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Implementation of Fisher-Yates Shuffle and Fuzzy Tsukamoto in Nusantara Educational Game

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ABSTRACT

This study introduces "PINUS: Petualangan Ilmu Nusantara," an Android-based educational game designed to enhance players' knowledge and interest in Indonesia's culture, flora, fauna, and national figures. The game implements the Fisher-Yates Shuffle algorithm to randomize question and answer sequences, creating engaging variations, and the Fuzzy Tsukamoto algorithm to calculate scores based on player performance, ensuring fair and competitive assessments. A quantitative research method was employed, with data collected through interviews, literature reviews, and system testing via alpha testing and beta testing (User Acceptance Testing/UAT). The UAT results indicated strong user acceptance, with an average score of 84.9%, demonstrating that the game meets user expectations in terms of functionality and design. Pre-test and post-test analyses showed an average score increase from 60 to 72.3, with an N-Gain value of 0.307, categorized as moderate improvement. These findings confirm the effectiveness of "PINUS" in enhancing material comprehension through interactive features and educational content, making it an engaging and technology-based learning tool.

I. Introduction

Conventional education often faces challenges in engaging students and maintaining their interest. Lecture-based teaching methods and limited classroom interaction can lead to boredom and low student participation. A report from the World Economic Forum (2023) revealed that 70% of students find traditional teaching methods irrelevant to their needs. This lack of engagement negatively affects memory retention, conceptual understanding, and ultimately, academic performance [1]. Moreover, conventional education systems often overlook the diversity of students' learning styles, leaving many feeling frustrated and disconnected from the learning process. Therefore, innovative solutions are needed to enhance motivation and learning effectiveness, one of which is the integration of educational games on smart devices.

Technological advancements have created new opportunities in education, particularly through the development of smartphone-based educational games. These games provide interactive and engaging learning experiences, differing significantly from traditional static teaching methods. Studies indicate that interactive media can enhance memory retention, conceptual understanding, and cognitive engagement more effectively [2]. However, improper implementation of educational game design can lead to a lack of challenge variation and inaccurate assessments of players' abilities. One of the main challenges in educational games is ensuring the diversity of questions and answers so that players do not merely memorize game patterns. Additionally, scoring systems in games often fail to consider the difficulty level of questions or individual player performance, resulting in suboptimal learning outcomes [3]. Therefore, this study proposes the implementation of the Fisher-Yates Shuffle algorithm for randomizing questions and answer arrangements, as well as the Fuzzy Tsukamoto algorithm for a more adaptive and accurate scoring system.

The concept of Wawasan Nusantara plays a crucial role in fostering nationalism and national identity, especially among young people aged 12 to 22. Previous research has shown that a deep understanding of Wawasan Nusantara positively correlates with a strong sense of nationalism, ultimately shaping the character of the younger generation as future leaders [4]. Furthermore, interactive learning methods, such as role-playing in social education, have proven to enhance students' understanding of national concepts [5]. In the context of educational games, the Fisher-Yates Shuffle algorithm has been used to randomize the order of questions and answers, creating a more dynamic and unpredictable gameplay experience [6][7]. Meanwhile, the Fuzzy Tsukamoto algorithm offers a fuzzy logic-based approach to evaluating player performance more flexibly, providing feedback tailored to individual skill levels [8]. Previous studies have also confirmed that personalized learning approaches can boost students' confidence and reduce frustration caused by challenges that do not match their abilities [9].

This study aims to develop a smartphone-based educational game focused on enhancing understanding of Nusantara. Specifically, this research evaluates the effectiveness of the Fisher-Yates Shuffle algorithm in randomizing the order of questions and letter answers to create a more competitive and non-monotonous gaming experience. Additionally, this study examines the implementation of the Fuzzy Tsukamoto algorithm in the game's scoring system to provide adaptive and accurate player performance evaluations. Thus, this research is expected to offer a more engaging, effective, and personalized learning experience for each player.

The results of this research are expected to contribute to various aspects, including academics, education, and technology. From an academic perspective, this study provides new insights into the implementation of the Fisher-Yates Shuffle and Fuzzy Tsukamoto algorithms in educational games. Additionally, it can serve as a reference for further research in the development of artificial intelligence-based games and interactive learning. In the field of education, the developed educational game offers a more engaging and interactive learning alternative compared to conventional methods. By utilizing a game-based approach, students can better understand the concept of Wawasan Nusantara in a fun and accessible way, thereby enhancing the effectiveness of learning. From a technological standpoint, this research produces an educational game model that integrates optimal question randomization and an adaptive scoring system based on fuzzy logic. This integration demonstrates how games can be used as effective educational tools to support digital learning initiatives. Therefore, it is expected that the developed educational game can serve as an innovative solution to improve the quality of learning, particularly in introducing and preserving Nusantara culture among younger generations.

II. METHOD

This research employed a quantitative method, involving the use of numbers or nominal values, commonly applied in survey or polling research. The quantitative approach facilitates the collection of measurable and objective data, allowing the research results to be analyzed statistically. Therefore, it provides valid and generalizable conclusions [10].

