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A study on the gamified design of Bouyei batik patterns from the perspective of immersive experience

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Abstract. Objective: This study aims to explore gamified design pathways for Bouyei batik patterns from the perspective of immersive experience, to construct gamification strategies for the dissemination of intangible cultural heritage, and to validate their effectiveness. Methods: The PAT model is introduced to analyze users' immersive needs across three dimensions—user, artifact (tool), and task—thereby establishing a triadic design methodology integrating "principles–strategies–levels". Taking *The Whisper of Secret Patterns* as a practical carrier, the design incorporates a dual-loop interaction of "pattern exploration + bronze drum performance", combined with wearable haptic feedback, to achieve an innovative integration of cultural narrative and multisensory interaction. Results: Four core principles are identified—user-centeredness, cultural authenticity, narrative scenarization, and multisensory experience—alongside a three-dimensional strategic framework encompassing interaction, scenario, and content. Conclusion: Gamified design from an immersive perspective provides an effective pathway for the digital dissemination of Bouyei batik patterns. It stimulates user interest, sustains flow states, and deepens cultural identity, offering an innovative paradigm for the digital communication of minority intangible cultural heritage.

Keywords: immersive experience, Bouyei batik patterns, gamified design, PAT model, experience design

1. Introduction

As a national-level intangible cultural heritage, Bouyei batik patterns embody the historical memory, nature worship, and aesthetic ideals of the Bouyei people, and are often regarded as an "epic painted on cloth" [1]. However, within the context of digital dissemination, traditional static display methods face challenges such as low audience engagement and the superficial transmission of cultural connotations. Gamification, by incorporating mechanisms such as goals, challenges, feedback, and narrative, can transform passive reception into active exploration [2]. Meanwhile, immersive experience theory provides a foundational framework for gamified design: when challenges are well-matched with user skills, goals are clearly defined, and feedback is immediate, users are likely to enter a highly focused immersive state [3]. Based on this premise, this study introduces the PAT model into the gamified design of Bouyei batik patterns. It analyzes the immersive needs of users at different levels from the three dimensions of user, tool, and task, and constructs a design methodology structured around "principles–strategies–levels". Through the practical case of *The Whisper of*

Secret Patterns, the study employs a dual-loop gameplay mechanism—"pattern exploration + bronze drum performance"—along with wearable haptic feedback devices, to achieve an innovative integration of cultural narrative and multisensory interaction.

2. Research on Bouyei batik patterns and immersion theory

2.1. Cultural characteristics and artistic value of Bouyei batik patterns

Bouyei batik patterns can be broadly classified into three categories according to subject matter: geometric patterns, plant patterns, and animal patterns [4]. Geometric motifs include spiral patterns, dot patterns, bronze drum patterns, dog-tooth patterns, sawtooth patterns, wave patterns, and meander (key) patterns. Plant motifs feature designs such as osmanthus flowers, tribulus, rice ears, rice grains, and bracken, while animal motifs commonly depict birds, fish, and butterflies. In terms of composition, traditional Bouyei batik adopts a predominantly planar approach, emphasizing a formal aesthetic of symmetry and balance combined with variation within unity. Pattern arrangements are carefully structured with upper–lower correspondence and a measured distribution of density and openness. Symmetrical or balanced compositions are frequently employed to organize the visual field, producing a rhythmic interplay between solidity and void, as well as motion and stillness. Symmetrical structures mainly include central symmetry and axial symmetry, while repetitive compositions encompass two-directional continuity and four-directional continuity. Radial compositions originate from a central point with motifs radiating outward to form visual structures characterized by centripetal force and dynamic expansion. Color usage is centered on a blue-and-white palette, resulting in an aesthetic style that is at once simple, elegant, and refined [5].

