Research on the Design Strategy of Dunhuang Murals Digital Picture Books: Take the Deer King Bunsen Tu as an Example

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Abstract: As a world cultural heritage, the digital inheritance and innovation of Dunhuang murals are of great significance to the protection of cultural heritage and the integration of culture and tourism. Taking "Deer King Bunsheng Tu" as a case study, this paper systematically discusses the design strategy of Dunhuang murals digital picture book. By analyzing the deficiencies of Dunhuang digital picture books in content innovation, multi-sensory interaction and resource integration, this paper proposes to construct the design framework of digital picture books from three dimensions: visual transformation, auditory transformation and interactive experience. At the visual level, the core gene of mural painting is extracted and modern design language is integrated to realize the visual translation from static to dynamic; At the auditory level, it combines the restoration of Dunhuang ancient music and scene-oriented sound effects to build an immersive sound landscape; At the interactive level, situational motivational interaction and gamification design are used to enhance user participation. The research shows that digital picture book design can break through the limitations of traditional media, activate the modern communication power of Dunhuang culture with multi-dimensional sensory experience, and provide an innovative path for the digital transformation of intangible cultural heritage.

Keywords: Dunhuang Murals; Digital Picture Books; Interaction Design; Multi-Sensory Experience; The Deer King Bunsen Chart

1. Introduction

The "Opinions on Implementing the Project of Inheriting and Developing Excellent Traditional Chinese Culture" and other policies clearly put forward: Technology enables the transmission of cultural vitality, and the Dunhuang Academy has made phased achievements in the field of digital collection and virtual restoration of mural paintings, but the existing digital picture books are still limited by the bottlenecks of content homogeneity, technology application surface and multi-sensory experience, which are difficult to meet the public's demand for in-depth cultural cognition and immersive experience. Taking "Deer King Bunsen Map" as the research object, this paper proposes a systematic design strategy of "gene decoding, scene reconstruction and narrative innovation": by refining core visual symbols such as Three rabbits and curly grass patterns and integrating dynamic narration, digital translation of traditional aesthetics can be realized; The restoration of Dunhuang ancient music and scene-oriented sound effects were combined to construct an immersive sound landscape; Relying on situational motivational interaction and gamified task design, it promotes cultural communication from "one-way output" to "multi-sensory collaboration".

2. Overview of Digital Picture Books

The concept of "picture books" originated in the field of Japanese picture books, and its greatest strength lies in the clever combination of words and pictures. This kind of combination of pictures and pictures not only avoids the dull feeling caused by the full text, but also accurately conveys the creator's intention, which greatly enhances the audience's interest in the reading process and enhances the reader's understanding of the content [1]. At present, digital picture books can be divided into three categories: the digital scanning form of traditional picture books, the interactive digital platform built on the basis of paper picture books and the digital picture book application.

On the one hand, digital picture books inherit

the characteristics of traditional picture books, which are vivid, simple and easy to understand, so that readers can easily immerse themselves in them; On the other hand, by virtue of multimedia integration and powerful interactivity, digital picture books have endowed reading with richer connotation and broad extension [2]. Traditional picture books are limited by the physical carrier, easy to be damaged by the environmental impact, and the dissemination range is limited. (Table 1) However, digital picture books break the limitation of static presentation of traditional picture books, and make story scenes more vivid through dynamic images, special sound effects, interactive experience and other elements.

Table 1. Difference between Traditional Picture Books and Digital Picture Books

	Traditional picture books	Digital picture books
Carrier	Physical books	Virtual/digital form
Interactivity	Unidirectional display	User engagement
Communication efficiency	Limited by physical space	Global instant communication
Life cycle	Easy to wear out, out of date	Can be dynamically updated, permanent storage

3. Development Status of Digital Dunhuang Picture Books

After years of development, Dunhuang digital literature and creativity has formed a system based on digital protection, with IP development as the core and means of technology empowerment. For example, the game "King of Glory" and "Meet the Flying Sky" under Tencent Studio cover hundreds of millions of players, virtual digital human figures, and a wide variety of digital NFT collections. However, due to the conservative creative concept, lack of professional talents, lack of technical integration, and vague market positioning, it is limited to the positioning of "tourist souvenirs", which makes it difficult to break through traditional thinking in design and promotion, and can not meet the diversified needs of a wider range of readers for cultural products.

