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Game development of Banjar archive for interactive cultural education utilizing large language models

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Abstract
The preservation of Banjar cultural heritage is threatened by globalization and the fading interest of younger generations. This study addressed these challenges by developing an interactive educational game using the Game Development Life Cycle (GDLC) framework and integrating Large Language Models (LLMs) for adaptive and immersive player interactions. The six stages of GDLC namely initiation, pre-production, production, testing, beta, and release were systematically applied, resulting in a game that blends dynamic narratives to engage players while educating them about Banjar culture. Black Box Testing verified 14 test scenarios that all passed successfully, ensuring system stability and reliability. Additionally, user experience evaluation using the Game Experience Questionnaire (GEQ) highlighted high levels of immersion (4.936), competence (4.448), flow (3.124) and positive affect (4.976) among players, with minimal reported tension (1), challenge (1.744) and negative affect (1.07). These results demonstrated that the game successfully balances educational goals with engaging gameplay, fostering meaningful connections to Banjar heritage. By leveraging LLM technology, the game enhances interactivity, offering an innovative approach to Banjar cultural preservation in the digital era. This research extends the existing body of knowledge on AI-driven gamification strategies in heritage conservation with a specific focus on Banjar culture.

1. Introduction

The preservation of cultural heritage among younger generations has emerged as a critical challenge in an era defined by globalization and rapid technological advancement [1] [2]. For the Banjar people of South Kalimantan, Indonesia, this challenge manifests in the erosion of traditional practices, folklore and language, which are increasingly overshadowed by global cultural influences and digital media consumption [3]. Recent studies highlight the dual role of technology as both a threat and a potential solution: while digital platforms accelerate cultural homogenization, they also offer innovative tools for documentation, education, and community engagement [4]. Without innovative solutions, the rich traditions, folklore, and language of the Banjar people may continue to erode, leading to a loss of cultural identity and historical knowledge [5]. This highlights the urgent need for sustainable strategies to ensure the transmission of cultural values and identity across generations in the face of modern challenges [6].

Researchers have turned to innovative digital solutions such as educational games to engage the younger generation and address these challenges. Games have the unique ability to combine learning with engagement, making them an ideal medium for cultural education. Recent studies have explored various approaches to preserving and teaching Banjar culture through educational games. For example, a study by [7] developed an action-adventure game based on the folklore of Sultan Suriansyah to preserve Banjarmasin's cultural heritage and teach the Banjar language. Similarly, another research conducted by [8] created an educational game to introduce the Banjar language to children through interactive quizzes. In a different approach, [9] designed a puzzle game incorporating AI technology, where a game agent acted as a virtual teacher to teach the Banjar language. Additionally, [10] proposed traditional Banjar games as a model for social science education, emphasizing their educational and character-building values. While these studies demonstrate the potential of gamification in cultural preservation and language learning, most approaches remain limited in interactivity, relying on predefined content and scripted interactions. The lack of adaptability in educational games can hinder their effectiveness as they fail to respond to the diverse needs and preferences of individual learners.

This study aims to address these limitations by introducing a more adaptive and interactive system that leverages the capabilities of Large Language Models (LLMs). LLMs such as GPT-4 and similar architectures are designed to process and generate human-like text based on vast datasets, enabling them to understand and respond to natural language inputs with high accuracy [11]. By integrating LLMs into an educational game, real-time dynamic interactions enabled, allowing players to engage in meaningful conversations with AI-driven characters [12] [13]. These characters can provide culturally relevant information, answer questions, and even adapt their responses based on the player's choices and progress. LLMs enable narratives that are responsive to player choices, increasing engagement through a variety of possible storylines [14]. Additionally contextual prompting is used to guide the LLM in generating relevant and engaging dialogue ensuring alignment with the educational goals of the game [15] [16]. Through this approach, gamified cultural preservation strategies effectively balance educational goals with engaging gameplay while fostering deeper emotional connections to cultural heritage [17] [18].

