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The Bajau-Tainment: An AI-Powered Puzzle Game for Learning the Bajau Language Using Finite State Machine and Shuffle Techniques

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***Abstract*—**The research titled "Bajau-tainment" Educational Game (Edu-game) is a research project that focuses on the development of a Puzzle Game designed to improve memory, specifically in language learning. In this game, players must arrange randomized letters to form a word in the Bajau language. This research applies the shuffle random algorithm, which aims to ensure that the arrangement of letters is always shuffled, making the gameplay dynamic, non-monotonous, and engaging. AI Artificial Intelligence (AI) technology will also be applied in this research. Using the Finite State Machine (FSM) model method, the game will feature a game agent character that will accompany children during gameplay, like how a friend accompanies students in a classroom. This virtual friend can display emotions such as happiness or sadness based on the game environment. The research aims to make this edu-game more appealing and interactive for children. The AI game agent will act as a friend who accompanies the child throughout the game.

Keywords— Bajau, Puzzle Game, Educational Game, Shuffle Random, Finite State Machine

I. INTRODUCTION

Local Content is a subject material that introduces various unique characteristics of a particular region, not only in terms of skills and crafts but also as manifestations of regional culture, legends, and traditions (Suherman & Winarso, 2021; Noor & Purnamasari, 2019). Learning local content, specifically the Bajau language, aims to preserve the linguistic and cultural heritage of the region, instilling a sense of regional identity and personality alongside national identity. Bajau language is the regional language of the Bajau tribe (Mahali, 2014; Mosum & Yusoff, 2024), they are the original inhabitants of Maratua Island, East Kalimantan (Andrea et al, 2023). Local Content is a form of regional-specific subject material that includes a wide variety of local characteristics, such as handicrafts and traditions, and it plays a crucial role in preserving linguistic and cultural heritage in the face of modern developments (Suherman & Winarso, 2021).

This study builds the educational game (Edu-game) "Bajau-tainment" as a learning medium for local content, specifically the Bajau language, by implementing shuffle random techniques and developing a game agent using the Finite State Machine (FSM) model. The goal of this game is to create an engaging and enjoyable learning environment that introduces the Bajau language while incorporating shuffle random logic in its gameplay. In this game, the game agent (an intelligent agent) will observe, react, and act based on the environment, appearing as though it has its own mind. Each action or activity performed by the agent is designed to interact with the game environment. Therefore, the game agent will be implemented using the Finite State Machine (FSM) method, a system control methodology that describes the behavior or working principles of a system through states (conditions), events (occurrences), and actions (responses) (Adeniyi et al, 2024; Mattei, 2023; Pupius, 2015)

The game agent involved is an animated character capable of expressing emotions during every step taken by the player. If the player makes a wrong move, the intelligent agent will express disappointment, and vice versa when the player makes a correct move.

Developing educational games has been a subject of numerous studies in the context of children's education (Andrea et al, 2023). Combining FSM as an interactive agent in educational games has been explored in previous research, particularly in picture puzzle and match-up games (Al Hamaq, 2024). In line with the state of the art, this research team integrates AI into this educational game to make learning the Bajau language more interactive through a playful learning process.

Despite the crucial role of preserving local languages, there is a noticeable scarcity of engaging educational tools focused on regional languages like Bajau. Existing educational games often fail to capture the interest of young learners, leading to decreased motivation and effectiveness (Barz et al, 2024; Steinkuehler & Squire, 2024; Behnamnia et al, 2023). Moreover, many of these games lack interactive elements that could enhance the learning experience (Freire, 2023; Steinkuehler & Squire, 2024; Behnamnia et al, 2023; Greipl et al, 2020). The absence of a game with integrated AI to offer personalized

feedback and support further limits the potential for interactive and immersive learning experiences (Vistorte et al, 2024; Zhan et al, 2024; Kuhail et al, 2022). This gap highlights the need for a game that not only teaches the Bajau language but also keeps learners engaged through innovative technology and interactive features.

