is carried out to provide solutions to problems that have been formulated previously. The A* algorithm is the fastest route finding algorithm. In the application that will be built, the A* algorithm is used by AI Enemy to follow the player.

The following is a simulation of Enemy movement with the fastest route in the Respiratory System RPG Educational game using the A* algorithm (Radita & Prakoso, 2024):

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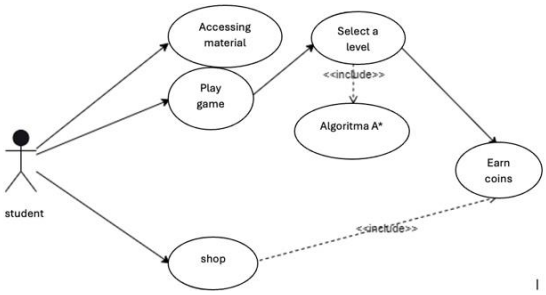
1. The initial node is the initial position of the enemy
2. The destination node is the enemy's destination, namely the player's position
3. Open List and Closed List are still empty
4. Add the start node to the Open List
5. Select the current node in the Open List (with the lowest cost)
6. If the Current Node is the same as the destination, then the search is complete and go to Step 10.
7. Check each directly connected Node, by; If the Node cannot be traversed or the Node is already in the Open List or in the Closed List, then it can be skipped and move on to the next Node in the list of connected Nodes, otherwise go to point b. then Calculate the cost of the Node with the formula f (n) =g (n) +h (n).
8. Add the current Node to the Closed List
9. Go back to Steps 5-9 with the updated Open List and this step will continue until it finds the destination Node.
10. The destination Node has been found, create a list of Nodes that will be the path list and add the destination Node to the list

The A* algorithm is used in the development of educational games due to its efficient ability to find shortest paths by combining heuristics and minimum cost search approaches. It is very effective at finding optimal paths in complex environments, such as maps with many obstacles, helping game characters to move intelligently and quickly. This is important for creating a more enjoyable and realistic gaming experience, especially in games that emphasize player interaction with the environment.

In addition, A* is highly flexible and can adapt to dynamic changes in the game, such as the appearance of new obstacles during gameplay. This makes the algorithm relevant for educational games that require intelligent and responsive navigation. The reliability and efficiency of A* has been proven in many simulation applications, making it an ideal choice for creating an optimized gaming experience in educational games, such as learning about the respiratory system.

Design

The design stage in the development of the Respiratory System RPG educational game for grade V SD involves designing the main elements of the game that aim to achieve learning objectives effectively and attractively. The design of this game begins with determining the storyline that will take players through various scenarios related to the human respiratory system. The story is designed in such a way that the player can explore the various organs and functions in the respiratory system, while completing challenges that require the application of learnt knowledge.



Source: (Research Result, 2024)

