Research Article

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Design and Application of Interactive Cultural Heritage Education Gamified Learning System

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ARTICLE INFO	ABSTRACT
	This article uses traditional Chinese handicrafts' intangible cultural heritage culture as the research object, mainly studying the design and application of interactive cultural heritage gamification. This study first analyzes the reasons for the low learning efficiency of Chinese traditional handicraft intangible cultural heritage and summarizes the gamification theory and its application status. Secondly, the advantages of gamification in cultural heritage education were proposed. Finally, taking the blue calico pattern as an example, it was designed to display the interaction process and behaviour of the application program. A usability test was conducted on the design scheme, and the test results showed that the design scheme could meet user needs and achieve the display and dissemination of the blue calico pattern. This study has specific reference value for promoting cultural heritage education through gamification and is of great significance for promoting the inheritance and promotion of cultural heritage. Traditional cultural disseminators and artisans can benefit from it. **Keywords:** Cultural Heritage, Gamification of Education, Blue Calico, Interactive Learning Systems, User Engagement.

INTRODUCTION

Cultural heritage is the crystallization of human culture and wisdom. China has many cultural heritages passed down for nearly a thousand years. These heritages have profoundly impacted the local style and culture and are a concentrated reflection of the local spirit and culture. With the changes of the times, some cultural heritage gradually integrates with the cultures of different places and countries, forming new distinctive branches. This also reflects the historical concept that culture, ethnicity, and the world constantly absorb and blend.

Therefore, protection and inheritance are two critical issues for cultural heritage. Although the achievements of cultural heritage have a certain degree of visibility, most of its processes still have invisibility and vulnerability to loss, especially the inability to mass produce and adapt to the needs of market-oriented development. The inheritance and protection of cultural heritage face many difficulties. Therefore, it is necessary to strengthen the education of cultural heritage. Cultural heritage education must be combined with practical education, patriotism education, and core literacy cultivation. However, cultivating cultural heritage education requires more than just relying on the content in textbooks. Teachers also need to supplement the national curriculum through different educational channels in the process of education, teaching, and cultivating students; Utilizing museums for cultural heritage education is an ideal method.

According to statistics, the number of museums in China has reached over 5500, of which more than 4900

are open to society for free, accounting for up to 90%. The "museum craze" marks a new chapter in China's cultural heritage education. As an integral part of informal learning, museums allow visitors to develop emotional connections while learning extracurricular knowledge (Lyytinen, Erskine, Kujala, Ojanen, & Richardson, 2009; Doering & Pekarik, 1996; Engeström, 2009). However, currently, in cultural popularization activities of domestic museums, conventional methods such as multimedia interactive screens, voice-guided tours, manual explanations, and learning manuals commonly face practical problems such as weak interactivity, low resource utilization, lack of innovation, and insufficient attractiveness during the audience's visit process, which leads to passive acceptance of museum knowledge by visitors and even the situation of "nothing," To a large extent, it reduces the willingness to revisit the museum. Although Chinese cultural heritage has received widespread attention, the existing forms of cultural heritage display are still single, making it challenging to meet the personalized needs of the public and achieve widespread and effective dissemination effects, which is not conducive to the dissemination of Chinese cultural heritage (Hein, 1998; J. F. Zhao & Q. Zhao, 2016; Pramling, 1988; Falk & Storksdieck, 2010; Shan, 2006).

Nowadays, the development of digital media technology has significantly impacted the spread of Chinese traditional culture. In the new media, how to use digital media technology to promote the learning, inheritance, and dissemination of Chinese culture has become an important issue to consider in developing Chinese culture. In recent years, with the rapid development of AI, education, big data, STEAM makers, and other emerging technologies and educational games, the research on game-based learning has kept rising rapidly worldwide. Adopting a gamified approach to cultural heritage learning will achieve good results (H. J. Zhao, 1997; Chen & Lian, 2005; Goodyear, 2008).