A. Research Flow

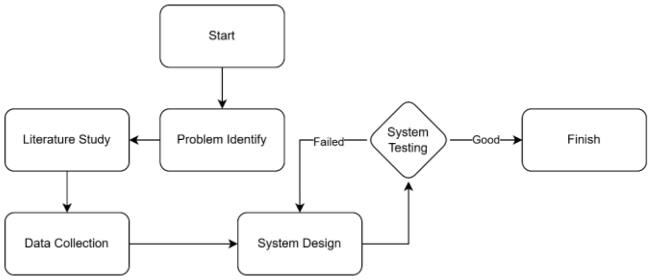

Figure 1 Research Flow

Figure 1 illustrates the sequence of steps taken to achieve the research objectives. The stages involved are as follows:

1) Problem Identification

Learning media play a vital role in bridging the interaction between teachers and students. They help deliver lessons in a more engaging and comprehensible manner. In today's digital age, where students are increasingly accustomed to technology in their daily lives, the demand for creative and interactive learning media has become more significant [9]. In response to this need, this research developed a learning medium in the form of a game.

2) Literature Study

The researcher conducted a literature study to gain a deeper understanding of the concepts behind the implementation of the Fisher-Yates Shuffle Algorithm and the Fuzzy Tsukamoto Algorithm in a game. The data were gathered through reviewing and analyzing journals, articles, theses, papers, and other educational resources [11].

3) Data Collection

Data collection was conducted by directly engaging with the game [11]. The data were gathered through questionnaire distributed to 30 students of SMP Negeri 2 Palu.

4) System Design

The system was designed by developing a Unified Modeling Language (UML) model, including the creation of a Use Case Diagram and Activity Diagram to illustrate the functionalities and processes within the system. Furthermore, a Data Flow Diagram (DFD) was created to describe the flow of data throughout the system.

B. Data Analysis Methods

The data analysis method used in this research is Unified Modeling Language (UML), serving for visualization, specification, development, and documentation of software.

The UML types utilized in this study covered the Use Case Diagram, Activity Diagram, and Data Flow Diagram (DFD).

C. *System Development Menthods*

The method applied in the development of this system was the prototype method. A prototype is a stage in the development process that facilitates the transformation of a system into an information system [12]. This approach enables the researchers as the developers to make more effective model of the software based on user needs [13].

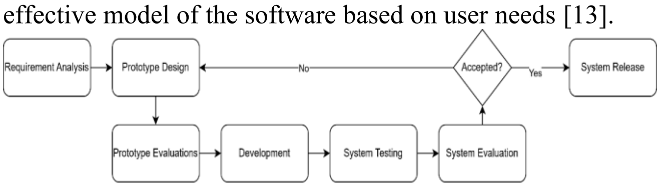

Figure 2 Prototype Method System Development

In Figure 2, the stages involved in the prototype method are illustrated. These stages include:

1) *Requirements Analysis*

At this stage, the researcher identifies the necessary features to achieve the desired learning objectives. In this context, two main algorithms are implemented: Fisher-Yates Shuffle and Fuzzy Tsukamoto, each playing a crucial role in enhancing the effectiveness and interactivity of the game. At the needs analysis stage, the researcher identifies that variation in question presentation is crucial to maintaining player interest. The Fuzzy Tsukamoto algorithm is used to calculate scores based on player performance. In the needs analysis, the researcher realizes that an adaptive and accurate scoring system is essential for providing constructive feedback to players.

At this stage, the membership degree curve plays a crucial role in transforming crisp values into fuzzy values, allowing the system to evaluate player performance more adaptively and accurately.

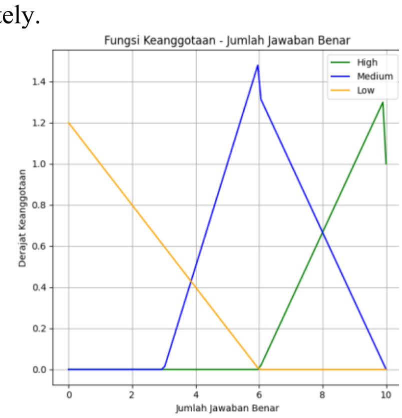

Figure 3 Fuzzification Correct Answer Membership Function

$$\mu Low(x) = \begin{cases} 1 : x \leq 0 \\ \frac{5-x}{5} : 0 \leq x \leq 5 \\ 0 : x > 5 \end{cases} \quad (1)$$

$$\mu Medium(x) = \begin{cases} \frac{x-3}{3} : 3 \leq x \leq 6 \\ \frac{9-x}{3} : 6 \leq x \leq 9 \\ other \end{cases} \quad (2)$$

$$\mu High(x) = \begin{cases} 0 : x \leq 6 \\ \frac{x-6}{4} : 6 \leq x \leq 10 \\ 1 : x \geq 10 \end{cases} \quad (3)$$

The Fuzzy Tsukamoto system converts crisp values into fuzzy values for adaptive performance evaluation. It classifies correct answers into Low (0–5), Medium (peak at 6, zero at 3 and 9), and High (6–10, then 1). This ensures accurate assessment and adaptive feedback in the educational game.

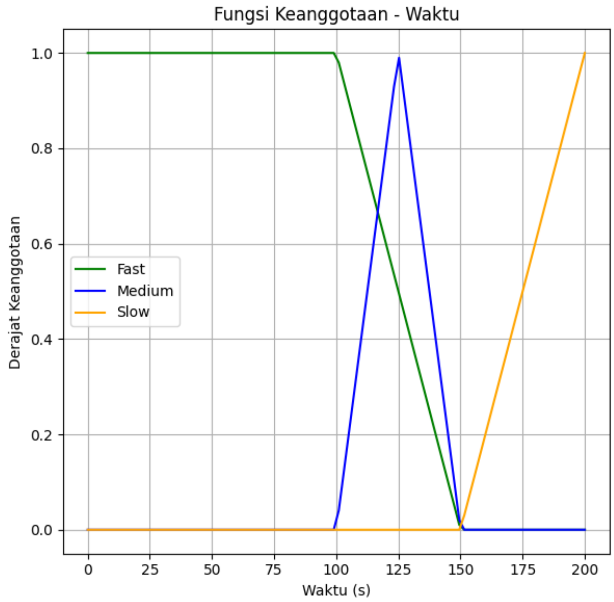

Figure 4 Fuzzification Play Time Membership Function

$$\mu Fast(x) = \begin{cases} 1 : x \leq 100 \\ \frac{150-x}{50} : 100 \leq x \leq 50 \\ 0 : x > 150 \end{cases} \quad (4)$$