Beyond their formal qualities, Bouyei batik patterns carry profound cultural meanings. The bronze drum motif symbolizes authority and sacredness, rooted in the Bouyei people's reverence for bronze drums, whose sound is believed to connect the realms of heaven, earth, and humanity. Spiral patterns metaphorically represent clan lineage and water worship; referred to as "Wotuo patterns" by the Bouyei, they are often rendered as composite spirals symbolizing genealogical structures and branching relationships. Fish motifs embody wishes for fertility, reproduction, and agricultural abundance, reflecting totemic beliefs. Dog-tooth patterns convey protective power against evil and the attraction of good fortune, derived from the special role of dogs in Bouyei mythology [6]. These patterns are not merely decorative symbols; they constitute visual expressions of the Bouyei worldview of animism, ancestral worship, and agrarian civilization.

2.2. Core tenets of immersion theory and the PAT model

At the heart of immersion theory lies the dynamic balance between challenge and skill. The four-channel model proposed by Massimini and Carli categorizes psychological states into four zones: apathy, anxiety, boredom, and immersion, corresponding respectively to low-skill/low-challenge, low-skill/high-challenge, high-skill/low-challenge, and high-skill/high-challenge conditions [7]. Csikszentmihalyi further identified nine key elements of immersive (flow) experience: clear goals, a balance between challenge and skill, immediate feedback, the merging of action and awareness, intense concentration, a sense of control, loss of self-consciousness, distortion of temporal perception, and the autotelic nature of the activity [8]. These elements provide actionable evaluative dimensions for gamified design.

In digital contexts, Finneran introduced the PAT model (Person–Artifact–Task), which decomposes the antecedents of immersion into three dimensions: Person, referring to the user's cognitive capacity and intrinsic motivation; Artifact, referring to the usability and interactive characteristics of the digital medium; and Task, referring to the difficulty and attractiveness of the activity content [9]. The degree of alignment among these

three dimensions directly determines the emergence of immersive experience. Compared with traditional immersion studies that often focus on a single dimension, the PAT model offers a systematic analytical framework for understanding immersion mechanisms in human–computer interaction environments.

2.3. Application value of integrating gamified design and immersive experience

Gamified design constructs engaging interactive systems by combining external incentives with intrinsic motivational structures such as narrative, exploration, and achievement. Its core elements include clearly defined goals, appropriately calibrated challenges, immediate feedback mechanisms, progressive task hierarchies, a sense of user autonomy and control, and compelling narrative frameworks [10]. The integration of gamification and immersive experience lies in their functional complementarity: gamification mechanisms act as external stimuli that establish clear objectives and appropriate levels of challenge, while continuous feedback sustains user engagement, thereby triggering immersive states. In the context of pattern design, the objective of gamification is to activate the cultural value embedded in patterns through game-based mechanisms, guiding users from passive observation to active exploration. This objective closely aligns with the fundamental premise of immersion theory, as both seek to transform external informational stimuli into internalized cognitive schemas through optimized interaction experiences. Immersion theory not only elucidates the psychological characteristics of optimal experience but also, through its structured framework of antecedent conditions, provides systematic theoretical support for the gamified design of cultural patterns.

3. User research

3.1. Analysis of user needs

To clarify the direction of gamified design, this study conducted a preliminary user investigation. Through in-depth interviews and questionnaire surveys, the following findings emerged: (1) Overall user awareness of Bouyei batik patterns is relatively low, with 64.49% of respondents indicating that they "basically have no understanding"; (2) Existing digital experience products exhibit issues such as limited interaction forms, superficial content, and insufficient engagement; (3) Users' expectations for future products are primarily concentrated on "acquiring deeper cultural knowledge" (55.8%), "convenient and user-friendly interfaces" (54.35%), and "a visually rich ethnic aesthetic atmosphere" (52.17%); (4) Users believe that "smooth operational feedback" (55.8%) and "appropriately calibrated challenge levels" (42.75%) contribute significantly to enhancing immersion.

