



Digital Preservation of Balinese Heritage through Educational Game: A Case Study of Perang Pandan Tradition

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ABSTRACT

The declining interest of younger generations in traditional culture presents a significant challenge for cultural preservation in the digital era. Conventional preservation approaches, such as textual documentation and static visual media, tend to be passive and less effective in engaging digital-native audiences. As a result, innovative and interactive strategies are required to ensure the sustainability and transmission of indigenous cultural values. This research proposes an Android-based educational game as an interactive medium for preserving and introducing the Perang Pandan tradition of Tenganan Peglingsingan Village, Bali. The game was developed by implementing the Finite State Machine (FSM) method to manage adaptive character behavior, enemy intelligence, and game state transitions. FSM enables dynamic responses to player actions, resulting in a more realistic and engaging gameplay experience that supports experiential learning. This study employs the ADDIE instructional design model, limited to the Analysis, Design, Development, and Evaluation stages. Functional reliability was assessed using Black-box Testing to ensure that all features operated according to the system requirements. User experience quality was measured using the User Experience Questionnaire (UEQ), covering both pragmatic and hedonic aspects. The results of Black-box Testing indicate high functional success rates across all tested menus, demonstrating system stability and usability. Furthermore, the UEQ results show an overall average score of 1.63. These findings suggest that FSM-based educational games are effective not only as digital cultural preservation tools but also as interactive learning media that provide engaging and high-quality user experiences.

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1. Introduction

Tradition is a habit that is passed down from one generation to the next[1]. According to the Indonesian Dictionary[2], tradition is defined as "customs still practiced by society," reflecting values considered true. Tradition holds significant roles, such as serving as a foundation for actions, legitimizing rules, strengthening collective identity, and providing an escape from modernity.

Indonesia is rich in traditions, particularly in Bali, known as a cultural tourism destination. Data from BPS Bali (2024) recorded 5,273,258 foreign tourists visiting Bali throughout 2023. One of its cultural attractions is Tenganan Pegringsingan Traditional Village in Karangasem Regency, renowned for the Perang Pandan Tradition. Perang Pandan is an annual tradition held in the fifth month of the Tenganan Pegringsingan community's special calendar, corresponding to June in the Gregorian calendar. During this event, young men—from children to adults—engage in duels using thorny pandan leaves as weapons and rattan shields for protection. This tradition aims to honor Lord Indra, the God of War and Fertility. Lord Indra is considered the highest deity by the Tenganan Pegringsingan community, as he is believed to have granted them vast land to inhabit[3].

In the digital era, cultural preservation can be achieved through games as an interactive and accessible medium[4]. A 2D casual fighting game was chosen to introduce Perang Pandan, as it reflects the bravery and fighting spirit of Tenganan youth. According to GoodStats (2024), 43% of Gen Z in Indonesia play games daily, with 76% using mobile phones. Games offer an interactive approach to cultural preservation and tourism promotion by introducing traditions to a wider audience.

For the development of the Perang Pandan game, the Finite State Machine (FSM) method was selected. FSM is a computational model implemented using hardware or software to simulate sequential logic and various computer programs. FSM operates based on states (conditions), events (triggers), and actions (responses) that are interconnected. FSM was chosen because: (1) It simplifies character behavior management in a structured manner, making it easier to define actions such as attacks, defense, and movement, (2) It provides flexibility in adding or modifying character behaviors without overhauling the entire program structure, and (3) It enables the game to respond to player inputs in real-time, creating a more realistic and interactive gameplay experience[5].

Despite the growing number of studies on cultural preservation through digital games, most existing research focuses on documentation-oriented gamification or narrative-based cultural representation, with limited attention to adaptive gameplay mechanics that dynamically respond to user behavior. Previous studies on cultural games predominantly emphasize visual representation and storytelling, while the integration of intelligent behavior model, such as Finite State Machine (FSM) to support engagement and experiential learning remains underexplored, particularly in the context of Balinese indigenous traditions.