LITERATURE REVIEW

Scholars have conducted relevant research on educational work that utilizes museums and combines gamified forms of education. Jiang (2018) elaborated on the problems existing in the existing museum learning, conducted research from the theoretical and practical aspects, explained that it is necessary to identify the learning motivation of visitors to improve the overall learning effect of the museum, and developed the system design of game-based learning in the process of Discovery Museum; Dichev, Dicheva, Angelova, and Agre (2014) focus on explaining the motivational factors that affect learning and behavioral change understanding, providing analysis and guidance for gamification related work areas, and outlining emerging trends, providing a foundation for evaluating and identifying potential areas for improvement; Francisco et al. mainly analyze existing games or gamified activities and help design or improve them. The focus of gamification is to allow participants to invest the same intensity of learning in the game to gain experience in successfully designing gamified environments. This type of research promotes the design process of gamified learning technology models, evaluates data, and summarizes participatory technology design in conclusions to enhance visitor interaction ability. In the context of relevant motivational psychology and teaching methods, it explores the main teaching activities, behavioral patterns, and emerging technological aspects of gamified learning. However, research primarily focuses on theoretical exploration and model construction, and empirical research on research-based learning is rare. Few researchers systematically sort out and explore the gamified learning process and strategy methods through design. Dai (2019) proposed a design proposal for the interactive mode of the digital museum based on the establishment of an emotional bond between the user and the museum, and on this basis, confirmed the guiding method of museum Interaction design based on the user; Liu (2014) elaborated on the critical significance of modern museums in terms of the social education function, focusing on studying the problems currently existing in this function education, and by analyzing and explaining that museums should play their educational role in social education function at present; Seale et al. (2021) evaluated the success of a participatory research project and developed a participatory approach. The project explored how to make the museum learning experience more inclusive of visitors' different visit preferences. William and others discussed specific teaching strategies, summarized the importance of Empathy and analogical reasoning in object-based teaching, and promoted dialogue with museum visitors; The basis for operation and consumer-based museum services; Garone and Nesteriuk (2019) attempted to understand the museum service experience consumption of visitors based on their language and actions. The research showed that visiting museums has four benefits: cognition, emotion, reflection, and entertainment.

There are many cases of using museum gamification to carry out cultural education. For example, the Children's Museum in Houston has set up many innovative educational projects to provide children visitors with hand-drawn maps and role-playing-based cultural activities. Visitors can learn practical knowledge through personal experience based on automatic access to visitors to stimulate enthusiasm for lifelong learning and

exploration. The diverse, multi-level, and partially three-dimensional display forms at the Electronic Museum in the United States make the audience feel as if they are in a virtual scene, experiencing the artistic conception more realistically (Spector, Merrill, van Merrienboer, & Driscoll, 2008; Deterding, Dixon, Khaled, & Nacke, 2011; Domínguez et al., 2013; OECD, 2007). Visitors complete game tasks by recombining materials, and in this process, they can have a deeper understanding of the museum's development process and related knowledge of exhibits, as shown in **Figure 1**. In Chinese museums, visitors have the opportunity to delve into the vast facial features and understand the body structures that are not usually visible; In the grassland area, you can not only build a Yurt, understand the traditional nomadic life, but also experience the process of wind power generation and solar power generation. The exhibition area has bright and vibrant colors, clear activity themes, and a tall and spacious venue to avoid uncomfortable oppression. The design of wall signs runs through the elements of the traditional Chinese zodiac sign, conveying Chinese culture (Jong, Shang, F. L. Lee, J. H. M. Lee, & Law, 2006; Wang, 2021).

By designing the theme, content, and methods of museums in a gamified manner, the primary purpose is to help the audience gain a better visiting experience during the visit process. However, in the process of popularizing museum culture, there needs to be more interaction with visitors, and it is necessary to focus on the factors of design in gamified learning of museums, genuinely leveraging the role of museums as informal learning venues.
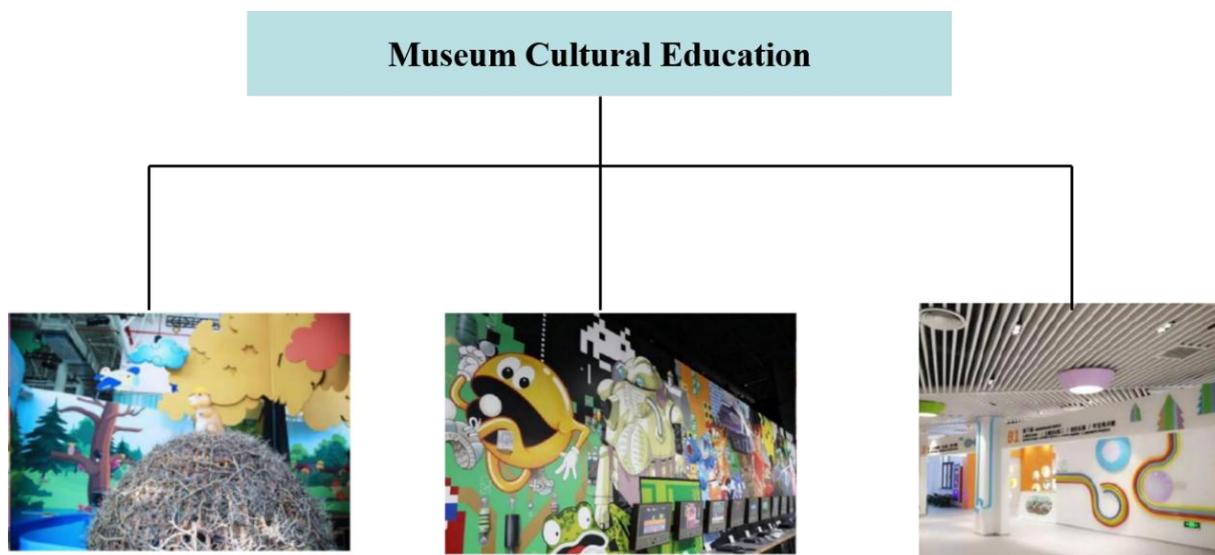