Figure 3. Use Case Diagram

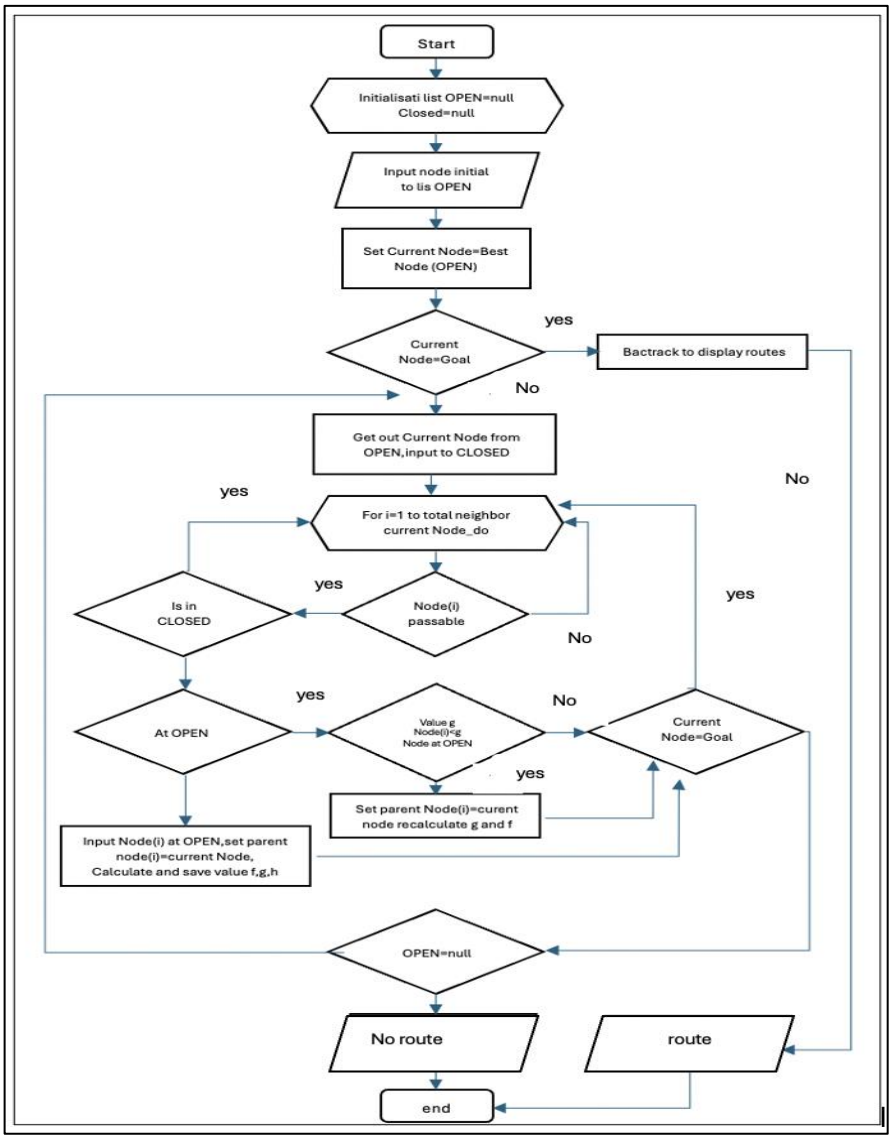
In Figure 3 explains Use Case DiagramIs a that describes the process flow of the actor (user) against the system and what the system does to the actor (user) command. at this stage a use case definition is made describing the relationships that occur between actors and activities contained in the system. The goals of use case modelling include defining the functional and operational needs of the system by defining usage scenarios agreed upon by users and developers. The definition of the application use case can be seen in Table 1.

Table 1. Definition of Use Case

No.	Use Case	Description
1	Play	Functionality to play the Respiratory System RPG Educational game
2	Select level	Functionality to select the game level to be played
3	Algoritma A*	Functionality for AI enemy system
4	Learn	Functionality to learn respiratory system material
5	Intruction	Functionality to tell how to play the game
6	About	Functionality to provide information about the game
7	Exit	Functionality to exit/stop the application/game

Source: (Research Result, 2024)

Next, the game mechanics were determined by utilising the A* algorithm to create realistic and challenging navigation challenges. The A* algorithm is used to organise the movement of the characters in the game, ensuring that players must plan their strategies well to achieve the learning objectives. The A* algorithm is a fastest route finding algorithm. In the application to be built, the A* algorithm is used by the Enemy AI to follow the Player. Figure 4 illustrates how the A* algorithm is applied in this study.



Source: (Research Result, 2024)

Figure 4. Flowchart of A* Algorithm

User interface (UI) and user experience (UX) were also a major focus in this design stage. Intuitive and child-friendly UI design ensures that students can easily access information and understand game instructions. Meanwhile, attractive visual and audio elements were added to increase student engagement and create a fun learning atmosphere.

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Table 2. illustrates some of the game objects, in this game has elements or entities that can interact with the player or other game elements. Game objects include player characters, enemies, items, obstacles, backgrounds.

Table 2. Game Objects

No	Game Object	Name	Action
1		Knight Stand	Still, Move, Attack
2		Non Player Character (Evil Skull)	Standby, chase, attack the player.
3		Quest box	Displays quest questions
4		Health box	Increases player health
5		Sword	Power

Source: (Research Result, 2024)

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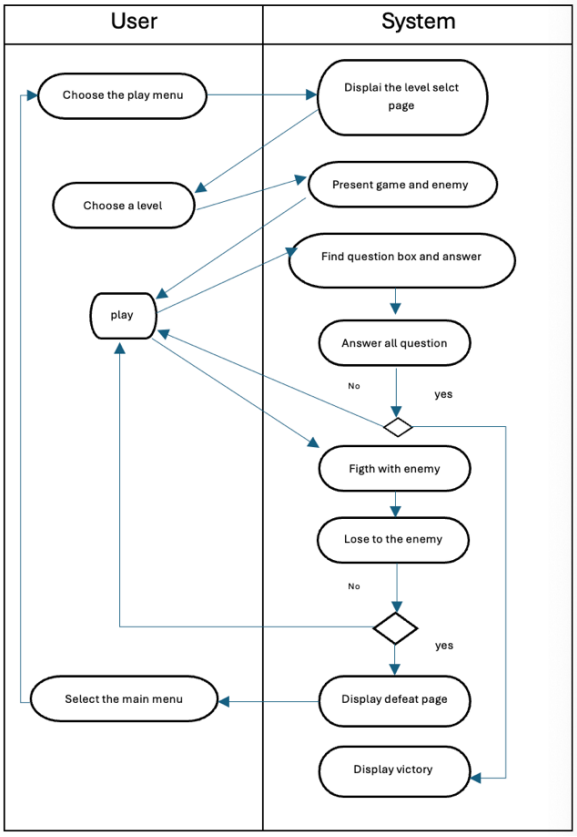
Development