Based on users' levels of familiarity with Bouyei batik patterns, the target audience is categorized into three tiers: novice, intermediate, and expert users. Novice users possess limited cultural knowledge and are more easily attracted by engaging and entertaining interaction forms; intermediate users have a certain cognitive foundation and are willing to actively explore, thus identified as the core target group; expert users possess systematic knowledge and extensive practical experience, with a stronger focus on the integration of culture and digital technology. This stratification provides a scientific basis for the development of differentiated gamification strategies.

3.2. Analysis of user factors based on immersion theory

According to users' cognitive levels regarding Bouyei batik patterns, the target audience is divided into three categories: novice users (limited or no prior exposure), intermediate users (with some foundational knowledge), and expert users (with systematic cultural understanding). Based on the PAT model, the

immersive requirements of users at different levels are analyzed across three dimensions—Person, Artifact, and Task—as shown in Table 1.

Table 1. Analysis of immersion factors across user levels under the PAT model

Dimension	Novice Users	Intermediate Users	Expert Users
Person	Limited understanding of cultural connotations; easily attracted by engaging interactions	Possess basic knowledge; seek a balance between entertainment and cultural depth	Systematic cultural knowledge; focus on cultural authenticity and technological integration
Artifact	Emphasize ease of operation and interface friendliness	Require immediate feedback and systematic integration of cultural resources	Pursue high-quality experiences and refined interaction design
Task	Low level of cultural cognition; attracted by entertaining operations	Require both entertainment and deeper cultural engagement	Emphasize authenticity of content and integration with real-life contexts

From the user (Person) dimension, different user groups exhibit stratified concerns. Novice users, with limited cultural understanding, are more responsive to highly engaging interactions; intermediate users require a balance between entertainment and cultural depth; expert users place greater emphasis on the integration of cultural content and technological means. Stimulating intrinsic motivation and enhancing the sense of presence are critical to facilitating immersion [11].

From the tool (Artifact) dimension, variations in users' skill levels determine their acceptance of interaction tools. Usability directly influences users' acceptance of and satisfaction with digital media. Multimodal interaction can provide richer feedback, blur the boundary between virtual and real environments, and enhance the sense of presence [12].

From the task (Task) dimension, the difficulty and nature of tasks directly affect immersive outcomes. Basic tasks can stimulate exploratory motivation among novice users; composite tasks help intermediate users deepen their understanding; and innovative forms of presentation enable expert users to achieve a higher level of satisfaction. Designing engaging tasks tailored to different target groups helps participants maintain focused attention throughout the experience.

4. Gamified design strategies based on immersive experience

4.1. Principles of gamified design

Based on the analysis of immersive factors, four design principles are proposed: (1) User-centered principle: Gamified design should accommodate the differentiated needs of users at different levels. Interfaces should be simple and intuitive, with clear visual hierarchies and direct interaction feedback to reduce cognitive load. (2) Cultural authenticity principle: Design should be grounded in the inherent forms and cultural meanings of traditional patterns. Gamified translation must be carried out on the premise of preserving core cultural taboos and symbolic integrity. (3) Narrative scenarization principle: Game narratives should be constructed around Bouyei mythology, legends, and festivals. Patterns are embedded within specific cultural narrative contexts, allowing cultural information to be conveyed through emotional engagement and gameplay situations. (4) Multisensory experience principle: Multiple sensory channels—visual, auditory, and tactile—should be orchestrated in a coordinated manner. Visually, the design adheres to a blue-and-white color scheme; aurally, it

incorporates traditional Bouyei music; tactilely, vibration feedback is employed to enhance the realism of interaction.

4.2. Gamified design strategies

Building upon the above principles, a systematic design strategy is constructed across three dimensions: interaction, scenario, and content. (1) Interaction level: Gamified experience mechanisms are employed to enhance users' sense of control and participation through clear goal setting, appropriately calibrated challenges, and immediate feedback. User tasks are decomposed into progressive game levels, each with explicit guidance and staged objectives. Multimodal interaction is integrated: visually, interfaces are clearly structured; aurally, background music and sound effects are incorporated; tactilely, wearable devices simulate operational feedback, reinforcing embodied interaction.