These reasons lead to the following three problems in the digital picture book of Dunhuang murals. First, content innovation and product design are insufficient. At present, most Dunhuang themed picture books focus on simple reproduction of mural paintings or mechanical reorganization of traditional patterns, resulting in a lack of innovation and serious homogenization of content. The lack of in-depth exploration of the deep cultural connotation and regional characteristics of the mural paintings in these picture books makes it difficult to bring readers a new reading experience. In the design of derivative cultural and creative products, refrigerator magnets, postcards and other products are relatively simple, and have not yet built a series design with strong IP extension, which is difficult to break through the limitation of "tourist souvenirs". Secondly, the application of multi-sensory interaction technology is not sufficient. Although the "Digital Dunhuang" project has introduced augmented reality (AR) and virtual reality (VR) technologies, most of the applications remain at the visual presentation level, failing to fully integrate multi-sensory interaction experience such as touch and hearing. For example, the picture book "Deer of Figure 1 in KaDa reading APP superimposed a simulated page-turning effect on the dynamic effect, but the dynamic effect was not fully compatible with the picture book. Thirdly, there is still the problem of insufficient integration of digital communication and physical resources. Although Dunhuang Books Bureau has started the operation mode of "online + offline", the online resources mainly focus on book sales, and the digital picture book platform with strong interaction is lacking. This makes it difficult for readers to easily access digital picture book resources, and it is difficult to form an effective linkage with the resources of physical bookstores. As a result, readers' participation and stickiness are low, which affects the market expansion of Dunhuang digital picture books.

Figure 1. Picture Book The Nine-Colored Deer (Source: KaDa Reading App)

Therefore, we need to keep up with the pace of The Times and reorganize and reproduce the traditional Dunhuang murals with the help of advanced motion-sensing equipment and sound simulation technology. At the same time, by integrating online and offline resources to build a highly interactive digital picture-book platform, Dunhuang culture to the world.

4. Dunhuang Murals Digital Picture Book Design Strategy

As a shining pearl of the world cultural heritage, Dunhuang murals have far-reaching cultural and educational value and industrial potential by integrating thousand-year artistic treasures with digital interactive picture books [3]. Starting from three aspects of visual transformation, auditory transformation and interactive experience, this paper combines digital picture book design with Dunhuang local characteristic cultural and tourism resources in an all-round way. Through digital translation, the paper explores the design strategy of picture books enabled by technology (Figure 2).

4.1 Visual Transformation Strategy: Modern Interpretation of Traditional Aesthetics

Compared with the static images of Dunhuang mural art, the presentation forms of digital picture books can achieve a variety of visual integration and create a rich and diversified visual experience [4]. The visual integration design of Dunhuang murals and digital picture books should start from the following three aspects. First, establish a bidirectional path of cultural gene decoding and digital translation, and try to extract the core visual genes of Dunhuang murals. For example, the fluid linear language of three rabbit ears, curly grass beads and flying ribbon is transformed into modern visual symbols by using visual presentation techniques of abstract expression. Elements such as figures, animals and plants in the mural are refined and reorganized to build a dynamic and interesting interactive scene that ADAPTS to the dynamic browsing needs of mobile devices. To realize the dynamic vision from the plane mural. Secondly, in the use of color, the rule of hue proportion and brightness rhythm is refined, and this rule is applied to the color matching of picture books, and then innovatively designed a "local picture book"[5]. Finally, based on the two-dimensional plane modeling based on the visual elements of Dunhuang murals, it further realizes the expansion and integration of visual elements into three-dimensional space. Through the help of 3D modeling software, C4D, PS and other two-dimensional image processing software to accomplish.

4.2 Auditory Transformation Strategy: The Construction of Immersive Soundscape

As a new bright spot of electronic picture books different from traditional paper picture books, sound effects can be flexibly and freely added according to the content of picture books. This feature can transform the static reading experience of traditional paper picture books into a dynamic immersive experience. Dunhuang mural art elements have a strong decorative and unique Oriental aesthetic taste, with the coordination of sound effects, digital picture books in the artistic expression more appealing. The immersive sound landscape is mainly constructed through the following three points:

In the construction of auditory transformation strategy, the fusion of Dunhuang ancient music score and contemporary electronic sound effects should pay attention to the balance of cultural authenticity and modern aesthetics, and realize the trans-time and space dialogue between classical and modern, east and West through musical instrument selection, sound arrangement and technical means. On the instrument level, based on the traditional Musical Instruments in the mural (such as pipa, Tarmac and Konghou), the texture of Silk Road music is preserved through digital sampling, and electronic synthesizers and atmospheric sound effects are integrated to create an ethereal sound field. In terms of music style, it adopts the "collage" creative technique, combining Dunhuang five-tone mode with western electronic rhythm; At the technical level, multi-track mixing and dynamic balance are carried out, and the complementary frequency of traditional melody and electronic sound effect is coordinated through side chain compression technology, and the distance between modern users and Dunhuang culture is finally brought closer by the "familiar strangeness", and the creative transformation of cultural heritage is

promoted.