This study contributes to ongoing efforts to digitally preserve cultural heritage by integrating Large Language Models (LLMs) into an interactive game. While prior studies have utilized game-based approaches for the preservation of Banjar culture, this research emphasizes interactivity and personalization through LLM-driven player interactions. By combining gamification with LLM technology, this study aims to create an engaging and interactive platform that enables players to actively explore Banjar culture through adaptive narratives.

2. Research Method

2.1 Game Development Process

This study adopts the Game Development Life Cycle (GDLC) method as formulated by [19], which provides a structured framework for developing games. The GDLC method consists of several stages that are designed to ensure systematic development, from the conceptual phase to the final product. This development process follows the Game Development Life Cycle which consists of six stages namely Initiation, Pre-production, Production, Testing, Beta, and Release, as shown in Figure 1 [20] [21].

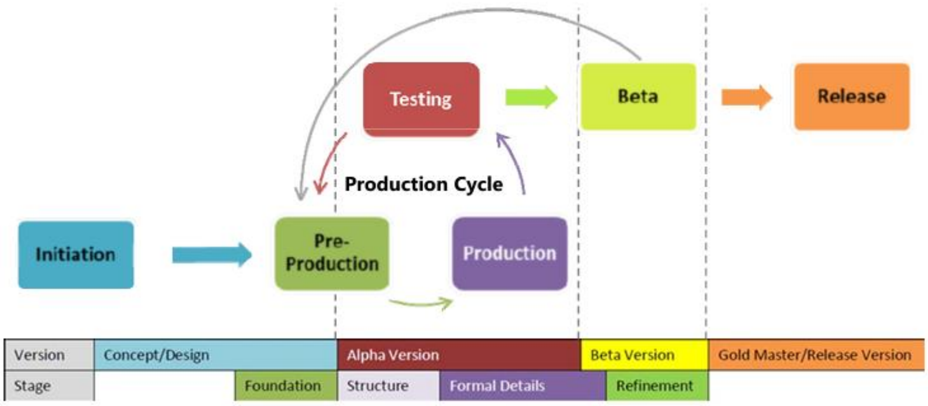

Figure 1. GDLC Steps

In the initiation stage, the basic ideas and concepts of the game were formulated through brainstorming where the game's objectives, target audience, and core gameplay mechanics were defined. The pre-production stage involved the creation of a Game Design Document (GDD), which served as a blueprint outlining the storyline, characters, visual style, and technical requirements. During the production stage, the game technically developed by implementing assets, menu systems, gameplay mechanics and integrating supporting technologies. The testing stage ensured the game's functionality through methods such as Black Box Testing where bugs were identified and fixed. In the beta stage, the game was tested by participants to evaluate the user experience, and feedback was used for final adjustments. The release stage marked the completion of development, where the game was ready to be launched to the public as a final product. The GDLC ensured a systematic and structured development process, making it reproducible for various game projects.

2.2 Game Measurement

Game testing ensured that a product functioned correctly and met stability and readiness requirements before release. This study employed two methods: Black Box Testing and the Game Experience Questionnaire (GEQ) to evaluate the Banjar Archive game.

2.2.2 Black Box Testing

Black Box Testing evaluated system behavior by analyzing inputs and outputs without accessing internal code or structure [22]. The main goal was to confirm whether the system met functional requirements by observing how it processed inputs and produced outputs [23]. This method treated the system as a "black box," focusing only on external functionality without considering internal workings [23]. Black Box Testing validated user-facing features to ensure they performed as intended and aligned with specifications [24].

The testing process was conducted iteratively with test cases executed repeatedly to identify defects and verify corrections until all requirements were satisfied. Scenarios were simulated during testing to uncover errors that could not be identified through code review alone. This approach ensured the system adhered to user expectations while maintaining usability and reliability.

2.2.1 Game Experience Questionnaire (GEQ)

The Game Experience Questionnaire GEQ) is a comprehensive and modular instrument designed to evaluate the subjective experiences of players during and after gameplay. It measures seven key components of game experience: immersion, flow, competence, positive affect, negative affect, tension, and challenge. These components are assessed through structured statements rated on a 5-point Likert scale, ranging from "not at all" to "very" satisfied [25]. The GEQ is divided into three main modules: the Core Module, which evaluates in-game experiences; the Social Presence Module, which assesses psychological and behavioral involvement with social entities within the game; and the Post-Game Module, which examines players' emotional states after completing a session [26].