$$\mu Medium(x) = \begin{cases} \frac{x-100}{25} : 100 \leq x \leq 125 \\ \frac{150-x}{25} : 125 \leq x \leq 150 \\ 0 : other \end{cases} \quad (5)$$

$$\mu Slow(x) = \begin{cases} 0 : x \leq 150 \\ \frac{x-150}{50} : 150 \leq x \leq 200 \\ 1 : x > 200 \end{cases} \quad (6)$$

The fuzzy membership function classifies player speed into Fast, Medium, and Slow based on completion time. Fast has full membership at ≤100s, decreasing linearly to zero at 150s. Medium follows a triangular shape, starting at zero at 100s, peaking at 125s, and returning to zero at 150s. Slow begins at 150s, increasing linearly to full membership at 200s. This adaptive approach improves performance evaluation and feedback accuracy.

TABLE 1
FUZZY RULES

Rule	Correct Answer	Time	Score
R1	High	Fast	High
R2	Medium	Fast	High
R3	Low	Fast	Low
R4	High	Medium	High
R5	Medium	Medium	Medium
R6	Low	Medium	Low
R7	High	Slow	Medium
R8	Medium	Slow	Low
R9	Low	Slow	Low

The fuzzy rules determine the final score based on Correct Answer and Time. High scores are given for fast and accurate answers (R1, R2, R4), Medium for moderate performance (R5, R7), and Low for slow or inaccurate responses (R3, R6, R8, R9). This ensures adaptive and fair evaluation.

The defuzzification process aims to convert the fuzzy values obtained from inference into crisp values that can be used as the final score in the system using the Weighted Average method.

$$W = \frac{\sum(\alpha Predikat_i \times Z_i)}{\sum \alpha Predikat} \quad (7)$$

2) Prototype Design

In this phase, the researchers created an initial prototype of the game, including the user interface and key features, such as the question display and material display. This prototype aimed to provide users with an initial overview of the game, allowing them to interact with the planned main features.

3) Prototype Evaluations

Initial testing was conducted by asking users to play the game prototype, followed by gathering feedback to evaluate whether the prototype met the identified needs. If any discrepancies were found, immediate improvements were made to refine the prototype and to ensure that it aligned better with the requirements.

4) Development

In this stage, the approved prototype was further developed. This process included integrating the user interface according to the design and implementing the necessary algorithms.

5) System Testing

System testing was conducted to minimize errors using Alpha Testing and Beta Testing methods. In the Alpha Testing phase, the Black Box method was applied to evaluate system functionality without examining its internal workings. Following this phase, Beta Testing was carried out, focusing on User Acceptance Testing (UAT). UAT involved 30 students aged 12–13 years from junior high school (SMP) backgrounds. They played the game in a controlled environment, completed quizzes, and accessed educational materials. Afterward, they filled out a questionnaire to provide feedback on their experience.

In UAT, aside from functionality, several criteria were assessed, including ease of navigation and accessibility, user engagement and interactivity, educational value in terms of learning effectiveness, system performance and responsiveness to input, and the aesthetics of the design, covering graphics and audio.

To quantify the evaluation results, a scoring formula was applied as follows:

$$\text{Presentation} = \frac{\text{Total Actual Score}}{\text{Maximum Total Score}} x100 \quad (8)$$

This formula converts the total actual score obtained from respondents into a percentage, providing a clear representation of the overall assessment in UAT.

Additionally, Beta Testing included a learning effectiveness evaluation using the One Group Pre-Test Post-Test method. This method involved administering a pre-test before gameplay and a post-test after completing the game. The questions in both tests included comprehension-based and recall-based items to assess whether players genuinely understood the material or simply memorized answers. This approach helped measure the game's impact on learning outcomes, ensuring that the educational content was effective in improving players' knowledge.

TABLE 2
LIKERT SCALE INTERPRETATION CRITERIA

Category (%)	Abbreviation	Explanation
0 - 20	STS	Strongly Disagree
21 – 40	TS	Disagree
41 – 60	N	Neutral
61 – 80	S	Agree
81 - 100	SS	Strongly Agree

The table presents the interpretation criteria for the Likert scale based on percentage categories. Responses are classified into five levels: Strongly Disagree (STS) for 0–20%, Disagree (TS) for 21–40%, Neutral (N) for 41–60%, Agree (S) for 61–80%, and Strongly Agree (SS) for 81–100%. These categories help quantify user perceptions and feedback systematically.

This study continues with the implementation of a one-group pretest-posttest design to evaluate the effectiveness of the educational game. In this design, students take a pretest before using the game to measure their initial knowledge, followed by a gameplay session, and conclude with a posttest to assess their improvement in understanding the taught material.