This research addresses this gap by proposing an educational game that integrates FSM-driven adaptive character behavior with authentic cultural elements of the Perang Pandan tradition. The novelty of this study lies in (1) the application of FSM not only for technical character control but also as a mechanism to enhance learning engagement, (2) the transformation of a ritual-based tradition into an interactive experiential learning medium, and (3) the empirical evaluation of user experience using quantitative UEQ analysis. Unlike previous cultural gamification studies, this research emphasizes intelligent gameplay adaptation as a pedagogical and cultural preservation strategy.

Based on these considerations, this study aims to digitize traditions by developing a game that introduces, preserves, and provides a virtual experience of Perang Pandan

through the research titled “Play to Learn: Exploring Balinese Indigenous Culture through a Perang Pandan Game”.

2. Method

This study employed a research and development (R&D) approach using the ADDIE instructional design model, which consists of Analysis, Design, Development, Implementation, and Evaluation. In this research, the ADDIE model was applied only up to the Evaluation stage, focusing on user-based evaluation. Classroom implementation and learning effectiveness testing were beyond the scope of this study.

Analysis

The analysis stage aimed to identify cultural content requirements, user needs, and technical specifications for developing an educational game based on the Perang Pandan tradition. Data were collected through observation and interviews with community representatives of Tenganan Pegringsingan Village, as well as literature studies related to cultural preservation, educational games, and Finite State Machine (FSM) implementation. This stage resulted in the identification of key cultural elements, learning objectives, and gameplay requirements.

Design

In the design stage, the system architecture and instructional flow of the game were developed. This included the creation of use case diagrams, game flow diagrams, interface designs, level structures, and the conceptual design of FSM-based character behavior. Game mechanics were designed to reflect the values and meaning of the Perang Pandan tradition through staged battles, adaptive enemy behavior, and rule-based interactions.

Development

The development stage involved implementing the designed system using the Unity game engine. FSM was applied to control character states, enemy behavior, and game progression. Visual assets, audio elements, and cultural attributes were integrated into the game environment. At this stage, the application became a fully functional Android-based educational game ready for user testing.

Implementation (Limited Scope)

The implementation stage in this study was limited to individual user testing, not classroom-based instructional implementation. The developed game was distributed to users for trial using Android devices to ensure functionality and usability in real-use conditions.

Evaluation

The evaluation stage focused on quantitative user-based assessment involving 44 respondents selected through purposive sampling. Functional quality was evaluated using Black-box Testing, while user experience was measured using the User Experience Questionnaire (UEQ). The evaluation results were used to assess system reliability and user experience quality rather than learning outcome effectiveness.

3. Result and Discussions

A. Implementation

The following section presents the implementation results of the Android-based Perang Pandan Traditional Game design. The layout was designed using graphic processing applications, starting from the creation of buttons and game elements to the overall interface design. Once the interface design was completed, all assets were exported in JPG and PNG formats and then imported into the Unity game development software.

1) Splash Screen

This layout appears before the game starts, displaying the INSTIKI logo and Unity logo before transitioning to the Loading screen.



Figure 1. Splash Screen

2) Loading

At this stage, the Loading screen is designed as an initial display before players access the main menu. It serves as a bridge between game initialization and the main interface. The screen features the game logo centered on the screen, with the text "Tap to start the game" at the bottom. This text provides a simple instruction for players to proceed to the main menu by interacting with the screen.



Figure 2. Loading

3) Main Menu

This is the first layout displayed after the Loading screen. Players must tap the text "Tap to start the game" to enter the main menu. The main menu includes several options, such as:

- Start Game: Directs players to the level and character selection menus, allowing them to choose the difficulty level and character they want to use.
- Settings Menu: Enables players to turn sound effects and background music on or off based on their preferences.
- Information Menu: Provides details about the application, including gameplay guides and background information on the Perang Pandan tradition.
- Exit Button: Allows users to exit the game.



Figure 3. Main Menu

4) Level Selection Menu

This layout serves as the level selection menu, designed to provide players with various difficulty levels and enemy characters they will face in the game. This menu appears after selecting "Start Game" in the main menu. Players can view available levels, each offering different challenges, such as varying enemy types and in-game obstacles.