(2) Scenario level: A blue-and-white tonal scheme serves as the visual foundation. Representative cultural elements—such as Bouyei architecture, costumes, and everyday artifacts—are extracted and integrated into the design. Drawing on compositional principles such as symmetry, continuity, and radial structure, culturally distinctive game environments are constructed. Scene complexity is tiered according to user level: novice scenarios are simple and vivid, intermediate scenarios incorporate richer details, and expert scenarios reconstruct complete village environments with high fidelity.

(3) Content level: A multi-layered narrative system is developed around Bouyei legends, employing a first-person perspective that positions the user as a cultural explorer within the game world. As users progress, they unlock narrative fragments, forming a closed-loop experience of "exploration–interaction–unlocking". Bouyei epic narratives are segmented into progressive levels, with narrative depth increasing in accordance with the player's degree of interaction, thereby fostering emotional resonance and deepening cultural understanding.

In this framework, the three dimensions of the PAT model—Person, Artifact, and Task—are respectively mapped onto content, interaction, and scenario within gamified design, transforming an abstract theoretical model into a set of actionable design guidelines.

4.3. Hierarchical model of gamified experience

The above strategies are integrated into a three-tiered experiential model—sensory, interactional, and cognitive—guiding users progressively toward deep immersion. The sensory layer, as the "surface interface" of the experience, establishes initial immersion and emotional connection. Visually, blue-and-white tones and pattern-based interfaces capture attention and create a cultural atmosphere; aurally, background music and ambient sound effects are incorporated; tactically, force feedback facilitates the integration of virtual and physical sensations, constructing an immersive experiential field.

The interaction layer extends and deepens the sensory experience. Through immediate feedback mechanisms and gamified task design, users are granted agency in exploration. Interaction modalities such as mouse input and gesture recognition allow users to directly engage with the system, enhancing participation and autonomy through activities such as triggering dynamic dialogues and exploring the meanings embedded in patterns.

The cognitive layer presents cultural information through visualization and narrative structuring. Bouyei legends, symbolic meanings of patterns, and traditional craftsmanship are conveyed through progressively unfolding storylines. Users acquire cultural knowledge organically during gameplay and interaction, deepening their understanding and identification with Bouyei batik culture through emotional engagement, ultimately achieving a state of deep immersion (Figure 1).

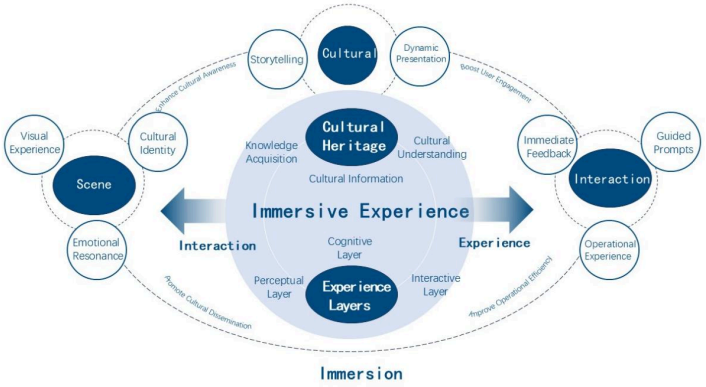

Figure 1. Model of gamified design strategy

5. Design practice: a gamified case study of the whisper of secret patterns

5.1. Design overview

The Whisper of Secret Patterns is a gamified experiential product centered on Bouyei batik patterns, with the core narrative of "restoring lost batik pattern atlases". In the game, users assume the role of explorers of intangible cultural heritage, assisting artisans in a traditional Bouyei village to complete the restoration of twelve sets of core batik patterns. The product operates on a PC platform and integrates gesture recognition with haptic feedback gloves to deliver a multimodal interactive experience. The design emphasizes the deep integration of bronze drum culture and batik patterns. Through a dual-loop gameplay structure—"pattern exploration + bronze drum performance"—it achieves an organic linkage between different cultural elements.