TABLE 3
N-GAIN INTERPRETATION CRITERIA

Value (g)	Score
F > 0,7	High
0,3 ≤ g ≤ 0,7	Medium
0 < g < 0,3	Low
g ≤ 0	Failed

This table presents the N-Gain criteria for measuring the improvement in understanding after using the educational game. High ($g > 0.7$) indicates significant improvement, Medium ($0.3 \leq g \leq 0.7$) moderate, Low ($0 < g < 0.3$) minimal, and Failed ($g \leq 0$) means no improvement. The N-Gain formula is as follows:

$$N - Gain(g) = \frac{(Spost)-(Spre)}{(Sm-ideal)-(SPre)} \quad (8)$$

6) System Evaluations

The system was evaluated based on the testing results to ensure its functions as expected by the user. If the discrepancies were identified, improvements will be made to address those issues and enhance the system's performance.

7) System Release

The system, having been tested and meeting user's requirements, is now ready to use.

D. Implementation of Fisher-Yates Shuffle Algorithm

The Fisher-Yates Shuffle algorithm was used to efficiently randomize questions and answer letters without repeating patterns, enhancing variation and providing a unique challenge for each question. Figure 5 shows the algorithm's implementation flowchart.

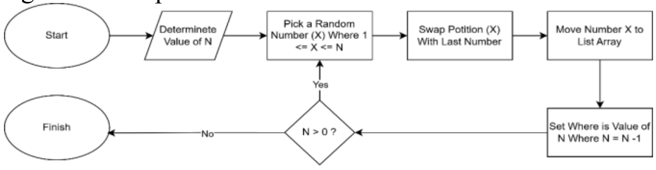

Figure 5 Fisher-Yates Shuffle Algorithm Flowchart

III. RESULTS AND DISCUSSION

A. System Analysis

The educational game system was developed using the Fisher-Yates Shuffle algorithm to ensure optimal randomization of questions and answer letters, as well as the Fuzzy Tsukamoto algorithm for assessing player performance. A structured approach was employed in designing the system to provide an interactive and educational experience. The design process incorporated several diagrams to represent the system's functions and workflows in detail, ensuring clarity in the system's architecture and logic.

1) Use Case Diagram

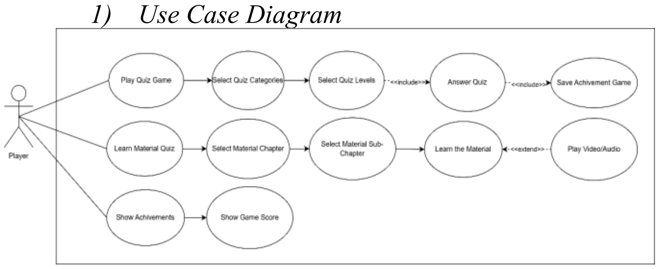

Figure 6 Use Case Diagam Nusantara Education Game

The use case diagram is used to understand the system's behavior after it has been developed [14], providing a visual representation of how users interact with the system's functionalities. It helps identify the key processes and actions that the system performs based on user inputs.

In Figure 6, three main features are shown that can be accessed by an actor, where the actor is the "Player." The first feature is "Play Quiz Game," where the actor can select the game chapter and choose the game level. In this feature, the actor needs to guess all the answers to the available questions until completion and save the game results. The second feature is "Learn Material Quiz," where the actor can select and view the materials used in this game. This feature includes an option to play videos/audio for the available materials, and the actor can choose whether to play them or not. The third feature is "Show Achievement," where the actor can view their achievements throughout their gameplay.

2) Activity Diagram

An activity diagram is a tool used to illustrate procedural logic in business processes and the circulation of workflows in various cases [15]. It visually represents the sequence of activities, decisions, and actions taken during the execution of a process, helping to understand the system's operation and flow.

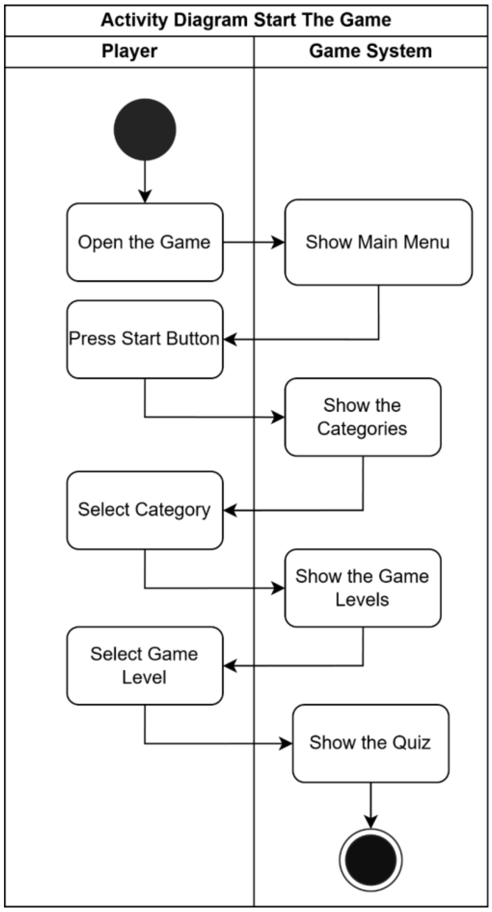

Figure 7 Activity Diagram Start Game

Figure 7 shows the activity diagram for starting the game. The process begins when the player opens the app, and the system displays the main menu. The player presses 'Start Game,' selects a chapter, chooses a level, and the system displays the game questions.