Previous studies on the integration of AI in educational games have demonstrated its potential to enhance learning experiences. Research has explored various methods, such as Finite State Machines (FSM) and randomization techniques, to make educational games more engaging and effective (Khoirunnita et al, 2023; Pukeng et al, 2019). For example, FSM has been used to create responsive game agents that simulate emotional reactions, enriching the learning process. Similarly, shuffle randomization techniques have been employed to prevent monotonous gameplay by ensuring that game elements, such as puzzle pieces, are arranged in unpredictable ways (Alvian et al, 2024; Astuti et al, 2022). In developing "Bajau-Tainment" we will use shuffle randomization to maintain the game's challenge and keep the gameplay fresh. The Finite State Machine model will guide the design of the game agent's behavior, allowing it to respond to player actions with appropriate emotional expressions, such as happiness, disappointment, or encouragement.

The methodology for this research involves several phases. Initially, a literature review will be conducted to gather information on educational game development, shuffle randomization, and FSM. Educational materials related to the Bajau language will also be collected. Following this, the game will be designed and developed, incorporating the shuffle randomization and FSM techniques. An AI-based game agent will be created to provide interactive feedback. The developed game will then be implemented on devices used by students and teachers, followed by beta testing with a sample group to gather feedback on gameplay and educational content (Bryant, 2024). The results from the beta testing will be analyzed to assess the effectiveness of the shuffle randomization and FSM methods, and adjustments will be made as necessary. Finally, the game will be distributed, and a final review will be conducted to ensure it meets educational and entertainment standards. This comprehensive approach aims to create a compelling educational tool that supports the preservation and learning of the Bajau language in an engaging and interactive manner.

The research aims to achieve several key objectives. it seeks to develop a puzzle game that aids in learning the Bajau language by requiring players to arrange letters into meaningful words. The research will implement shuffle randomization techniques to ensure that the letter arrangements in the game remain dynamic and engaging, preventing the gameplay from becoming monotonous. the research will integrate AI using the Finite State Machine model to create a virtual friend or game agent that interacts with players, providing emotional feedback based on their performance. The research aims to conduct beta testing with students and teachers to evaluate the game's effectiveness and gather user feedback for further refinement.

This research provides several significant contributions to the field of educational technology and language preservation. It introduces a novel approach to language learning through the integration of advanced AI and game mechanics. By employing the Finite State Machine model, the game agent's ability to interact with players and provide real-time emotional feedback represents a meaningful advancement in creating immersive and supportive learning environments. The use of shuffle randomization techniques in the game ensures that the learning process remains dynamic and challenging, thereby maintaining player engagement and interest. This aspect of the research addresses a common issue in educational games monotony by ensuring that each gameplay experience is unique (Juul, 2024; Dunnett, N. 2024; Barthel & Hoffmann, 2023; Cirant & Porretta, 2021).

The research contributes to the preservation of the Bajau language by providing a modern and interactive tool that can appeal to younger generations, helping to keep the language relevant and accessible in the digital age. Its integration of multiple innovative elements within a single educational game. While educational games are not new, the combination of shuffle randomization and an AI-driven game agent based on the Finite State Machine model is unique in the context of language learning games. This approach allows for a more personalized and responsive learning experience, where the game adapts to the player's performance and provides emotional feedback akin to human interaction. The focus on the Bajau language adds a layer of cultural significance, ensuring that the game not only serves an educational purpose but also contributes to the preservation of a regional language that is at risk of fading. The research thus stands out by combining cutting-edge technology with cultural preservation, creating a tool that is both innovative and meaningful.

II. METHOD

A. Multimedia Development Life Cycle

The research was carried out through the stages of multimedia development as follows:

1. Literature study on the process of making Edu-games and the application of the algorithms used, as well as collecting game-making materials.
2. The process of developing edu-games with multimedia development methods, starting from the design to the assembly stage, applying the finite state machine with probability in the game system.
3. Installation of edu-game applications into the iPad of children and elementary school teachers.
4. Distribution and doing beta testing to produce a satisfactory percentage value

B. Concept and Design of Finite State Automata Model

Each stage is carried out sequentially starting from the first step to the last step, each step that has been completed must be reviewed.