The GEQ is widely recognized for its adaptability across different gaming contexts. For example, it has been validated in various cultural settings, such as the Arabic version, which demonstrated strong discriminant and convergent validity [25]. Additionally, its modular structure allows researchers to tailor its application based on the specific aspects of gameplay being investigated. The questionnaire can also be administered immediately after gameplay or during intervals within a game session using its concise in-game version [27].

This instrument has been extensively employed in both academic research and industry applications to analyze user experience. It provides valuable insights into how game design elements influence player engagement and satisfaction. Developers often use GEQ results to identify areas for improvement in game mechanics or user interface design to optimize player enjoyment and emotional impact [28].

3. Results and Discussion

3.1 Initiation

The initiation phase started with the conceptualization of an educational game that integrates Large Language Models (LLMs) to promote Banjar cultural awareness among younger generations. The main objective was to develop an interactive platform that combines dynamic dialogue, cultural narratives, and quizzes to foster engagement and learning. The game was designed for high school and university students aged 18 to 24, given their frequent exposure to digital media and educational technology.

Previous studies have shown that learners in this demographic tend to prefer visual, interactive, and narrative-based learning environments, which enhance attention, emotional connection, and knowledge retention [29]. Educational games that employ storytelling and exploratory mechanics are particularly effective in cultural learning contexts, as they simulate real-life experiences and promote curiosity [30].

This game design was developed through a combination of informal observation and literature review, ensuring that both educational and cultural elements were appropriately adapted into the gameplay. It was observed that younger users respond more positively to gamified content that allows exploration, self-paced progression, and interactive feedback. This insight was supported by prior research on educational games for cultural preservation, including works that introduced Banjar culture through folklore-based action games [7], language-learning quizzes [8], and AI-assisted puzzle systems [9]. These studies informed the decision to design a game with flexible learning flow, dynamic content, and adaptive interaction powered by LLM.

The design of the game was further grounded in local cultural representation by referring to the Lambung Mangkurat Museum in Banjarbaru. a well-known cultural museum in South Kalimantan that focuses specifically on Banjar heritage, which offers an organized and thematic depiction of Banjar traditions suitable for adaptation into interactive media. The museum served as a reference point for structuring in-game exploration and interaction, allowing the game to reflect cultural authenticity while maintaining an engaging player experience.

Based on this foundation, the initial idea evolved into a culturally grounded educational game that reflects Banjar heritage while incorporating modern interactive features suitable for today's learners.

3.2 Pre-Production

The pre-production stage of the game development focused on creating a comprehensive Game Design Document (GDD) as the foundational blueprint for the production phase. This document outlined the game's core concept, gameplay mechanics, visual and audio style, and technical requirements. The concept of the game's story revolved around a new employee at a recently opened museum tasked with organizing cluttered exhibits after the opening. This narrative framework was designed to incorporate Banjar cultural heritage in a way that aligned with the game's educational and cultural preservation goals.

The core gameplay mechanics involved exploring the museum, finding scattered cultural artifacts, and placing them in the correct display areas. These mechanics were designed to simulate real-world museum tasks such as cataloging items and arranging exhibits while ensuring the gameplay felt both authentic and engaging. Players also handled basic operations like sorting collections, cleaning display areas, and preparing exhibits for public viewing. These tasks added depth to the gameplay, giving players a sense of responsibility and accomplishment as they progressed.

Another key mechanic designed for the game was the utilization of an LLM. When players successfully placed an artifact in the correct display area, they could interact with the LLM to learn more about it. Players were able to ask questions about the artifact's history, cultural significance, or relevance to Banjar traditions. For example, if a player placed a traditional Banjar weapon, they could inquire about its use in historical battles or its symbolic meaning in ceremonies. This mechanic was designed to enrich the educational experience while encouraging players to engage more deeply with the cultural content.