- Available levels are displayed clearly, while locked levels appear dimmed to indicate they are not yet accessible.
- Each level features a specific enemy character, previewed before the game starts.
- A "Start" button is available for players to confirm their level selection and proceed to the next menu.



Figure 4. Level Selection Menu

5) Character Selection Menu

This layout provides players with the flexibility to choose the main character they will control. It appears after the player selects "Start" in the level selection menu. The menu displays a list of available characters, with locked characters appearing dimmed to indicate

they are not yet accessible. Once the player selects a character, they will automatically enter the game.



Figure 5. Character Selection Menu

6) Gameplay

In this layout, which appears after the user selects the main character, the background features Bale Banjar and the rural atmosphere of Tenganan Village, creating an authentic and serene setting. Several key elements are present in this layout, including the health bar, which displays the remaining health points (HP) of the player's character. The HP decreases each time the enemy successfully lands an attack. A timer is also displayed to indicate the remaining game time.

Each game session lasts one (1) minute per stage, with two (2) stages per level. If the main character wins both stages, they advance to the next level. However, if the enemy wins both stages, the main character is considered defeated, and a prompt appears to restart the game. In the case of a draw, where one character wins Stage 1 and the other wins Stage 2, a third stage is initiated to determine the final winner of that level.

The user must attack the enemy using three (3) action icons located in the bottom right corner. The pandan leaf and sword icons are used for attacking and moving the character in different directions, such as forward, backward, and upward. The shield icon is used to block enemy attacks. On the bottom left corner, a joystick button allows the user to control the character's movement with ease. Additionally, a plus or medicine icon is available to restore health points, providing an extra chance to survive longer in the game.



Figure 6. Gameplay

The level design in the Perang Pandan Traditional Game consists of multiple stages, each presenting different challenges that increase in difficulty as the player progresses. Each

level introduces unique enemy behaviors and obstacles, requiring players to strategically adapt their attack and defense tactics.

Table 1. Level Design and Challenges

No.	Level	Challenges
1	Level 1 : <i>Warrior's Trial</i>	a. Win by Knockout (KO): Defeat the opponent by completely depleting their health. b. Land 10 Hits: Successfully land 10 attacks on the opponent within a single round. c. Use Special Moves: Execute at least three (3) special attacks during the match.
2	Level 2 : <i>Champion's Challenge</i>	a. Win Without Losing a Round: Maintain a perfect victory in both rounds. b. Finish with a Special Move: End the match using a special attack as the final blow. c. Block 10 Attacks: Successfully defend against 10 enemy attacks during the battle.
3	Level 3 : <i>Master's Test</i>	a. Win a Round in Under 60 Seconds: Defeat the opponent within the time limit. b. Win Without Losing a Round: Secure a flawless victory. c. Dodge 5 Attacks: Successfully evade five (5) enemy attacks.
4	Level 4 : <i>Hero's Quest</i>	a. Win with at Least 50% HP Remaining: Finish the round with at least half of your health points. b. Win Using Only Basic Attacks: Complete the round without using special moves. c. Land 20 Basic Attacks: Successfully hit the opponent with 20 basic attacks.
5	Level 5 : <i>Legend's Challenge</i>	a. Win Without Losing a Round: Achieve a perfect victory. b. Perfect Round: Win a round without taking any damage. c. Win in Under 60 Seconds: Defeat the opponent within the given time frame.

Each level progressively increases in difficulty, requiring more strategic gameplay, precision, and timing. As players advance, enemies become smarter and more adaptive, utilizing more complex attack patterns and defensive strategies, enhancing the challenge and excitement of the game.