The development phase of this project involved the technical implementation of the design that had been formulated for the Respiratory System RPG educational game for grade V students. This process began with the creation of the digital assets, including graphics, animations and sounds, that would be used in the game. The use of game development software such as Unity or Unreal Engine allows the creation of interactive environments and attractive visuals. Character designs, backgrounds and other game elements are created to support the pre-designed storyline and learning objectives. In addition, the development of programme code for the game logic and interaction system is carried out. Each game element was programmed to support learning scenarios, such as interactive quizzes, problem-solving tasks, and breathing process simulations. These features were designed to provide immediate feedback to the player, helping them understand important concepts about the respiratory system.



Source: (Research Result, 2024)

Figure 5. Play Activity Diagram

In development stage, the A* algorithm is implemented to manage the navigation and movement of the characters in the game. This algorithm ensures that the player faces realistic navigational challenges, requiring good strategic planning to reach the goal. The development team integrated the A* algorithm into the game mechanics, allowing players to interact with the game environment dynamically.

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In Figure 5. illustrates the Activity diagram of the game, this is a description of the process of user interaction with the system and the sequence of activities in a process used in business modelling to show the sequence of process activities.

Implementation

The implementation stage in the development of the Respiratory System RPG educational game for grade V elementary school involves applying the developed game into a real learning environment and collecting data related to its effectiveness. This process began with training teachers at SD X on how to use the game in the learning process. Teachers were provided with guidance and technical support to ensure that they were able to properly integrate the game into the existing science curriculum.

Next, the game was implemented in the classes selected as the research sample. Grade V students were introduced to the game and given the opportunity to play during learning sessions. The implementation was conducted over several sessions to allow students to get used to the game mechanics and to ensure that they had enough time to absorb the material presented.

During the implementation, data was collected through direct observation, questionnaires, and interviews with students as well as teachers. Observations were made to monitor students' engagement and interaction with the game, while questionnaires and interviews were used to gather feedback regarding their learning experience. Pre-test and post-test were also conducted to measure the improvement of students' understanding of the respiratory system before and after using the game. Selain itu, pengumpulan data analitik dari game dilakukan untuk melihat pola penggunaan dan kesulitan yang dihadapi siswa. Data ini mencakup waktu bermain, level yang diselesaikan, dan skor yang dicapai, yang semuanya dianalisis untuk mengevaluasi efektivitas game dalam membantu siswa mencapai tujuan pembelajaran.

Implementation also involves iteration based on the feedback received. Any findings from the implementation process are used to improve and

refine the game, both in terms of content, game mechanics, and user interface. With this approach, it is hoped that this RPG educational game will not only be able to improve students' understanding of respiratory system material, but also become a learning tool that is favoured and widely used in various elementary schools.

Through a comprehensive and sustainable implementation process, this research is expected to make a significant contribution to science learning innovation and improve the quality of education in primary schools.

Evaluation

Testing and debugging is a critical part of the development stage. Every aspect of the game is thoroughly tested to ensure that there are no bugs or technical issues that could disrupt the learning experience. Beta testing was conducted by involving a group of grade V students from SD X as early adopters. Feedback from this testing was used to refine and perfect the game before the official launch.

The evaluation stage in the development of the Respiratory System RPG educational game for grade V SD involves a thorough assessment of the effectiveness of the game in achieving the desired learning objectives. This evaluation was conducted through both quantitative and qualitative methods to ensure that the data obtained was comprehensive and reliable. Firstly, statistical analyses were conducted on the students' pre-test and post-test results to measure the improvement in their understanding of the respiratory system material. A t-test was used to determine the significance of the difference between the pre-test and post-test scores, which gives an idea of the impact of the game on students' knowledge.

Furthermore, qualitative data was collected through in-depth interviews with students and teachers. These interviews were designed to uncover users' experiences, level of engagement, and their perceptions of the game. Thematic analysis was used to identify patterns and key themes from the feedback provided. Classroom observations were also conducted to observe students' interactions with the game, as well as how it facilitated active and collaborative learning.