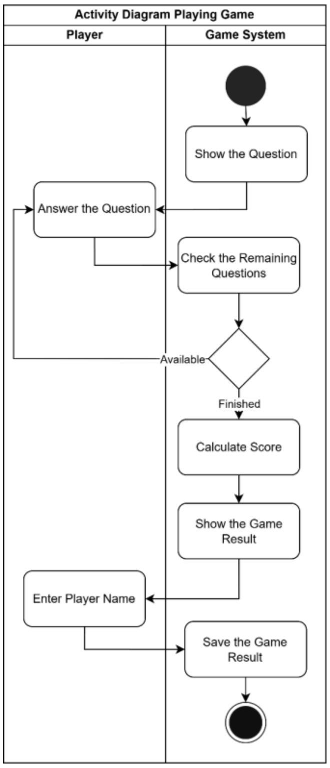

Figure 8 Activity Diagram Playing Game Quiz

Figure 8 illustrates the activity diagram for the player answering questions in the game. The system displays a question, and the player provides an answer. This process repeats until all questions are answered. Once completed, the system calculates and displays the score, prompts the player to input their name, and saves the results.

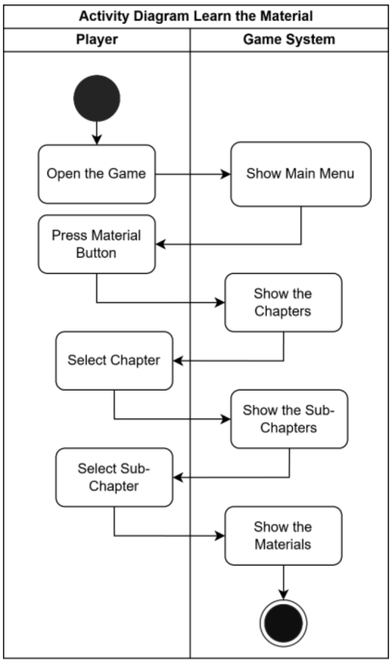

Figure 9 Activity Diagram Learn Materials

Figure 9 shows the activity diagram for accessing learning materials. Players open the app, select 'Material' from the main menu, choose a chapter, then a sub-chapter, and the system displays the selected material.

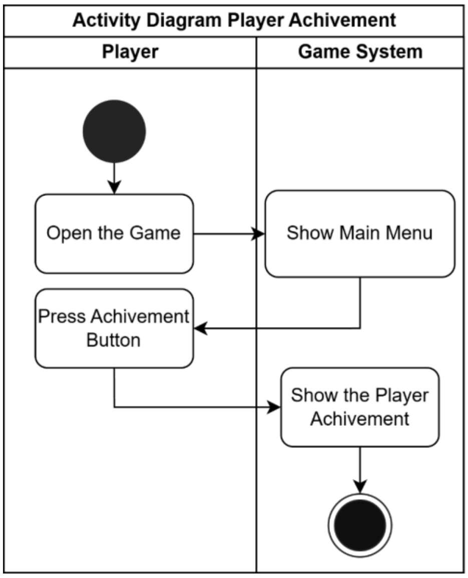

Figure 10 Activity Diagram Player Achievement

Figure 10 illustrates the activity diagram for accessing the player's achievement records for each level. The process begins with the player opening the game application, and the system displays the main menu. The player then selects the 'Achievement' button, prompting the system to display the achievements page.

3) Data Flow Diagram (DFD)

The Data Flow Diagram (DFD) is a system documentation form in the form of diagrams that illustrates the flow of data within a system or process, between its components. The creation of a DFD is essential to understand the inputs, outputs, and entities within a system [16]. DFDs are detailed starting from Level 0, Level 1, and Level 2. The Level 0 DFD is the highest level, representing a single large circle that shows the interaction between the system and external entities. All entities in the DFD, including data flows, are sent directly to the system. The Level 1 DFD breaks down the entire process into subprocesses, which are further documented in more detail. The Level 2 DFD provides a more comprehensive explanation than the Level 1 DFD [17].

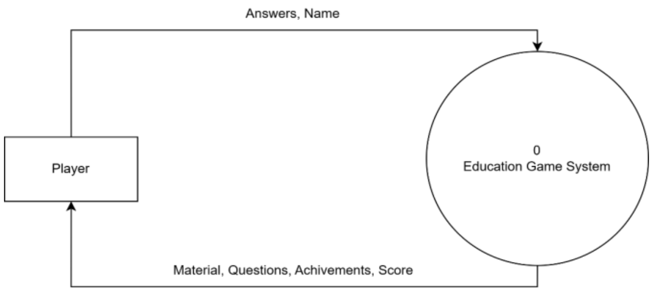

Figure 11 DFD Level 0 (Context Diagram)

In Figure 11, the DFD Level 0 of the Nusantara educational game system shows 'Player' as an entity and 'Education Game System' as the main system. The entity 'Player' provides input data, such as answers to questions and name, to the system, and the system gives output data in the form of material, questions, achievement, and score.

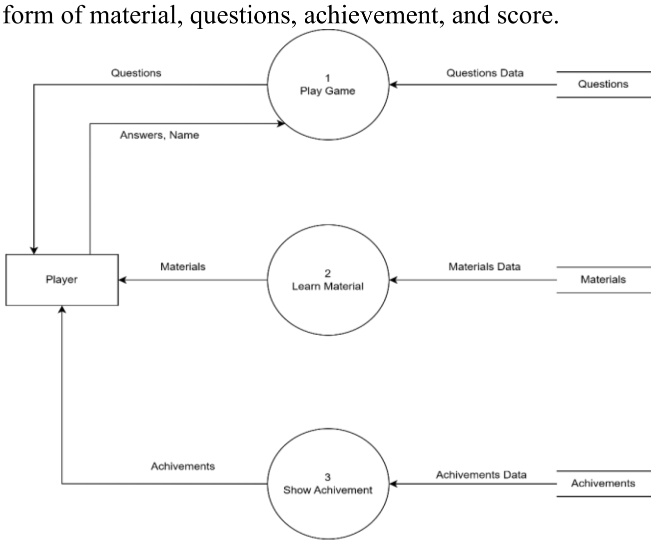

Figure 12 DFD Level 1

In Figure 12, the DFD Level 1 shows three processes in the game: 'Play Game', 'Learn Material', and 'Show Achievement'. There is one entity, 'Player'. The data storage used is local-based, which handles the data related to the game processes, such as storing scores, achievements, and learning materials.