B. Implementation of Finite State Machine

In the Perang Pandan Traditional Game, the Finite State Machine (FSM) serves as the core logic framework to dynamically and systematically manage the behavior of the main character[6]. SM allows characters to transition between different states based on player input and game conditions, ensuring smooth and responsive gameplay[7]. The following table outlines the FSM transition states used in this game:

Table 2. Transition Finite State Machine

No.	Current State	Event	Next State
1	Idle	Start Walking	Walking
2	Idle	Start Jumping	Jumping

3	Idle	Start Attacking	Attacking
4	Idle	Get Hit	Hit
5	Walking	Stop Walking	Idle
6	Walking	Start Jumping	Jumping
7	Walking	Start Attacking	Attacking
8	Walking	Get Hit	Hit
9	Jumping	Land	Idle
10	Jumping	Get Hit	Hit
11	Attacking	Finish Attack	Idle
12	Attacking	Get Hit	Hit
13	Hit	Recovery	Idle

There are two types of states managed in the game: the main state (`_currentState`), such as standing (`StandingState`) or jumping (`JumpingState`), and the sub-state (`_currentSubState`), such as idle (`IdleState`), walking forward (`WalkingForwardState`), or attacking (`AttackingState`). These states are initialized in the `Awake` method using the `InitializeState` and `InitializeSubState` functions. Each state transition is managed through the `ChangeState` and `ChangeSubState` methods, ensuring that every state executes its specific actions upon entry (`OnEnterState`) and exit (`OnExitState`). For example, when the player presses the upward direction button, the character transitions to the jumping state (`JumpingState`). State transitions are handled by the `UpdateState` method, which is called within the `Update` function to ensure each state knows when to start or stop functioning. All states are updated regularly throughout the game to create smooth transitions, such as moving from idle to walking or switching from attacking to defending.

```
if (_movementReadValue.y > 0) {
    ChangeState(_jumpingState);
}
```

Figure 7. Jumping Character Script



Figure 8. Jumping Character Illustration

The Finite State Machine (FSM) is also used to manage game progression. The game state is defined as GameState, which consists of several stages, such as starting a round (GameBegin), running the game (GameRun), and ending a round (GameEnd). State transitions are controlled in the FixedUpdate method, where each state contains specific game logic. For instance, in the GameBegin state (at the start of a round), the game time is reset, and player input is locked. In the GameStart state (when gameplay begins), the timer starts counting down, and the player can control the main character in battle. A new state transition occurs automatically using methods like StartNewRound, which is triggered when the game timer runs out or when a player wins a round, resetting the state back to GameBegin[8].

At each level, FSM ensures that enemy behavior becomes more complex and adaptive[9]. In early levels, enemy behavior is relatively simple, such as direct attacks or forward movement without strategy. However, at higher levels, FSM enables enemies to make smarter decisions, such as waiting for the right moment to attack, dodging player attacks, or setting up specific formations. With FSM, enemies can automatically adapt to the player's gameplay patterns, increasing the difficulty and creating a more engaging challenge[10].

FSM is also implemented in Health Point (HP) management for enemies[11]. As enemy HP decreases, FSM adjusts their behavior dynamically. For example, enemies with full HP tend to be more cautious and defensive, whereas enemies with half HP or less become more aggressive and attack continuously. FSM triggers a state where enemies prioritize survival, creating the illusion of "awareness" and adding a layer of realism to the game[12].

C. Testing Result

After the implementation phase was completed, the testing phase was conducted to evaluate the game's quality based on its information delivery and media aspects. The test involved 44 respondents from the general public who used Android smartphones, with data collected online via Google Forms. The testing process included distributing questionnaires containing several evaluation questions. Furthermore, the application was tested using Black-box testing and the User Experience Questionnaire (UEQ). Black-box testing is a software quality assessment method that focuses on testing the functionality of the software [13]. Meanwhile, the User Experience Questionnaire (UEQ) is a measurement tool used to analyze user experience survey data in a simple, reliable, and fact-based manner to assess subjective quality aspects of the game

1) Black-box Testing

The testing process was conducted using the percentage of success formula[14] to measure the effectiveness and functionality of the game features. This formula helps determine the success rate of each tested component by evaluating whether the game meets expected performance standards. The PASS calculation assesses different aspects of the game, including usability, functionality, and user interaction, ensuring that the game operates as intended across various scenarios.

$$\text{Percentage of success} = \left(\frac{\text{Number of Successful Tests}}{\text{Total Tests Conducted}} \right) \times 100\% \quad (1)$$

Based on the Black-box Testing conducted on the Perang Pandan Traditional Game, a high success rate was achieved for each tested scenario. In the Main Menu, the success rate reached 88.63%, indicating that most users were able to open the application smoothly. In the Information Menu, the success rate was 97.73%, meaning that this menu functioned almost perfectly according to user expectations without any issues. Furthermore, in the Settings Menu, the success rate reached 95.45%, where most users were able to adjust sound and music settings without difficulty. Meanwhile, in the Level Selection Menu, the success rate also reached 95.45%, demonstrating that users could select levels and start the game without problems. Overall, these testing results show that the application successfully meets user needs and expectations with a very high success rate, indicating that the application is stable and suitable for user deployment.