Table 1 provides a structured summary of the key mechanics driving the game's objectives. Together, these mechanics form the foundation for delivering an engaging and meaningful gameplay experience that aligns with the study's focus on cultural preservation.

Table 1. Game Mechanics and Features

Game Mechanic	Description
Artifact Collection	Players search for scattered cultural artifacts within the museum environment to collect and use them.
Artifact Placement	Player's place collected artifacts in the correct display areas based on contextual hints or instructions.
Task Completion	Players complete operational tasks such as cleaning areas, organizing collections, and preparing exhibits.
Point System	Players earn points for completing tasks or correctly placing artifacts, reflecting their progress.
Navigation	Players explore the museum, moving between sections to find artifacts and complete tasks.
LLM-Driven Cultural Dialogue	Players interact with the LLM to receive context-sensitive explanations and engage in dynamic dialogue about the cultural significance of the artifacts.

The visual style for the game planned to use 2D graphics, with detailed backgrounds and assets designed to reflect the museum setting, reinforcing the theme of cultural preservation. The art style was designed to balance visual appeal with simplicity, ensuring it could run smoothly on various devices. The museum environment was divided into themed sections, such as history, art, and daily life, each showcasing different aspects of Banjar culture. A user-friendly menu system was also planned for navigation, allowing players to start the game, view instructions, adjust settings, or exit easily. The menu was designed to be intuitive, with clear visual and auditory feedback to guide players through their choices.

3.3 Production

The production phase of this study employed Unity Engine as the primary development framework. Unity was chosen as the game development platform due to its ease of use, speed of development, and extensive plugin support [31]. Pre-made assets such as artwork and music were sourced from third-party asset marketplaces to speed up development and allocate more focus on implementing game mechanics. Cultural artifact assets which were not available from these libraries were manually created using Aseprite, a specialized pixel art and sprite editing software to fulfill the specific visual and functional requirements of the game. Figure 2 illustrates examples of cultural assets created specifically for the game, including traditional Banjar houses, panting musical instruments, Mandau weapons and floating market scenes.

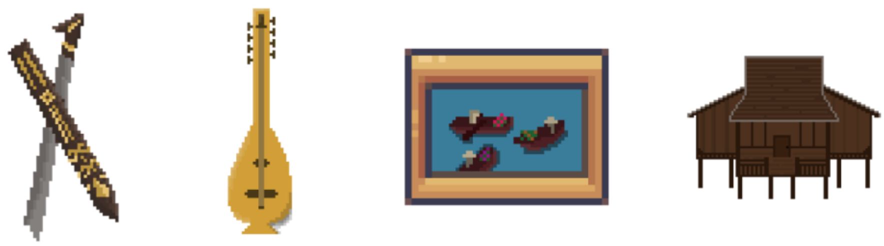

Figure 2. Sequentially from Left to Right are the Designs of Mandau Weapons, Panting Musical Instrument, Floating Market and Traditional Banjar House which are Cultural Assets Created for the Game

Following the creation of cultural assets, the next step was the development of the menu and tutorial scenes. The menu scene serves as the primary interface, enabling players to initiate the game, select levels, and access settings. It features seamless transitions to enhance user navigation. The tutorial scene guides players through the game mechanics, covering controls and objectives. Both scenes prioritize ease of use and user engagement to ensure players can quickly understand the game. Figure 3 illustrates the developed menu and tutorial scenes.

Figure 3. Sequentially from Left to Right shows the Main Menu options and the Tutorial Scene

The next phase of production focused on implementing key gameplay features to support user interaction and progression. The artifact collection system was added to allow players to find and collect cultural artifacts within the game environment. When collected, these artifacts are stored in the player's inventory. A progress system was integrated to indicate player scores, granting progression for completing tasks and correctly placing artifacts. The navigation system was developed to ensure smooth movement between different areas of the game, providing an uninterrupted experience. Figure 4 shows an overview of the implemented gameplay features.