In the scene-oriented sound effect design, the dynamic sound effect system should be customized according to the emotional tone and narrative rhythm of the picture book plot. Take "Prince Saattva sacrifices himself to feed the Tiger" as an example. The background music can be composed of low cello and guqin ensemble, supplemented by slow chime rhythm. The descending melody and disharmonious chord render the tragic sense of sacrifice; The interactive sound effects incorporate the low-frequency vibration of the tiger whistle and the granular sound of dead branches breaking, and use dynamic compression technology to control the volume threshold to avoid the low-frequency sound effects from drowning the main melody. When the scene is changed, the plot tension is set up by the increasing string, and the impact is strengthened by the sudden stop white at the moment of Prince jumping off the cliff, and then the transition to the "influence of the tiger group" with the ethereal tone of the wind chime and the rising mode, symbolizing spiritual sublimation. At the same time, with the help of multi-track automatic control, the frequency of environmental sound effects (such as wind and chanting) and the main music are complementary, ensuring that the sound field is clearly layered, guiding users to immerse themselves in the continuity of the story in the emotional ups and downs.

According to the user's browsing progress and interest points, real-time voice explanation is provided, and the intelligent voice system is specially designed to design three interpretation roles, "historian", "virtual artist" and "digital provider". The content is transmitted directionally through bone conduction headphones to ensure that it does not interfere with the background sound effects. Users can switch the interpretation depth by sliding gestures. Or long press the picture elements to activate the multi-perspective comparison, realize the organic integration of academic research, art appreciation and humanistic narration, and help users perceive the deep meaning of Dunhuang culture in multiple dimensions.

4.3 Interactive Experience Design: The Organic Combination of Technology and Art

The significant difference between traditional picture books and electronic picture books is that electronic picture books have touch interaction functions. In digital picture books, the interface operation of interaction design can be divided into three types: non-situational guided interaction, motivational interaction that presents different page-turning effects by touch according to the development of the plot, and game-based interaction [6]. The use of these rich and diverse interactive forms has greatly increased people's interest in electronic picture books, and allowed the artistic elements of Dunhuang murals to be integrated into public life with the new media form of digital picture books.

4.3.1 Non-situational guided interaction

The non-situational guided interaction in digital picture books has nothing to do with the specific plot of the mural painting story, and its core function is to preliminatively guide readers how to appreciate the unique charm of Dunhuang mural painting with the help of digital technology. Such guidance must be clearly marked, easy to use, and fit the user's browsing habits. For example, tap the screen to see the high-definition details of some murals, and swipe left and right to switch between different cave murals. In terms of operation mode, it is not appropriate to set too many complicated control types, otherwise it will destroy readers' immersive experience of appreciating Dunhuang murals, weaken their love for digital picture books, and cause them to give up reading. This interactive guide is not directly related to the narrative of the mural paintings, though. However, in the overall design, Dunhuang art elements should be cleverly integrated to match the Dunhuang cultural atmosphere created by the digital picture book, and the visual and operational experience should organically echo the contents of the mural painting.

4.3.2 Scenario-type motivational interaction

The situational motivational interaction of Dunhuang murals in digital picture books is fundamentally different from the non-situational guided interaction. This kind of situational motivational interaction closely revolves around the story context behind the Dunhuang murals, and inspires users to participate in the story context, which has a direct impact on the promotion and interpretation of the story. The significant

difference in interface presentation from non-situational interaction is that situational motivational interaction does not abruptly add new elements that have nothing to do with the original picture of Dunhuang murals in digital picture books. On the contrary, it guides users to interact with the picture elements by digging deeply into the existing elements such as character movements, architectural structures and natural landscapes in the picture. Take King Shipi cutting meat to save pigeons as an example. When the picture shows King Shipi preparing to cut meat, readers can click the knife in King Shipi's hand to trigger the dynamic picture of the meat cutting action; Drag the pigeon, the position of the pigeon can be changed, so that the story is promoted according to the new position of the pigeon. This interactive way, on the premise of not destroying the original beauty and historical heritage of Dunhuang murals in digital picture books, deeply integrates users into Dunhuang stories, strengthens their understanding and perception of Dunhuang culture, and brings more immersive digital reading experience.