Figure 1. Gamification Learning in Museums

Conducting cultural heritage education through gamification reduces participants' negative emotions, improves learning efficiency, and expands the scope of cultural heritage. However, why gamification have a good effect on cultural dissemination, what is the difference between traditional cultural dissemination methods and gamification methods, and how to improve them? This question is worth studying.

INSPIRATION OF GAMIFICATION LEARNING

Issues in the Popularization of Museum Culture

The cultural popularization activities created by museums aim to enable visitors to grasp the relevant knowledge contained in the exhibits fully. The museum has a large flow of people and complex information, especially for special events related to cultural popularization. Promoting, guiding, and transmitting information in cultural popularization activities should be considered more. However, taking the information dissemination in the cultural popularization activities of the Sichuan Museum as an example, each layer of the exhibition learning rack is equipped with manuals tailored to different age groups, with the primary colors being red, green, yellow, and white. The learning content presents a difficult-to-distinguish distinction, and the design needs to be more attractive. The selected colors are grey, low saturation, and lack attractiveness (Lee, Lim, & Grabowski, 2007), as shown in **Figure 2 (a)**.

(a) Poster Exhibition　　　　　　　　　　　　　　**(b)** Museum Interactive System

Figure 2. Existing Problems (Lee et al., 2007)

At the same time, the survey found that both the game props used by visitors and the feedback reward stage could have provided a better Service design. Suppose visitors use virtual brushes with different sizes and models on both sides to fill in the preset colors of Dunhuang character line sketches but in reality. In that case, the line-drawn characters are already built-in in advance, and the complex lines make it challenging to fill in the colors (Lee et al., 2007; Spector et al., 2008; Nikolić, Jurković, & Kalčić, 2015). The audience cannot flexibly use the brushes in the interactive system, and the interactive experience could be better, as shown in **Figure 2 (b)**.

The Meaning of Gamification

Gamification does not simply refer to game design but to applying game elements in related fields, which involves driving user motivation. Therefore, the application of gamification requires the support of relevant theoretical foundations or methods. The Octalysis gamification framework (Chou,2015) (**Figure 3**) and ARCS motivation model (Keller, 1987) (**Figure 4**) are the foundation of gamification (Jiang, 2018).
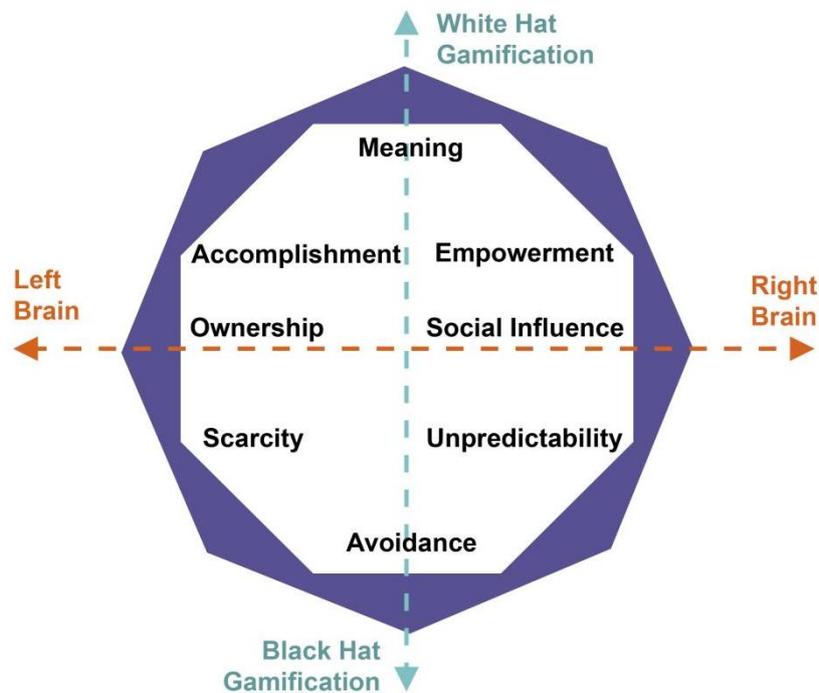