Figure 4. Implementation of the Artifact Collection Feature, where Players Collect Banjar Cultural Artifacts to be Displayed in the Museum

The next phase focuses on integrating the LLM into the game environment. This study utilizes Phi-2, a lightweight LLM designed for local execution on the player's device. Phi-2 was selected due to its lower computational requirements compared to other models while still providing sufficiently acceptable response quality [32]. By running the model locally, the game eliminates reliance on cloud servers and ensures lower latency. Each cultural artifact in the game is embedded with a structured contextual prompt that provides historical and cultural information, making it a more practical approach for implementation and faster game development. The local execution of the model also improves accessibility by allowing uninterrupted gameplay without requiring an internet connection.

As part of this integration, the game employs an LLM to facilitate player interaction with cultural artifacts. The system activates when a player correctly places an artifact on its designated display, triggering the appearance of a UI element designed as a magical book. This interface enables players to input textual queries, which the LLM processes using predefined contextual prompts to ensure responses remain relevant to the artifact's cultural significance. For instance, after placing the traditional instrument Panting, players can inquire about its historical background, craftsmanship, and role in Banjar culture. The generated responses align with the educational objectives of the game, reinforcing cultural engagement through structured interaction. This gameplay interaction is depicted in Figure 5, illustrating the activation of the LLM-based system within the game environment.

Figure 5. Implementation of the LLM Feature in the Game for Educational Interaction about Banjar Artifacts

3.4 Alpha Testing

Black Box Testing is used to validate the functionality of the game's features against defined requirements. Table 2 outlines the tested mechanics, including artifact collection, placement, task completion, navigation, and LLM interaction. This method ensures each feature performs as intended and supports the delivery of a seamless user experience. Each feature is evaluated based on predefined criteria, with a "Passed" result indicating compliance and a "Failed" result highlighting deviations that require further refinement.

Table 2. Black Box Testing Checklist

Test Class	Test Scenario	Expected Result	Test Result
Application Execution	Verify game startup	Game displays the main menu screen	Passed
Menu Navigation	Access the Play menu	Initiate the game from the first level successfully	Passed
	Access the About menu	Displays game about	Passed
	Access the Exit menu	Exits the game safely	Passed
Gameplay Controls	Home button functionality	Returns to the main menu	Passed
	Restart button functionality	Restarts the current level successfully	Passed
	Back button functionality	Returns to the game level	Passed
Artifact Interaction	Collect artifacts	Allows players to collect artifacts	Passed
	Place artifacts	Places artifacts in the correct display area	Passed
LLM Interaction	Artifact explanations	Displays context-sensitive descriptions about artifacts	Passed
	Dialogue accuracy	Responds correctly to user queries about artifacts	Passed
Point System	Task completion tracking	Updates progress upon successful task completion	Passed
	Artifact placement tracking	Updates progress when artifacts are placed correctly	Passed
Audio and Visual Feedback	Music and visuals	Play background sound when game is running	Passed

The testing phase with Black Box method has verified that all core functionalities of the game meet the specified requirements. Key features such as artifact collection and placement, task completion, navigation, and LLM interactions have been thoroughly tested and function as intended. The system shows stability and achieves the expected user experience objectives. These results indicate readiness to proceed to the next phase of development.

3.5 Beta Testing

The beta phase was conducted using the Game Experience Questionnaire (GEQ), specifically employing the Core Module. This module evaluates seven fundamental components of gameplay experience: Competence, Immersion, Flow, Tension, Challenge and Affect (Positive and Negative). The Core Module was selected because this study primarily aimed to assess individual gameplay experiences without considering social interactions or post-game effects. Thus, components related to social presence or post-game experiences were not included in the evaluation.

A total of 50 respondents aged 18 to 24 participated in this study and were selected to match the target demographic of the game, which focuses on high school and university students. Each participant played the game and then completed the GEQ Core Module questionnaire, consisting of 33 questions. The average scores for each component were calculated using Equation 1.

$$Average\ Score = \frac{Total\ Score\ for\ a\ Components}{Number\ of\ Question\ \times\ Number\ of\ Respondent} \quad (1)$$

The total score for all statements in component was obtained by summing all individual scores provided by respondents for each statement within a given component. For example, if the *Competence* component consisted of five statements, each respondent's scores (ranging from 1 to 5) for these five statements were summed across all respondents to obtain the total score. Results from this evaluation are summarized in Table 3.