In addition, game analytics were used to collect data on usage patterns and in-game interactions. Information such as playing time, levels achieved and frequency of challenges faced by students were analysed to understand how students interacted with the game content and which parts were most challenging or engaging.

Based on the results of this evaluation, recommendations for improvement and further development were made. Constructive feedback from students and teachers was used to refine certain aspects of the game, such as user interface improvements, difficulty level adjustments, and the addition of new features that could enhance the learning experience. The evaluation also helped determine the sustainability of using the game in other schools and its potential to be adapted to other learning materials.

With a rigorous and comprehensive evaluation approach, this research aims to ensure that the Respiratory System RPG educational game is not only effective in improving student understanding, but can also be widely adopted as an innovative learning tool that supports science education in primary schools. The results of this evaluation will also be published in a reputable international journal, making a significant contribution to academic literature and educational practice.

RESULTS AND DISCUSSION

This research has produced an RPG-based educational game that uses the A* algorithm to teach the concept of the respiratory system to grade V students. Evaluation was conducted through a series of tests and questionnaires to assess the effectiveness of the game in improving students' understanding.

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The implementation of the interface design results into the system built using the software previously described. This is how the implemented interface looks like.

Source: (Research Result, 2024)

Figure 6. Main Menu

In Figure 6 is the main menu page that displays several menus in the game, namely playing, learning, shopping, instructions, about and exit.

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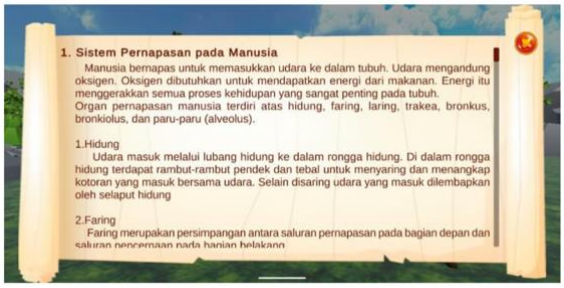
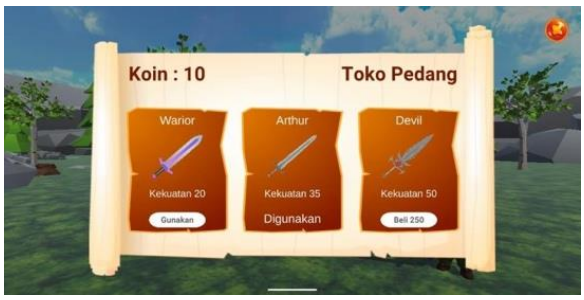
Source: (Research Result, 2024)
Figure 7. Level Select Menu

In Figure 7 is a level select page, in this menu there will appear 3 level options that must be completed sequentially.



Source: (Research Result, 2024)
Figure 8. Learning Menu

Figure 8 is the learning page, this page contains material about the respiratory system to help answer the questions available in the game.



Source: (Research Result, 2024)
Figure 9. Shop Menu

Figure 9 is the Shop page, this page contains weapons that will be used in the game, to buy weapons using coins that can be obtained from killing enemies and answering questions correctly.

Source: (Research Result, 2024)
Figure 10. Instructions Menu

In Figure 10 is the Instructions page, this page provides instructions on the controls in the game.

Source: (Research Result, 2024)
Figure 11. Game View

In Figure 11. is the game page, the player will enter the game area with a rural style in the forest, the analogue button on the right to run the player and the sword button on the left for basic attack/attack enemies that block.

Source: (Research Result, 2024)
Figure 12. Problem display

In Figure 12 will display a question which will appear when the question box is opened, the player will be given a question and required to answer the question.

Source: (Research Result, 2024)

Figure 13. Score Display

In Figure 13 will show the score, the score will appear when the player has found all the boxes in each level and answered all the questions, the system will stop the game and declare the game finished, and will return to the main menu to select the next level.

System Testing

Software testing that is carried out only on functional specifications without testing the design or program code is known as black box testing. This test is carried out to ascertain whether the software is functioning properly.

Table 3 is black box testing, which is testing software in terms of functional specifications without testing the design or program code. This test is to find out whether the software can function properly.