Figure 3. Octalysis Gamification Framework (Chou, 2015)

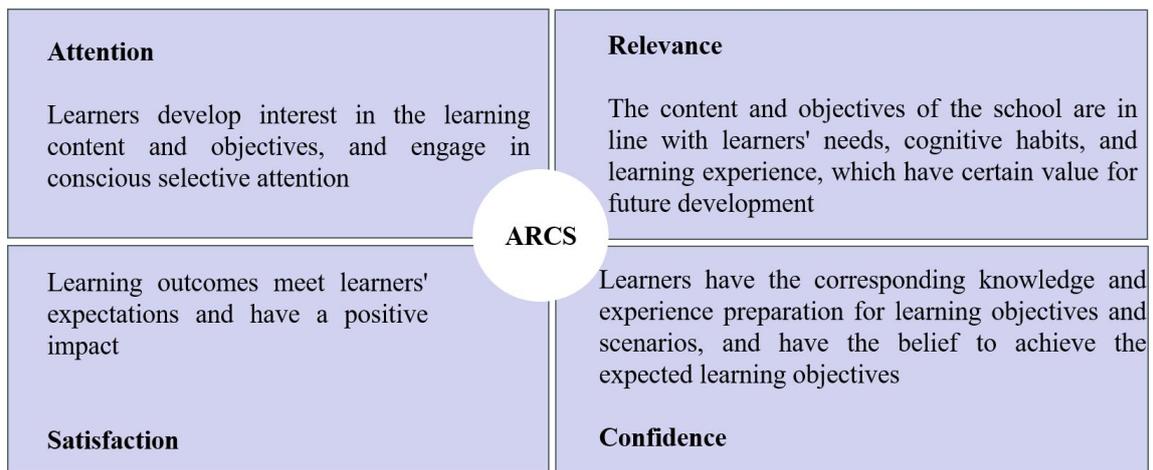| Attention	Relevance
Learners develop interest in the learning content and objectives, and engage in conscious selective attention	The content and objectives of the school are in line with learners' needs, cognitive habits, and learning experience, which have certain value for future development
Learning outcomes meet learners' expectations and have a positive impact	Learners have the corresponding knowledge and experience preparation for learning objectives and scenarios, and have the belief to achieve the expected learning objectives
Satisfaction	Confidence

Figure 4. ARCS Motivation Model (Keller, 1987)

The Significance of Gamified Cultural Heritage

Game chemistry learning will guide the audience to actively participate, stimulate learning motivation, and master relevant cultural knowledge. Combining handmade, virtual electronic products and other forms will achieve the goal of expanding horizons and cultivating learning initiatives. In museum cultural popularization activities, participation in gamified learning process design should enable visitors to freely imagine, enhance the interaction between exhibits and game props, and fully unleash their creativity and independence. In museum cultural popularization activities, exhibition staff should speak only a little. Tourists should be encouraged to actively explore and learn, fully developing their flexibility, curiosity, and spontaneous impulses.

The above analysis indicates that existing museums cannot effectively learn knowledge, and their learning models cannot serve the public well (Oliver, 2014). It is crucial to change this situation. Visiting some historical relics or cultural heritage in museums through gamified modes can make up for the shortcomings of existing museums, establish pleasant information transmission, improve the interactivity of information dissemination, stimulate public participation, and continuously enhance the dissemination of cultural heritage.

THE BLUE CALICO PATTERN EXAMPLE

The dissemination of cultural heritage through gamification can achieve good results. Through the on-site layout of game venues, handcrafting, or virtual electronic products, culture can be disseminated from different perspectives, allowing more people to understand the culture and feel its value. However, how to showcase cultural heritage through games is a challenge. By comparing different cultural heritage, this article selects blue calico patterns as the research object and demonstrates the impact of gamification on cultural heritage through gamification design.