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The design to build the FSM model is based on events that occur in the child's activity log while playing. The character FSM is designed in combination with randomization and probability, this is done creating agents can act as children's playmates as natural as possible. The following in Figure 1 is the design of the state on the finite state machine model that will be applied to the small character agent in Figure7.

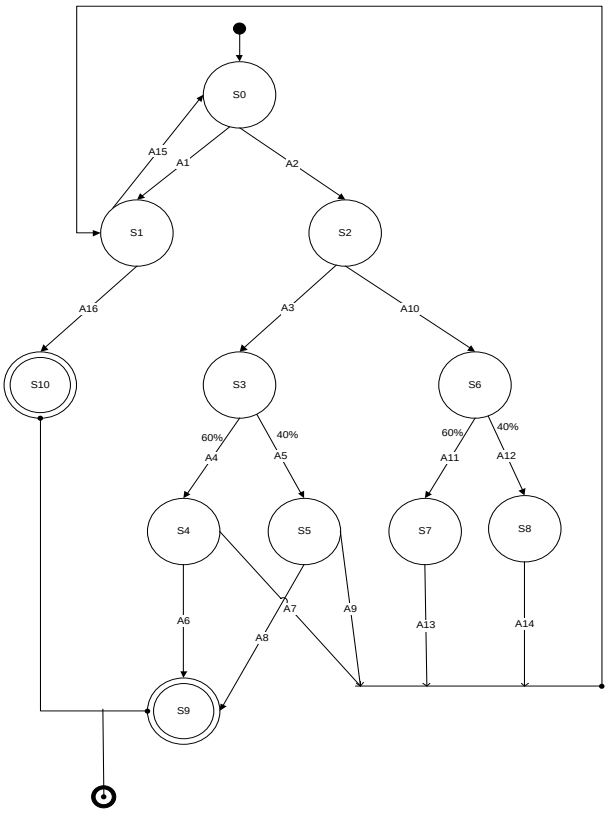

Figure 1. FSM logic model on character agent which has 11 states (S0 to S10) and 15 events (A1 to A15)

Description of Figure1

Description of Figure1

State:

S0. Silent Expression / Homing
S1. Check Time
S2. Check Answer
S3. Correct Expression
S4. Happy Expression_1
S5. Happy Expression_2
S6. Wrong Expression
S7. Sad Expression_1
S8. Sad Expression_2
S9. Losing Expression
S10. Winning Expression

Events:

A1. No answer
A2. Answering questions/matching pictures
A3. Correct answer
A4. Happy_1 expression will come out if the answer is correct
A5. Happy_2 expression will come out if the answer is correct
A6. All guessed and correct answers
A7. All the answers have not been answered
A8. All guessed and correct answers
A9. All the answers have not been answered
A10. Wrong answer
A11. Sad expression_1 will come out if the answer is wrong
A12. Sad expression_2 will come out if the answer is wrong
A13. All the answers have not been answered
A14. All the answers have not been answered
A15. Time still available

The model in Figure1 state S0, explains that at the beginning of the game, the characters (intelligent agents) who accompany the children play in a homing state. When answering, the time is checked whether time is still available or has run out (state S1), when answering the question correctly it will go to answer check (state S2), and if the answer is correct (event A3) then the character will give a happy response_1 (state S4) or happy_2 (state S5), if the answer is wrong (event A10) then the character will respond sad_1 (state S7) or sad_2 (state S8). The choice of this expression is based on the randomization of expressions that occur in states S3 and S6, where the probability values are 60% for happy_1 & sad_1, and 40% for happy_2 & sad_2 (see Figure1 event A4, A5, A11, A12). This means that the expression sad_1 has a higher probability of appearing as an expression of the agent than sad_2. For example, animal character are more dominant in frowning expressions (animation of sad_1) than expressing enthusiasm to find the right answer (animation of sad_2). Probability and randomization were carried out so that the animal character could express more variations. In the next event, if the answers are all guessed and all correct, the character will give a cheerful win response (state S9), but if all the answers have not been answered and time has run out, the game will end, and the character will cry (state S10). Each state and event model is described in a transition based on the character transitions in Figure1, the Deterministic Finite State Machine (DFSM) has the following characteristics:

Q = {S0,S1,S2,S3,S4,S5,S6,S7,S8,S9,S10}
={A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13, A14,A15,A16 }
S = {S0 }
F = {S9, S10}

In the character agent transition. The initial state is in the left column starting from S0 and going down to S10 using gray color. Events are in the gray top column, starting from A1 to A16. The final state is in the middle column which is white and irregular because the final state is determined by the initial state and events. There are 11 states and 16 events, on the finite state machine on the character agent. The character agent finite state machine process starts from S0. In state S1 it will check the time,

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and when the game is run, it will move to other states until it finally goes to the final state (finish from state S9 and S10).

II. Result and Discussion

"Bajau-Taiment" is a local content learning medium for the Bajau language that can be played on iPad. The concept is that children will play while learning the Bajau language. Maratua is an exotic island located at the tip of the island of East Kalimantan.

The child as a player must match pairs of pictures and words in the Bajau language. Like the concept of a matching game, if all the pairs of pictures and words are matched correctly, the player will emerge as the winner. On the other hand, if the player fails to match all the pairs of pictures and words until the time is up, the player will lose. There are 10 rounds in this game, where the number of pairs of pictures and words will increase in each round. In addition to the increasing number of pairs of pictures, the time to complete each round will be shorter, making it a challenge. Can be seen in Figure2. Game interface has 2 menus to learn and play. Children can choose to study first to find out the vocabulary in the Bajau language before playing.

Figure 2. The main menu interface of the game "Bajau-Taiment" has 2 options, namely, to play and learn.

The main menu display in Figure2 is the main view of the edu-game when a new player enters the system. There is a name or title from the Edu-game "Bajau-Taiment". Each button on the main menu has its own function, when pressing the learn button it will display a learning scene, when pressing the play button it will display a playing scene, when pressing the button how to play (symbol i) it will display a tutorial scene on how to play, and when pressing the exit button, then the game will exit the application.

In the learning scene (see Figure 3), the child as a player can choose the category of objects to be studied. There are 6 categories of learning objects, namely, animals, vehicles, plants, limbs, numbers and clothes in the Bajau language. This learning category can also increase as the application updates.

Figure 3. The learning menu scene displays 6 categories of Bajau language learning objects

Figure4 shows the learning interface when the player selects an animal category ("binateng" in Bajau language), there are several animals in this learning menu such as, chicken("manuk"), goat("bembe"), cat("meong"), and others. If the player presses an animal on this menu, a sound will appear pronouncing the name of the animal in the Bajau language.

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Figure 4. Learning scenes in the “beast” category featuring 8 animal objects in English and Bajau

To start the game, the player must press the play button from the main menu. In the game there are different time limits for matching the image elements of objects and words (see Figure 5). If the player runs out of time before completing the game, the player can choose to repeat or return to the main menu. There are 10 rounds in this game, where the number of pairs of pictures and words will increase in each round. In addition to the increasing number of pairs of pictures, the time to complete each round will be shorter. If the player has completed the 10 rounds, it will enter the award scene, and the player can repeat the game from the initial round again.

Figure 5. Scenes playing the first half, players must match 2 pairs of pictures with Bajau words within 60 seconds

Each round applies a randomization of the position of the image and word objects so that the game is not monotonous and easy to guess.

A. Assembly Randomization on Object Position

So that players cannot memorize the position of the picture and word that will be matched in each "Bajau-Taiment" round, the technique of randomizing the position of the image and word elements must be done at every start of the game. This means that all the element positions of each pair of pictures and words are always changing even though the player plays this game over and over again. This condition is shown in Figure6.