5.2. Game narrative framework design

Based on Bouyei epic narratives, the game is structured into three progressive levels (Table 2), each corresponding to a specific cultural theme. Patterns are embedded within distinct historical narratives, transforming them from isolated symbols into dynamic carriers of storytelling:

Table 2. Narrative framework design of game levels

Level	Theme	Cultural Connotation	Core Pattern Elements
Level 1	Creation Patterns	Re-creation of humanity after the great flood	Spiral patterns, dog-tooth patterns, dot patterns, sawtooth patterns, wave patterns, sun patterns
Level 2	Everyday Life	The myth of a hero stealing grain seeds, marking the foundation of rice civilization	Rice-ear patterns, bird patterns, fish patterns, grain patterns, osmanthus patterns, Rosa roxburghii patterns, meander patterns
Level 3	Heritage Patterns	Ancestor worship and cultural transmission during the "June Sixth" festival	Butterfly patterns, fish patterns, dog-tooth patterns, sawtooth patterns, dot patterns, meander patterns, rice-ear patterns, spiral patterns

Each level consists of two interconnected stages: "pattern exploration and collection" and "bronze drum rhythm performance". Players explore the game environment to discover fragments of patterns; once collected, these patterns are unlocked through bronze drum performance. The rhythmic structure of the performance

stage is derived from the cultural narratives associated with each pattern, with background music based on the twelve-tone system of Bouyei bronze drum music. This closed-loop design—"exploration–experience–unlocking"—aligns with the generative mechanisms of immersion theory, particularly the integration of clear goals, immediate feedback, and intrinsic motivation.

5.3. Visual design of game scenes

Level 1: The game scene is based on the karst stone landforms of the Bouyei ethnic group, where jagged rocks and layered cliffs metaphorically evoke the creation theme of "opening the heavens and earth" (Figure 2). Stilted houses and modern buildings are positioned at opposite ends of the scene, creating a spatial transition from traditional settlements to contemporary communities. A dog stationed at the village gate serves as a guardian symbol, reinforcing the sense of boundary within the village space.

Figure 2. Design of scene 1

Level 2: The game scene is modeled on the Wanfenglin mountain terrain, with terraced modules constructed according to the sequential logic of rice cultivation (Figure 3). The processes of plowing, sowing, and harvesting are allocated to terraces at different elevations. Between the terraces and the village, cloth-dyeing and weaving areas are added to reflect the traditional gendered division of labor in Bouyei society, where "men till and women weave".

Figure 3. Design of scene 2

Level 3: The game scene follows the narrative sequence "ritual fields and ancestor worship—bronze drum square—village parade—singing competitions—granary abundance" to structure festival-oriented gameplay (Figure 4). The bronze drum serves as the visual centerpiece, with stilted houses lining the streets and agricultural products such as corn and chili peppers hanging from the eaves to enhance the festive atmosphere. Youth social activities such as singing competitions and racing contests recreate the joyful ambiance of the June 6 festival.

Figure 4. Design of scene 3

5.4. Gamified interaction design

(1) Pattern Exploration Mechanism: Players roam the game scene and trigger dialog boxes by clicking on objects matching specific patterns (Figure 5). These dialog boxes display the pattern's name, cultural significance, and legend background, and players can choose to close or continue exploring. This game mechanism integrates knowledge transmission into the exploration process, aligning with the immersive experience principle of "unity of knowledge and action". Upon collecting all patterns in a level, players enter a performance segment, using the bronze drum to reconstruct the scene's thematic patterns.