4.3.3 Gamelike interaction under multi-level perception

Through 3D scanning, augmented reality (AR), virtual reality (VR) technology to build a multi-level perception system for game interaction [7]. Users can play the game through the mobile phone scanning screen. For example, after tracing and repairing the original mural painting, they can trigger the Flying 360° holographic dance, simultaneously presenting the original appearance of the mural painting and the restoration process, realizing the "touchable history" and realizing the cross-media synsensory experience of vision, hearing and smell. The game-like interaction under multi-level perception is also reflected in that when the user interacts with the picture book, such as clicking on a certain element or completing a certain task, the corresponding sound feedback should be given, which can enhance the user's operating experience and sense of accomplishment. Through hidden sound effects and Easter eggs, users' participation and desire to explore can be enhanced. Cloud platform can be built, and users can unlock Dunhuang music and dance digital skin of different eras by completing virtual tasks; The interactive game "Mural Repairer" can be implanted in the mini program. When the player uses the stylus to remove the virtual wall diseases, the ASMR sound effect and particle touch feedback can be generated in real time.

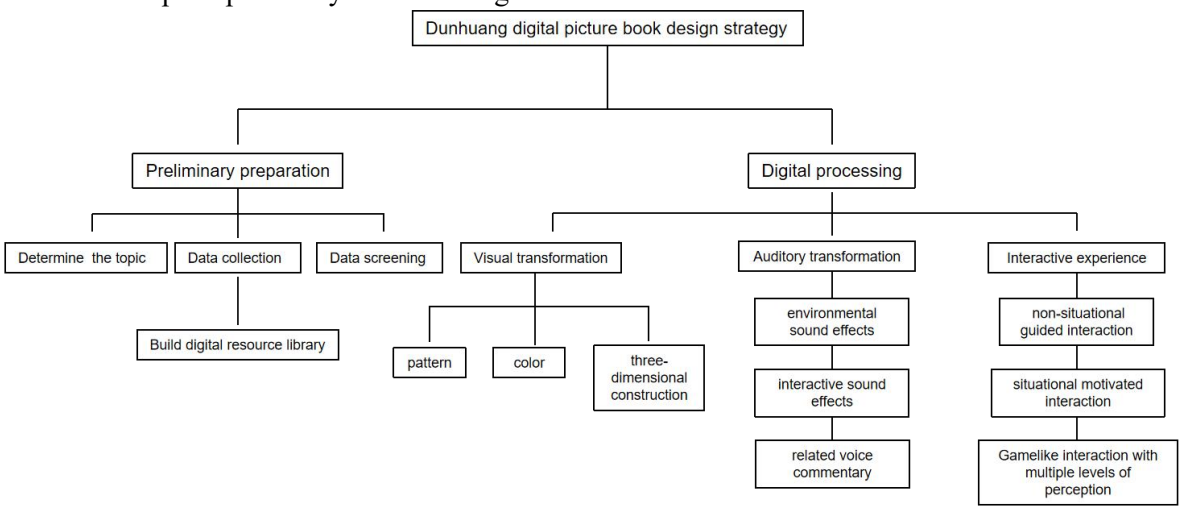


Figure 2. Digital Picture Book Design Strategy Diagram

5. The Digital Picture Book Design Taking "Deer King Bunsen Map" as an Example

5.1 The Selection of Story Subject Matter

The mural "Deer King Bunsheng Tu"(Figure 3), created during the Northern Wei Dynasty and located in Cave 257 of the Mogao Grottoes in Dunhuang, is the most fully preserved and representative comic strip among Buddhist story painting themes. It not only embodies the meticulous brushwork and heavy color style of the Northern Wei Dynasty, but also carries forward the noble character of sacrificing oneself to save people and selfless dedication. Its traditional painting techniques

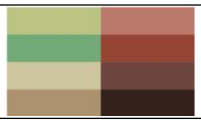
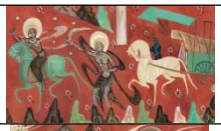
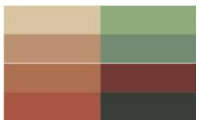
and excellent traditional virtues are worthy of in-depth study.