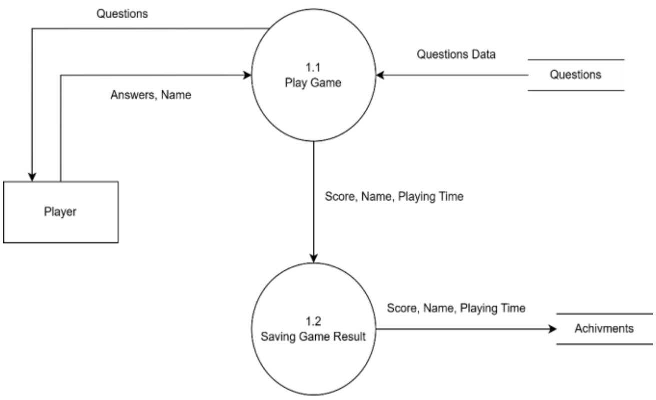

Figure 13 DFD Level 1 Process Play Game

In Figure 13, the DFD Level 2 illustrates the interaction between the entity 'Player' and the system 'Play Game'. In this process, the player is presented with questions and continues to play the game until completion. Once all questions are answered, the process proceeds to 'Saving Game Result', and the results will be saved in the data storage 'Achievements'. This level provides a detailed breakdown of the game's workflow, including the steps involved in completing the game and saving the results.

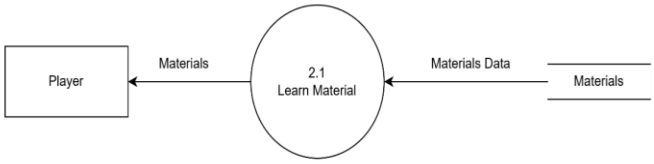

Figure 14 DFD Level1 Process Learn Material

In Figure 14, the DFD Level 2 illustrates the process of learning game material, where the player is presented with a summary of the game material from the data storage 'Materials'. This level provides a detailed flow of how the player accesses and interacts with educational content, including the retrieval of materials from the database and their presentation within the game for learning purposes.

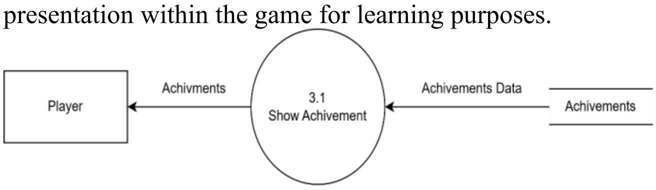

Figure 15 DFD Level 2 Process Show Achievement

In Figure 15, the DFD Level 2 illustrates the process of displaying game achievements, where the player is shown the achievements of previous gameplay stored in the data storage 'Achievements'. This process involves retrieving and displaying the player's progress and accomplishments, providing feedback to the player on their performance and success within the game.

B. Game Implementation

1) Quiz Game

Figure 16 Quiz Game Interface

Figure 16 presents the results of implementing the algorithm at the same level but at different times, generating different questions for the first number.

2) Game Score

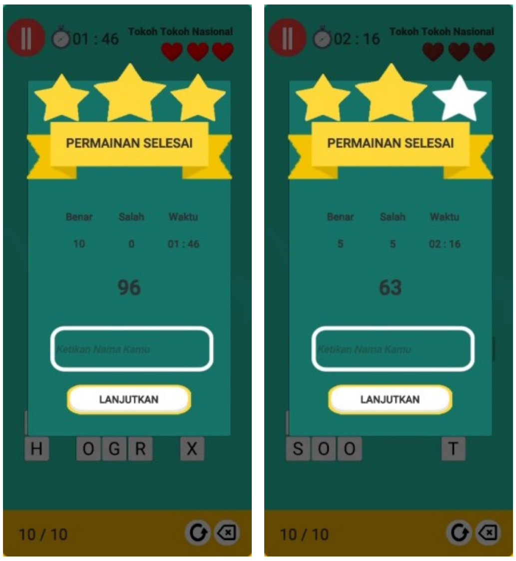

Figure 17 Achievements Menu Interface

Figure 17 shows the game score results in the achievement menu, where the scores obtained vary based on the player's performance. The score differences are influenced by the number of correct answers, mistakes, and completion time, reflecting the player's effectiveness and success in completing the quiz.

C. *Fisher-Yates Shuffle Algorithm Testing*

In this educational game, the Fisher-Yates Shuffle algorithm is applied to randomize the questions and answer letters. This test is conducted to demonstrate that the permutations generated by the Fisher-Yates Shuffle algorithm are non-repetitive and varied.