Table 3. Black Box Testing

NO	Function	Test Scenario	Expected Result	Test Result	Description
1	Play Button	The user presses the play button	The system displays the level menu	As expected	Valid
2	Learning Menu	Usage Press the learning button	The system will display the material page	As expected	Valid
3	Menu Shop	Usage Press the learning button	Sistem akan menampilan menu shop untuk membeli item	As expected	Valid
4	Instruction menu	Usage Pressing the hint button	The system will display an explanation in the game	As expected	Valid
5	About menu	The user presses the about menu button	The system displays the game developer menu	As expected	Valid
6	Exit menu	Usage presses the exit menu button	The system will exit the game	As expected	Valid
7	Level 1 menu	Usage Pressing the level 1 button on the level selection menu	The system displays the level 1 game menu	As expected	Valid
8	Level 2 menu	Usage Pressing the level 2 button in the game selection menu	The system displays the level 2 game menu	As expected	Valid
9	Level 3 menu	Usage Pressing the level 3 button in the game selection menu	The system displays the level 3 game menu	As expected	Valid

Source: (Research Result, 2024)

To test the performance of the A* algorithm, several aspects are considered, such as speed, memory efficiency and accuracy of the path found. The A* algorithm works by minimising the search time and resources used to find the shortest path between two points, where characters in the game need to move from one point to another on a map with many obstacles. A performance test was conducted by calculating the time it takes the algorithm to find a path on a simple map versus a more complex map with more obstacles.

In addition, A*'s performance can also be tested by measuring the number of nodes that need to be processed before reaching the destination. When a character in the game has to navigate a map containing a maze, the A* algorithm works by evaluating multiple nodes (map segments) that can be passed through. On denser maps, the more nodes that are processed, the higher the memory consumption. This test shows how A* adapts to dynamic changes in the environment, for example when new obstacles suddenly appear during the game. A*'s performance is then assessed by its ability to quickly update the path without having to repeat the entire process from the beginning, which can also be assessed by player feedback on the smoothness of the gameplay.

Pre-test and Post-test Results

Pre-test: Prior to the use of the game, students underwent a pre-test to assess their initial

understanding of the respiratory system. The average score of the pre-test was 58 out of 100.

Post-test: After the use of the game in learning, students underwent a post-test with the average score increasing to 85 out of 100.

Statistical Analysis: The t-test showed a significant increase ($p < 0.05$) in the post-test score compared to the pre-test, indicating that the game had a positive impact on students' understanding.

Student and Teacher Feedback

Students: The majority of students reported that the game was engaging and helped them understand the concept of the respiratory system better. They mentioned that the game elements and challenges present in the game made learning more enjoyable.

Teachers: Teachers involved in the study also gave positive feedback, noting that students were more engaged and active during learning. They also appreciated the use of technology as an effective teaching aid.

Game Usage Analytics

The analytics data showed that the average playing time per session was 45 minutes, with most students successfully completing the more challenging levels. This shows that the game is not only engaging but also has an appropriate level of difficulty for the students' abilities.

CONCLUSION

This research has successfully developed and implemented an RPG educational game titled 'Respiratory System' designed to improve the understanding of grade V elementary school students towards science material. Through the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model approach, each stage of the research has been carried out with rigour and based on high academic standards. Results from the evaluation showed that the game was effective in improving students' understanding of the respiratory system, as shown by the significant improvement in the post-test results compared to the pre-test. In addition, qualitative feedback from students and teachers indicated that the game was not only engaging and fun, but also able to facilitate active learning and increase student engagement. The use of the A* algorithm in the game also provided realistic challenges and motivated students to think critically in solving problems, which is an important aspect of science learning. Analytical data collection during implementation provided additional insights into students' interaction patterns with the game, aiding in the identification of areas that required further improvement. A thorough evaluation ensured that the game could be continuously refined and adapted for its use in different schools and other learning materials.

Thus, this research makes a significant contribution to innovation in education, particularly in the use of game technology for science learning. The educational game developed shows great potential as an effective, interactive learning tool that can increase student engagement and understanding. The findings are expected to encourage further development and widespread adoption of similar educational games in the primary education curriculum.

Although the results showed that the RPG-based educational game about the respiratory system was well accepted by the users with an acceptance percentage of 94.2%, there are some limitations that need to be recognised. Firstly, this study was carried out on a limited sample of grade V students in one primary school. Therefore, it may not be possible to generalise the results to a wider population. Also, this game only focuses on one topic, the respiratory system. The effectiveness of the game on other science learning materials has not been tested, so the implementation of the game on various other topics needs to be investigated.

Another limitation is that long-term testing of the effectiveness of this game has not been carried out. This study focused more on the initial acceptance by the students without considering the long term impact on understanding and retention of the material. The game used in this study was also not evaluated in the context of collaborative learning, which can enhance social interaction between students and help deepen understanding of concepts. Therefore, further research with a broader scope and longer duration is needed to obtain more comprehensive results.

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