Figure 3. The Deer King Bunsen in Cave 257 of the Mogao Grottoes (Source: Dunhuang Academy)

5.2 Visual Expression

When original "Chinese style" picture books tell Chinese stories well, they often intuitively reflect the creation of artistic conception of "lofty sense" and "nostalgia sense" [8]. Therefore, when refining the elements of mural paintings, we should not completely discard the traditional style, but simplify the smooth and rhythmic lines, remove the complicated details, and reflect the original "sense of nostalgia". The other part is exaggerated and deformed, and the expressive force of the lines is strengthened, so as to create more visually impressive characters and scenes.

Table 2. Main Color Application of the Mural Painting "Deer King Bunsen Tu"

Main Scene	Original mural painting	Extracted colors
Drowned man rescued, grateful to King Deer		
The drowned informant, the heart of evil thoughts		
Send troops to capture the king of deer		
The deer king talks to the king		

In terms of color application, earth red is the main color of the digital picture book "Deer King Bunsen Tu", and the use of earth red builds a warm and historic atmosphere. At the same time, it is supplemented with white, black, stone green and other colors. The use of these low-saturation colors makes the overall tone more harmonious and unified, and it appears harmoniously in the picture book (Table 2). White is used to depict the body of the deer king, highlighting its purity and nobility; Black Outlines details and enhances the sense of hierarchy. Stone green to embellish the scene, add vitality to the picture. For example, when depicting the forest scene, low-purity stone green and earth red background are used to complement each other, creating a mysterious and distant mood.

Finally, based on the two-dimensional plane modeling based on the visual elements of Dunhuang murals, the expansion and integration of visual elements into three-dimensional space is further realized. In the dynamic visual display, the author tries to abandon the composition of the original painting's long roll comic book, and adopts the unique lens language of animation to express it [9]. Take the deer running scene as an example: When the deer is running fast, the background changes with it, and trees, rocks and other elements are presented in turn, as if the audience were immersed in the scene and shuttled through the forest with the deer. Another example: when depicting the King of deer rescuing the drowning person, first show the scene of the drowning person's struggle from the perspective of overlooking from a high altitude, and then zoom in to the

perspective of the King of deer to depict the details of the king's rescue. In the whole process of scene design of the work, the continuous change of viewpoints promoted the development of the story, greatly enhanced the motion of the picture, and helped the readers immerse in the story world of the Deer King Bunsen Tu.

5.3 Aural Expression

The auditory design takes the sound gene of Dunhuang culture as the core, and builds an immersive auditory scene through the integration of environmental sound effects, music narration and interactive sound effects to strengthen emotional resonance and cultural memory. The story of "Nine Color Deer King Bensheng" propagates justice, kindness and gratitude, and the emotional tone is warm and firm. In terms of environmental sound effects, it restores the natural soundscape, simulates the howling sound of desert sand through realistic sound effects, and the wind carries the rustling sound of sand collision, creating the vastness and desolation of the desert. At the same time, the Gobi wind around the Mogao Grottoes was added to add regional characteristics to the scene. In the interval of wind, the light camel bell is subtly incorporated, and the crisp bell moves from far to near and gradually away, which is a metaphor for the prosperous scene of the caravan traveling on the Silk Road. In the beginning, soothing and melodious music with elements of Western regions music is adopted to guide users into the Dunhuang cultural context. As the story progresses, the music changes as appropriate. As the story progresses to a scene in which the King of the deer rescues a drowning man, the tempo gradually increases and the melody becomes intense. When the king is betrayed and in trouble, the music turns to depression, highlighting the king's helplessness and sadness. At the climax and turning point of the story, it guides the user's emotions to rise and fall by changing the musical verse, harmony and instrument combination. At the same time, the use of interactive sound effects can add fun and sense of reality to the interaction between users and the picture book. When the user clicks on the picture elements, the system will give corresponding sound effects feedback. If you click the Deer King, it will play the neighing sound of the deer King; Click on the river in the picture, you can hear the sound of flowing water. These sound effects not only confirm the user's actions, but also allow the user to become more deeply involved in the scene of the story.