TABLE 4
GAME SYSTEM FYS ALGORITHM TESTING

Trial	New Sequence Result
1	0, 9, 4, 7, 6, 1, 5, 2, 3, 8
2	7, 2, 9, 8, 4, 6, 5, 1, 3, 0
3	0, 3, 1, 6, 9, 4, 8, 2, 5, 7
4	8, 0, 1, 5, 2, 3, 9, 4, 7, 6
5	4, 2, 7, 8, 5, 1, 0, 9, 6, 3
6	2, 8, 6, 9, 0, 1, 7, 3, 4, 5
7	5, 8, 2, 7, 4, 0, 1, 9, 3, 6
8	0, 5, 7, 1, 3, 6, 9, 8, 4, 2
9	0, 4, 9, 1, 3, 6, 5, 7, 8, 2
10	7, 9, 4, 6, 2, 3, 5, 0, 8, 1

Table 4 presents the results of testing the Fisher-Yates Shuffle (FYS) algorithm over 10 trials. The "New Sequence Result" column displays the sequence of numbers generated in each trial. From the data shown, no two trials produce identical sequences, indicating that the shuffling effectively generates unique combinations. The variation in each trial also demonstrates that the algorithm successfully prevents repetitive patterns, ensuring a fair and unpredictable distribution of questions in the game.

D. *Fuzzy Tsukamoto Algorithm Testing*

The Fuzzy Tsukamoto algorithm was tested to demonstrate that the calculated scores vary based on input, and to compare the scores generated from different input combinations. In this study, the final score is determined using two input variables: correct answers and time.

TABLE 5
FUZZY TSUKAMOTO TEST RESULTS ON GAME SYSTEM

No	Input		Score
	Correct Answer	Play Time	
1	10	90	100
2	8	92	93
3	10	134	87
4	9	143	82
5	5	153	30

Table 5 presents the results of testing the Fuzzy Tsukamoto algorithm in the game system based on the number of correct answers and playtime. From five trials, the scores vary according to predefined rules. Players with more correct answers and optimal playtime achieve higher scores. For example, 10 correct answers with 90 seconds of playtime result in a score of 100, while 5 correct answers with 153 seconds of playtime yield only a score of 30. These results demonstrate that the Fuzzy Tsukamoto algorithm provides a more dynamic assessment based on two input variables, ensuring a fairer evaluation of player performance compared to standard linear calculations.

E. *Alpha Testing*

Initial testing was conducted to ensure proper functionality of the game. In the alpha testing phase, black-box testing was applied. This approach focused on evaluating the functionality of different components of the game system without delving into the internal workings of the code.

TABLE 6
ALPHA TESTING RESULT

No	Tested Case	Expected Results	Results	Explanation
1	Players press the game icon on the smartphone menu	The game displays the splash screen and displays the game start menu	The game displays the splash screen and displays the game start menu	Success

No	Tested Case	Expected Results	Results	Explanation
2	The player presses the start button on the start menu	The game opens the category menu	The game opens the category menu	Success
3	Players select a category by pressing a button on the category menu	The game opens the level menu	The game opens the level menu	Success
4	Players select levels by pressing the 1, 2, or 3 buttons	The game displays quiz questions according to the selected category and level	The game displays quiz questions according to the selected category and level	Success
5	The player presses the Material button on the start menu	The game displays a material category menu	The game displays a material category menu	Success
6	Players select a category by pressing the button on the material category menu	The game displays material sub categories	The game displays material sub categories	Success
7	Players select a sub category by pressing the button on the material sub category menu	The game displays materials based on material categories	The game displays materials based on material categories	Success
8	The player presses the achievement button on the start menu	The game displays an achievements menu	The game displays an achievements menu	Success
9	The player presses the settings button on the start menu	The game displays a settings menu	The game displays a settings menu	Success

Table 6 shows that testing using the black-box method, based on the testing model and expected outcomes, successfully produced the desired output.

F. *Beta Testing*

This testing is divided into two parts: functional testing using a Likert scale questionnaire and effectiveness testing through question provision. Functional testing is conducted using the User Acceptance Testing (UAT) method with 30 users, while effectiveness testing is performed using the One Group Pretest-Posttest Design method, also with 30 users as the sample.

1) *User Acceptance Testing (UAT)*

The questionnaire results from 30 respondents indicated predominantly positive evaluations of the educational game. Seventeen respondents Strongly Agreed that the content aids in understanding topics, and 13 respondents Agreed that the material feature facilitates quiz answering. The interface layout was considered user-friendly, and the audio-visuals enhanced the learning experience. Features like question variety, "listen to audio," achievements, and instructions were engaging, clear, and motivating. Furthermore, 13 respondents Agreed that they would recommend the game to friends, suggesting its effectiveness as an interactive learning tool.

TABLE 7
TESTING RESULT

Option	Score	Number of Respondent Choices	Total Score
SS	5	131	655
S	4	121	484
N	3	43	129
TS	2	1	2
STS	1	4	4
Total		**300**	**1274**

Table 7 presents the results of the UAT testing, which show that the total score from 30 respondents is 1274. To determine the percentage, the following calculation can be performed.

The UAT score of 84.9% falls into the "Strongly Agree" category, indicating high user approval of the game's functionality, usability, and design. This confirms the game meets expectations in navigation, engagement, learning effectiveness, and performance, making it a promising interactive learning tool.

2) *One Group Pretest-Posttest Design*

The study used a set of 10 multiple-choice questions to assess the respondents' knowledge related to the game content. Each correct answer earned the participants 10 points, while incorrect answers received 0 points. This scoring system was designed to provide an objective evaluation of the participants' understanding and performance.