Table 3. Black-box Testing Results

No.	Tested Menu	Test Scenario	Result
1	Main Menu	User opens the application	PASS (Meets expectations)
2	Information Menu	User clicks the "Information" button	PASS (Meets expectations)
3	Settings Menu	User clicks the "Settings" button	PASS (Meets expectations)
		User adjusts the sound settings	PASS (Meets expectations)
		User adjusts the music settings	PASS (Meets expectations)
		User adjusts the sound volume	PASS (Meets expectations)
		User adjusts the music volume	PASS (Meets expectations)
4	Level Selection Menu	User selects a level	PASS (Meets expectations)
		User clicks the "Start Game" button	PASS (Meets expectations)

The testing results confirm that the application meets user expectations with a very high success rate. This indicates that the game is stable, functional, and ready for user deployment.

2) User Experience Questionnaire (UEQ) Testing

After conducting Black-box Testing, the next phase involved testing the application using the User Experience Questionnaire (UEQ). The UEQ testing was carried out by distributing an online questionnaire via Google Forms to 44 respondents. This method was used to measure the user experience based on several aspects, including attractiveness, efficiency, and ease of use. The collected UEQ data was then imported into the Excel-based tool "Short_Data_Analysis_Tool_V12", which automatically processes and analyzes survey

responses. This tool helps generate accurate statistical results, allowing for a detailed evaluation of the application's user experience quality.

Items							
1	2	3	4	5	6	7	8
7	7	5	7	4	7	7	7
7	7	5	7	7	7	7	7
7	7	4	7	7	7	7	7
6	5	5	4	3	5	5	4
7	7	4	7	7	7	7	7
5	6	6	4	4	5	6	5
7	7	7	7	7	7	7	7
7	7	7	7	7	7	7	7
6	5	6	6	7	6	6	6
7	7	7	7	7	7	7	7
6	7	5	5	4	6	6	5
5	6	6	5	4	6	7	6
6	5	5	5	6	5	6	6
6	6	5	6	6	6	6	6
7	7	6	7	7	7	7	4
5	5	5	5	5	5	5	5
6	5	7	6	5	6	6	6
5	5	4	4	5	4	5	5
6	7	7	7	6	7	6	6
4	4	4	4	5	5	5	4
3	4	4	4	5	4	6	5
4	4	4	4	5	3	5	4
5	5	6	5	7	6	6	6
5	6	5	5	5	5	6	5
5	5	6	5	5	5	6	6
5	5	5	4	5	4	5	4
4	4	4	4	4	4	4	4

Figure 9. UEQ Results

Reliability testing was conducted using the Cronbach's Alpha internal reliability coefficient method. Cronbach's Alpha is a benchmark used to describe the correlation or relationship between the created scale and all existing variable scales[15]. This method aims to measure the extent to which the items within the UEQ instrument are interrelated, while also providing an overview of the overall reliability of the instrument. In the questionnaire, reliability is assessed based on the Cronbach's Alpha value, where a value greater than 0.6 (>0.6) is considered a reliable indicator. The closer the value is to 1, the higher the level of reliability and internal consistency of the indicators within the instrument. Based on Figure 10, it can be concluded that both indicators in this study demonstrate reliable Cronbach's Alpha values, as they are above 0.6.