(a) (b)

Figure 6. The play scene displays different randomization conditions of image(a) and image(b) of the same act.

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As in Figure 6 (a) and (b), the location of the picture and word pairs can move randomly. For example, in Figure 6, the image of the paddle is in the bottom position, while in the other randomization conditions, the image of the paddle is located on the top (see Figure6 (b)). If the player has matched all the pairs of pictures and words, then the player can move on to the next round. If the player has completed all ten rounds, it will enter the award scene, and the player can also repeat this game from the beginning again. Even if players play this game repeatedly, the pair of picture and word elements will be re-randomized. The probability ranges from 0 to 1. The probability of 0 represents an event that is unlikely to occur, while a probability close to 1 represents an event that is likely to occur frequently. The number 1 is perceived as 100%. Understood from Figure 6(a) and (b), the probability that the cat image is located at the topmost element as in Figure 6(a) is (1).

$$P(A) = \frac{n}{N} \quad (1)$$

$$P(A) = \frac{1}{4} = 0.25 \rightarrow 25\%$$

While the probability that the cat image is located at the bottom element along with the word "meow" is located at the top element as shown in Figure 6 (b) is (2)

$$P(A1 \cap A2) = P(A1) \times P(A2) \quad (2)$$

$$P(A1 \cap A2) = 1 / 4 \times 1 / 4 = 1/16 = 0.0625 \rightarrow 6.25\%$$

In (2) it is assumed, A1 is a series of animal picture elements, while A2 is a series of word elements. The row of animal image elements is only randomized to the left position either above or below, as well as the word element row is only randomized to the right position only. The respective probability of P(A1) and P(A2) is 1/4, so the independent probability of both is P(A1 ∩ A2) is 1/16. The more image elements that appear, the lower the probability. This will make the game less boring because the challenges of each round are always changing.

B. Assembly FSM with Probability

The FSM logic model (Figure7) is applied as an expression pattern for sea turtle characters, animal characters will notify children if they match pictures and words correctly or incorrectly, and provide notifications when time is running out, win and lose.

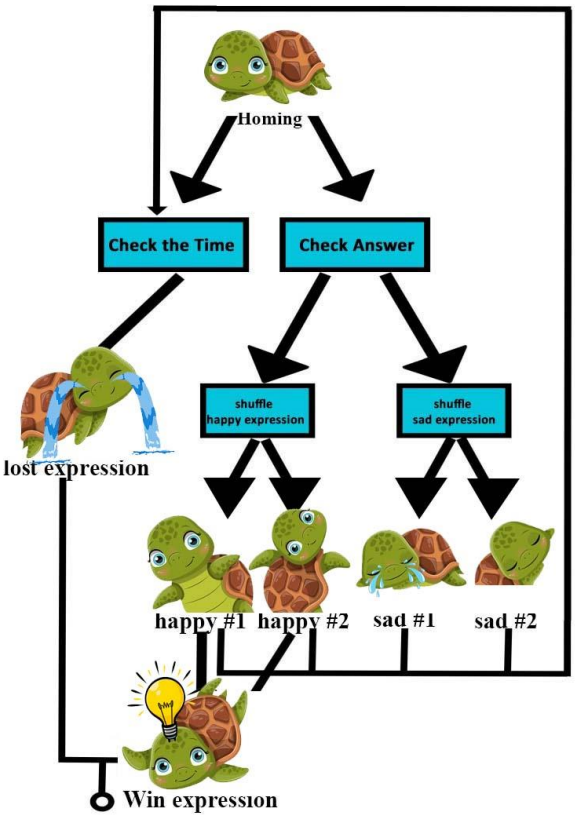

Figure 7. Notifications in the form of animated facial expressions of animal character, this expression is the embodiment of the finite state machine model

It can be seen in Figure7, that the characters can give expressions happy_1, happy_2, sad_1, sad_2, randomly. The probability of the appearance of happy_1 and sad_2 expressions is more likely to appear because they have a higher percentage, namely, 60%. FSM logic will make this notification appear according to the player's action. These animal characters can also make voices, for example saying, "let's find the right answer again!". Characters can also express happy when the player comes out victorious (see Figure 8).