TABLE 8
TEST RESULTS OF THE ONE GROUP PRETEST-POSTTEST DESIGN METHOD

No	Respondents	Pre-test Value	Post-Test Value
1	Respondent 1	100	60
2	Respondent 2	50	80
3	Respondent 3	50	90
4	Respondent 4	20	70
5	Respondent 5	20	50
...	...	…	…
26	Respondent 26	80	80
27	Respondent 27	80	80
28	Respondent 28	20	40
29	Respondent 29	90	100
30	Respondent 30	40	60

Table 8 presents the results of the one-group pre-test post-test design, where 30 respondents completed the pre-test before using the game and the post-test after using it.

This design allowed for the comparison of respondents' knowledge and performance before and after using the game as an educational tool.

TABLE 9
FINAL RESULTS OF PRE-TEST AND POST-TEST

Data	Pre-Test Value	Post-Test Value
Total Respondent	30	
Lowest Value	20	30
Highest Value	100	100
Average	60	72,3

The pre-test and post-test results show an increase in the average score from 60 to 72.3 after playing the educational game. However, to confirm that this improvement is truly due to the use of the game, a comparison with a control group that did not use the game is necessary. If the control group experiences a similar increase, other factors such as practice effects or additional understanding from other sources could be the cause. With a normalized gain value of 0.307, indicating a moderate level of improvement, it is essential to evaluate whether aspects such as gameplay, material presentation, or interactivity in the game can be further optimized to enhance its learning impact.

G. Discussion

This game implements the Fisher-Yates Shuffle algorithm to randomize questions and answers, creating engaging variations, as well as the Fuzzy Tsukamoto algorithm to calculate scores based on player performance, ensuring fair and competitive assessments. A quantitative method was used in this study, with data collected through interviews, literature reviews, and system testing via alpha testing (black-box) and beta testing (User Acceptance Testing or UAT). The results indicate that the Fisher-Yates Shuffle algorithm enhances challenge and engagement, while the Fuzzy Tsukamoto algorithm ensures balanced scoring, fostering learning motivation. UAT results showed strong user acceptance, with an average score of 84.9%, demonstrating that the game meets user expectations in terms of functionality and design. Pre-test and post-test analysis revealed an average score increase from 60 to 72.3, with an N-Gain value of 0.307, categorized as moderate improvement. These findings confirm the effectiveness of the "PINUS" game in enhancing material comprehension by offering interactive features, educational content, and dynamic question variations, making it an engaging, accessible, and technology-based learning tool to support educational initiatives.

The scoring system in educational games often faces challenges in capturing the complexity and nuances of player performance. A fuzzy approach is necessary due to the inherent uncertainty and subjectivity in the educational context, where assessments cannot always be expressed in precise numerical values. This approach allows the system to consider multiple factors simultaneously, such as the number of correct answers and time spent, without imposing rigid boundaries. Additionally, the fuzzy method can accommodate variations in player skill levels, providing a more holistic and fair assessment.

In the context of previous studies, this research aligns with existing studies that also utilize the Fisher-Yates Shuffle algorithm to randomize questions in educational games, such as those conducted by [7] and [6], which demonstrated that this algorithm effectively creates a dynamic and non-monotonous learning experience. However, this study distinguishes itself by integrating two algorithms-Fisher-Yates Shuffle and Fuzzy Tsukamoto-to create a more adaptive scoring system. Research by [8] also applied Fuzzy Tsukamoto, but without integrating it with a randomization algorithm, making this study a more comprehensive approach to educational game development. Additionally, this study introduces a one-group pre-test post-test design to measure the game’s effectiveness, providing concrete data on student comprehension improvement. Thus, this study not only confirms previous findings but also contributes new insights into developing more interactive and effective educational games.

The fuzzy approach, particularly Fuzzy Tsukamoto, is superior to conventional methods in educational game scoring systems due to its adaptability to diverse performance levels. This method adjusts evaluations based on various factors, including time and accuracy, providing scores that better reflect players' effort and outcomes. Additionally, fuzzy logic enhances fairness by considering multiple inputs, ensuring that players who make an effort despite difficulties receive appropriate recognition. Meanwhile, Fisher-Yates Shuffle outperforms other shuffling methods due to its high randomness quality and efficiency. This algorithm generates truly unpredictable sequences, ensuring that each question and answer arrangement is randomized without discernible patterns. With a time complexity of O(n), Fisher-Yates Shuffle is highly efficient for real-time applications like games, where fast shuffling is crucial. Furthermore, this algorithm minimizes the risk of players memorizing question or answer patterns, thereby enhancing fairness and the overall gaming experience. Overall, the integration of fuzzy logic and Fisher-Yates Shuffle significantly contributes to a more equitable and effective scoring system in educational games.

IV. CONCLUSION

This study successfully developed an Android-based educational game called "PINUS: Petualangan Ilmu Nusantara," aimed at enhancing players' understanding and interest in Indonesia's culture, flora, fauna, and national figures. The game implements the Fisher-Yates Shuffle algorithm to randomize the order of questions and answers, ensuring that each gameplay session offers a unique and challenging experience. Additionally, the Fuzzy

Tsukamoto algorithm is used to calculate player scores based on their performance, such as the number of correct answers and the time spent, providing a fairer and more adaptive assessment. Testing results indicate strong user acceptance, with an average score of 84.9% in the User Acceptance Testing (UAT). Pre-test and post-test analysis also revealed an increase in average scores from 60 to 72.3, with an N-Gain value of 0.307, categorized as moderate improvement. Overall, this game has proven effective as an engaging and technology-based interactive learning tool, supporting educational initiatives in introducing and preserving Nusantara culture.

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