Blue Calico Pattern Value

The humanistic value of blue calico patterns reflects the spirit of folk customs and personal style. The pattern starts from minor points and comprises point sets to form line segments. Then, the specific contours of the pattern are depicted using line segments, forming a pattern with special significance. Whether from the front or side, it is unique and not dull. After refining and transforming the original image, folk artisans change the curvature of the lines, forming a regular shape. The composition of the patterns is complete and rhythmic, with rich themes and continuity between the patterns. In terms of pattern design, embodies the auspicious concepts and emotions of ancient Chinese culture and is exquisitely crafted with profound meanings. The humanistic value reflected in it is the crystallization of the wisdom of the working people.

China's protection of intangible cultural heritage and increased dissemination of traditional culture have led to the emergence of many clothing accessories with traditional Chinese culture in the market. Blue calico, a unique folk handicraft, has also attracted much attention. With the increasing emphasis on traditional culture and the pressure of modern urban life, people's spiritual pursuit of returning to simplicity has also provided an opportunity to develop the blue calico tourism industry. Therefore, endowing blue calico patterns with cultural industry value will be based on the tourism industry and provide economic development.

Analysis of the Present Situation of Blue Calico Pattern Art Exhibition

There are two primary display methods for blue calico pattern technology: traditional physical media and new media. Traditional physical display, as the name suggests, refers to the display of natural objects in the form of museum displays, such as the Blue Calico Museum, which displays the printing and dyeing tools of the blue calico one by one and provides textual explanations of the techniques; New media display utilizes some new technologies, such as mechanically controlled display, touch screen display, sensor-based display, and virtual reality based display (Shang, Xiao, & Jia, 2014), as shown in **Figure 5**.

Figure 5. Display Method of Blue Calico Technique (Shang et al., 2014)

The pattern of blue calico is facing such a dilemma: blue calico is listed as a national intangible cultural heritage, and a national geographical indication product, and the Municipal People's Government has also actively held related exhibitions multiple times. However, the promotion effect is relatively short, and it is not easy to have a long-term impact. The public understanding and attention to blue calico pattern still needs to be improved (Tang & Zhang, 2017). The reason for this is that despite the advancement of technology and the emergence of various display methods on the market, the display of blue calico patterns has yet to align with the pace of the times, almost without modern technological elements. It is just a dull and single display, or adding some simple multimedia projection sound effects, which lacks novelty and cannot meet the audience's desire for novelty and interest; audiences find it difficult to leave a deep impression after browsing in a horse-watching style, which is also why the government's vigorous promotion often fails to achieve the expected results.

The display of blue calico pattern techniques is still in the traditional stage, and traditional displays cannot meet the needs of modern audiences. The modern display is a significant research hotspot and trend. The times need to progress, and traditional handicrafts must also be innovated. In order to revitalize the blue calico pattern technique in the new era, in addition to inheriting the technique well, it is also necessary to have an innovative awareness in the display form, expand the scope of dissemination, reduce visiting resistance, and explore the connotation and stories behind, enhance the interactivity in the display process, and inject fresh energy into the display of traditional handicrafts.

In recent years, the emergence of the interactive display has brought new era characteristics to display methods: (1) the design center has changed from "object" to "person"; (2) the viewing mode and interactive state have changed from passive to active; (3) The display space has expanded from physical space to virtual space. Due to these completely different characteristics from traditional monotonous display methods, interactive design has rapidly developed in contemporary display design. Applying interactive design to the display of blue calico pattern techniques can break away from the outdated and single pattern of current display methods, organically connect various elements of the technique, change the audience's experience mode and depth, shorten the distance with the audience, stimulate their interest, and provide spiritual enjoyment and spiritual pleasure. In this environment, the blue calico pattern technique can be passed down and developed dynamically, and it can be spontaneously disseminated and promoted by the public (Ma, Luo, & Bai, 2015).