In addition to the picture book itself, in order to help users fully understand the cultural connotation and artistic charm of Dunhuang murals, real-time voice explanations can be provided according to users' browsing progress and interest points. Three interpretation roles of "historian", "virtual painter" and "digital provider" can be provided, and dynamic switching can be achieved with the help of intelligent voice system. When users are interested in the historical background of the mural paintings, the role of "historian" appears and tells the historical background, historical changes and related archaeological discoveries of the mural paintings in a calm tone. When users pay attention to the artistic characteristics of the mural, "virtual painter" explains the application of the mural lines, color matching and composition skills from the perspective of professional painting; While "digital providers" share the stories of the characters and Buddhist principles behind the murals in a friendly tone. For example, when displaying the image of the King Deer, the "virtual artist" will introduce how the artist uses smooth lines to outline the king's vigorous posture, and gradients of colors to highlight the three-dimensional sense. A "historian" will describe the stylistic characteristics of Dunhuang art during this period; "Digital Donors" will share the implications of the deer king's story in Buddhist culture.

Through the above multi-dimensional auditory design, the digital picture book "Deer King Bunsen Map" can not only allow users to visually appreciate the exquisite Dunhuang murals, but also deeply feel the extensive and profound Dunhuang culture from the auditory level, achieve immersive cultural experience, and promote the inheritance and dissemination of Dunhuang culture.

5.4 Interactive Experience

According to the story development of "Deer King Bunsen Diagram", carefully design situational motivation interaction nodes. For example, when the picture book shows the

plot of the Deer King telling the king about being betrayed by an ungrateful man, set interaction points, let the user click on the ungrateful man, and a dialog box of the character's inner monologue will pop up to further enrich the story details. At key plot changes, such as when the King of Deer is running in the forest, users can control the direction of the King's walking by sliding the screen to determine the path of subsequent development of the story, transforming readers from mere bystanders to participants in the story. At the same time, the use of gravity sensing, shaking equipment to make part of the material shake, the original picture book into a book supporting gravity sensing under the multi-level perception of gamelike interaction. We can also design more game tasks based on the background of "Deer King Bunsen Tu". For example, the game "Find the footprints of the Deer King" can hide the footprints of the Deer King in different cave scenes. Users can unlock new story fragments or Dunhuang cultural knowledge cards by observing the details of the picture and following the clues of the footprints. After completing the game tasks, users can get a virtual badge or unlock the digital surrounding of the Deer King with collectible value, such as the Deer King theme wallpaper, emojis, etc., to stimulate the enthusiasm of users to participate in the development of the story, so that readers are no longer passive receivers of information, but can actively participate in the development of the story and have in-depth interaction with the content. It brings unprecedented reading pleasure and injects new vitality into the development of picture books as an art form in the new era.

In addition, with the help of digital information technology, AR experience mode is developed. Users can use their mobile phones to scan and depict the specific page, then they can present 3D three-dimensional deer King and story scene, and can freely walk around the scene to observe the mural elements from different angles. In VR mode, users wear VR devices, as if they were in Dunhuang Caves, to observe the mural closely from the first perspective, touch the texture of the mural, listen to the simulated sound of wind and birds in the cave, and get an immersive experience.

6. Conclusion

Digital picture book design has innovative significance for the digital transformation of Dunhuang cultural heritage. By taking Dunhuang mural "Deer King Bunsen Tu" as an example, focusing on the digital picture book design strategy, the modern inheritance framework of cultural heritage is systematically constructed in which vision, hearing and interactive experience are synergistic transformation. At the visual level, the core genes of the mural (such as the three rabbits with one ear and the pattern of rolling weeds) are extracted and integrated into the dynamic narrative to realize the modern translation of traditional aesthetics; At the auditory level, it combines the restoration of Dunhuang ancient music and scene-oriented sound effects to build an immersive sound landscape; At the interactive level, it innovates scenario-based motivational interaction and gamified task design, promoting users to transform from passive viewers to story participants. Compared with previous studies, this paper breaks through the limitations of sensory experience separation in traditional digital projects, proposes a multi-dimensional integration strategy, and combines symbol extraction of cultural genes with user-driven interactive innovation to solve the pain points of mechanical reproduction and one-way transmission. However, there are still some problems in the research, such as limited case coverage, insufficient technical practice verification, and the depth of interdisciplinary integration to be improved. In the future, it is necessary to expand to multiple mural themes, optimize the adaptation of AR/VR technology based on empirical research, and deepen the cross-field collaboration between art, archaeology and digital technology; At the same time, explore multi-modal sensory integration, quantitative evaluation of user behavior and global cultural adaptation paths, so as to provide more universal and influential solutions for digital non-genetic inheritance.

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