Figure 8. award scenes appear after completing each round

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Can be seen in Figure 8, is the award scene that appears when the player manages to match all the pictures and words. This scene also appears when the player has completed 10 rounds of the game (end). The game interface will display a happy little character, congratulate the child and invite him to play again. All animations of intelligent agents are made in such a way that players enjoy playing this game, especially for children.

C. Beta Testing

Beta testing is a live test of an application in an environment that cannot be controlled by the developer (Bryant, 2024). Our study looked at the effectiveness of the randomization method in this game for a wide range of children. Beta testing was carried out on 3 children of varying ages. We did 3 tests playing this game, until it was finished or game over. Respondent R1 is 9 years old, R2 is 12 years old, R3 is 13 years old. The test results are shown in table 1.

Table 1. Beta testing results

Test to-		**Time Remaining (s) per stage(b)**										∑
		b1	**b2**	**b3**	**b4**	**b5**	**b6**	**b7**	**b8**	**b9**	**b10**	
R1	1	8	6	5	4	3	9	1	0	0	0	**36**
	2	9	9	10	8	9	10	11	5	0	0	**71**
	3	7	10	2	7	2	7	12	0	0	0	**47**
R2	1	9	6	5	12	4	20	12	7	7	1	**83**
	2	19	7	8	13	7	22	8	8	9	0	**101**
	3	20	10	10	15	6	13	16	2	9	9	**110**
R3	1	20	10	5	6	10	15	15	5	0	0	**86**
	2	35	20	9	7	10	12	11	10	3	5	**122**
	3	26	30	5	20	15	7	31	11	4	0	**149**
	x	17,00	12,00	6,56	10,22	7,33	12,78	13,00	5,33	3,56	1,67	

Information Table 1:

R {1,2,3}	= respondent
st	= stage
s	= time remaining (seconds)
x	= average residual time
∑	= total time

It can be seen from table 1, that the first round (b1) is the easiest round, because the average (X) remaining time to complete this round is at the highest number, which is 17.0 seconds. While the most difficult round is the 10th round (b10) with an average remaining time of only 1.7 seconds, this is because many players lose (game over) with 0 seconds remaining. Based on the results of 3 tests on each respondent, in terms of the total remaining time, player R3 is superior to players R2 and R1. It can be seen from the total remaining time of player R3: 86+122+149=357 seconds, while player R2 is only: 83+101 +110=294 seconds. But from the other side, player R2 is superior because only player B has managed to complete all rounds until the game is over 2 times out of 3 trials. It is seen that only player B gets 1 time the value of 0 seconds in the b10 round column. This test table proves that randomization and probability techniques make the challenge in each round not reduced, because players cannot memorize the position of picture and word pairs, even though this game is played repeatedly.

IV. CONCLUSION

"Bajau-Taiment" is an educational game (Edu-game) which was built to introduce the local content of Bajau language education to children. The games that are built start from concept to testing and distribution according to the multimedia stages. The randomization technique is applied in each round of this game with the aim of preventing players from memorizing the position of the letter objects in each game, so that the game is not static and boring. It is evident from the results of the beta testing that the difficulty of the players completing each round is not reduced.

Games that are too easy will make players bored, while games that are too difficult will make players depressed. These things will make the game that is made easy to leave. We have conceptualized the presence of intelligent agents in this game in the form of sea turtle characters. Intelligent agents can accompany children to play like companions. By applying the logic of the FSM model, intelligent agents can express happy, sadness, or give encouragement when children start having trouble playing this game. We also apply randomization and probability in FSM logic making funny characters in the game can interact according to the logic of action-reaction which sometimes becomes random according to the player's playing style. This is what makes educational games with game agents more interactive and natural for children.

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