Table 3. Evaluation Results

No	Component	Average Score	Standard Deviation	t-value	p-value
1	Competence	4.448	0.3302	0.1678	0.8673
2	Immersion	4.936	0.1559	-0.4451	0.6582
3	Flow	3.124	0.3461	-0.2403	0.8111
4	Tension	1	0.00	0.00	0.00
5	Challenge	1.744	0.2654	0.6289	0.5323
6	Negative Affect	1.07	0.1122	-0.6196	0.5384
7	Positive Affect	4.976	0.0949	0.0000	1.0000

The evaluation results indicate that the game has achieved a feasible level based on player experience. Competence (4.448) and immersion (4.936) are high, showing that players feel skilled and engaged. Flow (3.124) suggests a good level of engagement that supports continuous gameplay. Challenge (1.744) and tension (1.0) are low, meaning the game is easy to play and does not cause frustration. Negative affect is very low (1.07) while positive affect is high (4.976), confirming that the game provides an enjoyable and motivating experience. These results indicate that the game successfully delivers an immersive and positive gameplay experience.

The results of the Game Experience Questionnaire (GEQ) in this study revealed high scores on the competence, immersion, flow, and positive affect components. These findings indicate that players felt skillful, were imaginatively engaged, experienced deep involvement, and enjoyed exploring the cultural content presented in the game. Notably, high immersion and positive affect scores suggest the game successfully fostered enthusiasm, happiness, and curiosity about culture, thereby increasing player interest in learning more. Immersion describes the extent to which players become deeply engaged in the game world, while positive affect refers to the enjoyment and satisfaction experienced during gameplay [33]. Therefore, positive GEQ scores in these dimensions can be considered strong indicators that the educational game effectively increases user interest and motivation toward cultural learning.

After conducting the Game Experience Questionnaire (GEQ) to assess player experience, further statistical analysis was performed to evaluate consistency and potential differences among respondents. Standard deviation was calculated to measure variation in player experience with results showing relatively low values such as 0.3302 for competence and 0.0949 for positive affect. This indicates that most players had a similar experience. A t-test was also conducted to determine whether there were significant differences in gameplay experience between male and female players. With all p-values exceeding 0.05, the analysis confirmed no significant differences between the two groups. This suggests that the game provides a balanced and inclusive experience without gender-based bias.

3.6 Release

The release phase in this study represented the final stage of game development, where the product, having been fully designed and tested, was declared ready for launch to users. The released game successfully met the development objectives by receiving positive feedback from users and opened opportunities for updates and additional content to enhance player engagement.

4. Conclusion

The development of the Banjar Archive educational game successfully applied the Game Development Life Cycle (GDLC) framework and integrated Large Language Models (LLMs) to enhance interactivity. Testing results confirmed the effectiveness of this approach, with all 14 test scenarios in Black Box Testing passing successfully, ensuring system reliability. User experience evaluation using the Game Experience Questionnaire (GEQ) demonstrated high immersion at 4.936, competence at 4.448, flow at 3.124, and positive affect at 4.976, while tension remained low at 1, challenge at 1.744, and negative affect at 1.07. These findings indicate that the game effectively balances engagement and educational value. The integration of LLMs enabled dynamic and adaptive interactions, reinforcing the game's potential as an innovative tool for cultural preservation. This study demonstrates that AI-powered gamification can contribute to sustaining Banjar culture in the digital era.

However, the game still has several limitations. The current version only presents a limited range of cultural content and focuses mainly on physical artifacts. In addition, the LLM model used in the game still requires relatively large computational resources, making it less suitable for devices with lower specifications.

It is hoped that future research can expand the cultural content of the game to include oral traditions, language, and traditional games of the Banjar people. The integration of small language models (SLMs) and the use of fine-tuned models based on local culture are also expected to improve performance and accuracy. Moreover, the addition of voice-based interaction and broader cultural content from other regions in Kalimantan may enhance the learning experience and strengthen the game’s cultural education impact.

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