Figure 5. Visualization of pattern information

Bronze Drum Performance Mechanism: The performance interface uses the drum surface as the judgment area, with game notes falling along concentric circular paths (Figures 6-8). Players strike the drum through gesture recognition, and the system calculates scores based on the alignment of notes with the judgment area. Hits generate corresponding visual effects, and upon completion, statistics display normal hits, perfect hits, misses, and accuracy. This design transforms the bronze drum, a sacred Bouyei artifact, from a passive visual object into an interactive cultural experience.

Figure 6. Level 1 performance scene

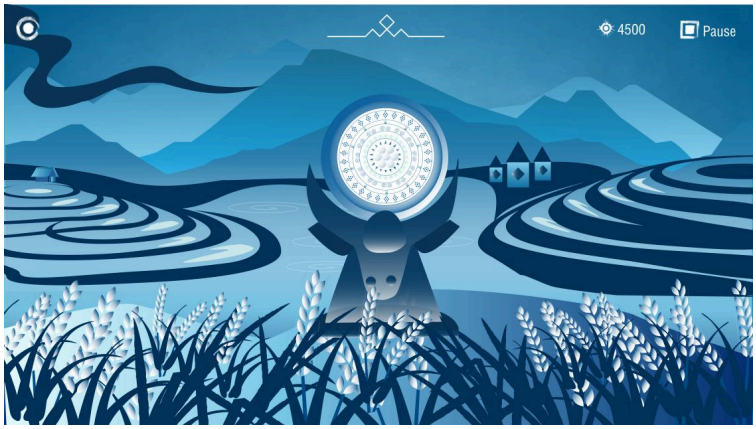

Figure 7. Level 2 performance scene

Figure 8. Level 3 performance scene

5.5. Haptic feedback mechanism

The product is developed using the Unity engine, constructing 3D scenes with Unity 2D and controlling scene navigation, collision detection, and event triggers through C# scripts. The Leap Motion SDK tracks hand position and recognizes gestures, enabling natural interaction with the game. Using the Ardity plugin for

Unity-Arduino serial communication, flexible haptic actuators are integrated into wearable gloves. Arduino receives serial commands and precisely controls vibration frequency and intensity via PWM signals, providing real-time tactile feedback that creates a multi-sensory immersive experience.

5.6. Immersive experience evaluation

To assess the immersive experience of the gamified product *"The Secret Language of Patterns"*, this study employed a survey tool based on the Flow State Scale (FSS), measuring nine dimensions: balance of challenge and skill, clear goals, immediate feedback, concentration, merging of action and awareness, sense of control, loss of self-consciousness, altered sense of time, and intrinsic involvement. Results show that average scores for all dimensions exceed 4 points (on a 5-point scale), with high scores for intrinsic involvement (4.5), sense of control (4.4), and immediate feedback (4.3). These findings indicate that the product effectively stimulates user interest, provides smooth operational experiences, and maintains appropriate difficulty levels, supporting sustained immersion. This validates the feasibility and effectiveness of an immersion-based gamified design strategy for the digital dissemination of Bouyei batik patterns.

6. Conclusion and future prospects

This study introduces immersion theory into the digital experience design of Bouyei batik patterns. Based on the PAT model, it analyzes the immersive needs of users at different levels from the three dimensions of Person, Artifact, and Task. Four design principles are proposed—user-centeredness, cultural authenticity, narrative scenarization, and multisensory experience—alongside a systematic strategy framework encompassing interaction, scenario, and content. Furthermore, a progressive immersive experience hierarchy of "sensory–interaction–cognitive" is established. The effectiveness of these strategies is validated through the design practice and evaluation of *The Whisper of Secret Patterns*.

The findings indicate that immersion theory provides a systematic theoretical framework and practical pathway for the digital experience design of Bouyei batik patterns. Design approaches grounded in immersive experience can transform static patterns into dynamic forms that are explorable, interactive, and immersive. Such approaches effectively stimulate user interest, sustain immersion, and deepen cultural identification, thereby offering both conceptual guidance and practical solutions for the digital dissemination and innovative transformation of ethnic minority pattern heritage.

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