Kualitas Pragmatis		Kualitas Hedonis	
Items	Correlation	Items	Correlation
1.2	0.85	5.6	0.58
1.3	0.44	5.7	0.56
1.4	0.87	5.8	0.57
2.3	0.42	6.7	0.83
2.4	0.83	6.8	0.75
3.4	0.48	7.8	0.78
Average	0.65	Average	0.68
Alpha	0.88	Alpha	0.89

Figure 10. Cronbach's Alpha Coefficient

After calculating the average score for each indicator on the two available scales, the next step is to compare the results with benchmark data that has been collected. Benchmarking is the process of comparing similar elements using predetermined standards, with the goal of obtaining comparative results that can be used for improvements. By comparing the average score of the tested product against other products in the benchmark data, it becomes possible to determine whether the product's quality is superior or inferior compared to similar products[16].

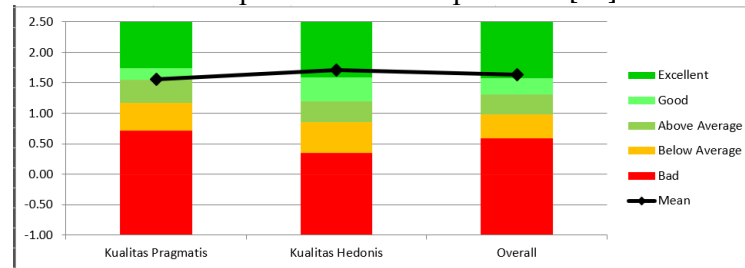


Figure 11. Benchmark Diagram of UEQ Scale Scores for the Perang Pandan Traditional Game

Scale	Mean	Comparisson to benchmark	Interpretation
Kualitas Pragmatis	1.55555556	Good	10% of results better, 75% of results worse
Kualitas Hedonis	1.7037037	Excellent	In the range of the 10% best results
Overall	1.63	Excellent	In the range of the 10% best results

Figure 12. Benchmark Analysis Results

Based on the benchmark results from the UEQ testing, the application's pragmatic quality achieved an average score of 1.56, placing it in the Good category. Meanwhile, the hedonic quality received an average score of 1.70, which falls under the Excellent category. Overall, the application obtained an average score of 1.63, placing it in the Excellent category and ranking it among the top 10% of benchmark results. From these results, it can be concluded that the Perang Pandan Traditional Game provides an exceptional user experience, with high scores in attractiveness, ease of use, and efficiency.

D. Game Mechanics as Cultural Learning Experience

This educational game is designed as a digital cultural preservation medium, where traditional values and meanings are transmitted through interactive gameplay. By transforming the Perang Pandan tradition into an educational game, cultural knowledge is preserved and communicated through player interaction, aligning with recent studies that emphasize the role of serious games in sustaining intangible cultural heritage [17]. Game mechanics such as staged ritual combat, adaptive enemy behavior, time constraints, and health management are deliberately structured to represent the symbolic and rule-based nature of the Perang Pandan tradition. The use of Finite State Machine (FSM) enables adaptive interactions that encourage players to experience values of bravery, discipline, and respect embedded in the ritual. This experiential approach supports cultural learning by allowing players to internalize traditional meanings through repeated interaction rather

than explicit explanation, which is a key principle in cultural preservation-oriented educational games.

Through immersive environments, traditional weapons, and culturally inspired audio, the game creates a contextual learning space that supports the preservation of cultural identity in a digital format. As a result, the Perang Pandan tradition is not only documented but also actively sustained through interactive learning experiences that are accessible to younger, digital-native generations.

4. Conclusion

This study contributes to the field of educational technology by demonstrating how Finite State Machine (FSM) can be effectively integrated into a cultural educational game to enhance engagement and experiential learning. The main contribution of this research lies in the development of an adaptive gameplay system that combines intelligent character behavior with authentic representations of the Perang Pandan tradition. Quantitative evaluation using Black-box Testing and the User Experience Questionnaire (UEQ) indicates that the game achieves high functional reliability and excellent user experience quality, particularly in hedonic and pragmatic aspects. These findings confirm that FSM-based adaptive mechanics can support both cultural preservation and meaningful user interaction. This research is limited to user experience evaluation and does not yet measure cognitive learning outcomes related to cultural understanding. Future research is recommended to incorporate experimental designs to assess learning effectiveness and to involve broader cultural stakeholders for extended validation.

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