Model Construction

Based on research on the interactive design of the blue calico pattern display, the research on functionality content, interactive behavior, and visual attributes is integrated to construct an interactive design model, as shown in **Figure 6**.
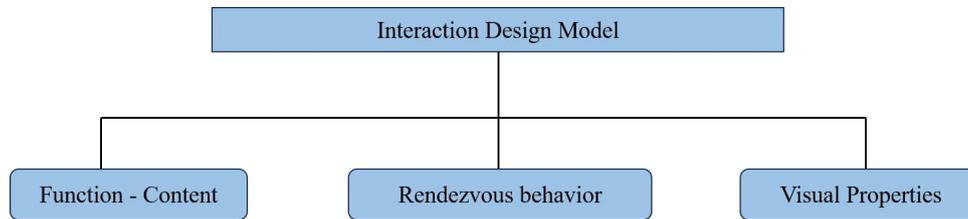

Figure 6. Model Construction

Interactive Process Design

The overall interaction process of the game is as follows: (1) Draw a sample or replace the version. Drawing samples or replacing templates is the first step in creating an experience where users choose to draw or replace templates according to their preferences. Select a sample to enter painting creation; Selecting a replacement plate presents users with multiple traditional blue calico patterns. The pigment brushing process begins after selecting the pattern plate to be replaced. Once completed, the following process begins. (2) Engraved patterns. Guide users to carve patterns in the order of double knives, single knives, and round spears. After completion, proceed to the following process. (3) Upper tung oil. Repeatedly brush and wipe the paper board until evenly brushed, then proceed to the following process. (4) Scrape the slurry. Firstly, the user is asked to mix soybean powder and lime powder in a particular proportion for stirring and mixing; After the mixing is completed, prompt the user to scrape the slurry, and once completed, proceed to the following process. (5) Staining. Firstly, soak the scraped and dried fabric evenly; Guide the user to take out the fabric repeatedly—wait for a few seconds—and put it into the dye tank, allowing them to feel the changes in color from green to blue and from light to profound. After completion, proceed to the following process. (6) Scrape the dust. Firstly, guide users to use wooden sticks to tap randomly stacked fabrics, Straighten the fabric and scrape off the mortar. After completion, proceed to the following process. (7) Cleaning and drying. After cleaning and drying, the finished product is displayed. (8) After the work is completed, users can choose whether to make a souvenir and the type of souvenir, make preview adjustments, and start production.

Interactive Behavior Design

Design interaction behavior based on the judgment of interaction behavior mode, the characteristics of crucial actions in skills, and the design of the interaction process. The interactive behavior design of the blue calico pattern technique display is shown in **Figure 7**, which combines elements such as spatial direction, movement range, movement speed, path mentality, flow characteristics, and strength to design operational gestures; Design a feedback mechanism in interactive behavior that combines the speed and formal elements of feedback.
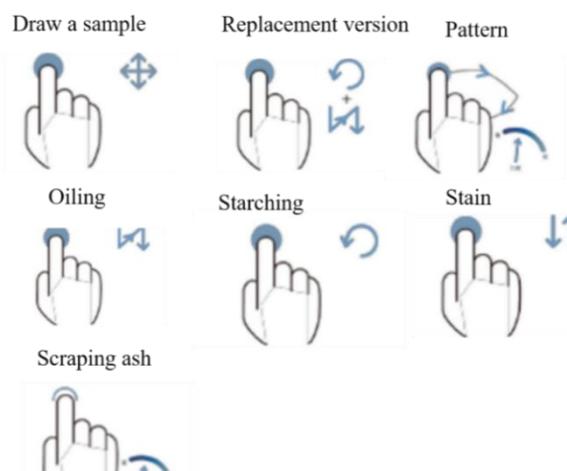

Figure 7. Interactive Behavior Design

Pattern Color Design

Color Design

According to research on color, blue can better capture people's emotions, while red and yellow can attract people's attention and provide reminders. Therefore, the primary color of the interface is blue, and the decorative colors are red and yellow, as shown in **Figure 8**. The main color tone of blue printed patterns is blue, which originally belonged to the category of black and white patterns. It has only two tones, black and white, both of which are extreme colors. Adding yellow and red as supplements can improve recognition and facilitate game design.

Figure 8. Color Selection

Pattern Design

First, select "Draw" or "Replace," click "Draw" to enter the drawing, create a new pattern, and click "Next" after the drawing is completed; Click "Substitution" to enter the pattern selection interface. Click on any pattern to view the introduction. Click "Select" to enter the substitution interface, as shown in **Figure 9**.

Figure 9. Operation Process

On the left side of the interface are the tools required for engraving patterns, and on the right is the operation area. The pattern can be enlarged for engraving. The system automatically processes the remaining parts after the user experiences the engraving process, avoiding repetitive operations. The specific process is shown in **Figure 10**.
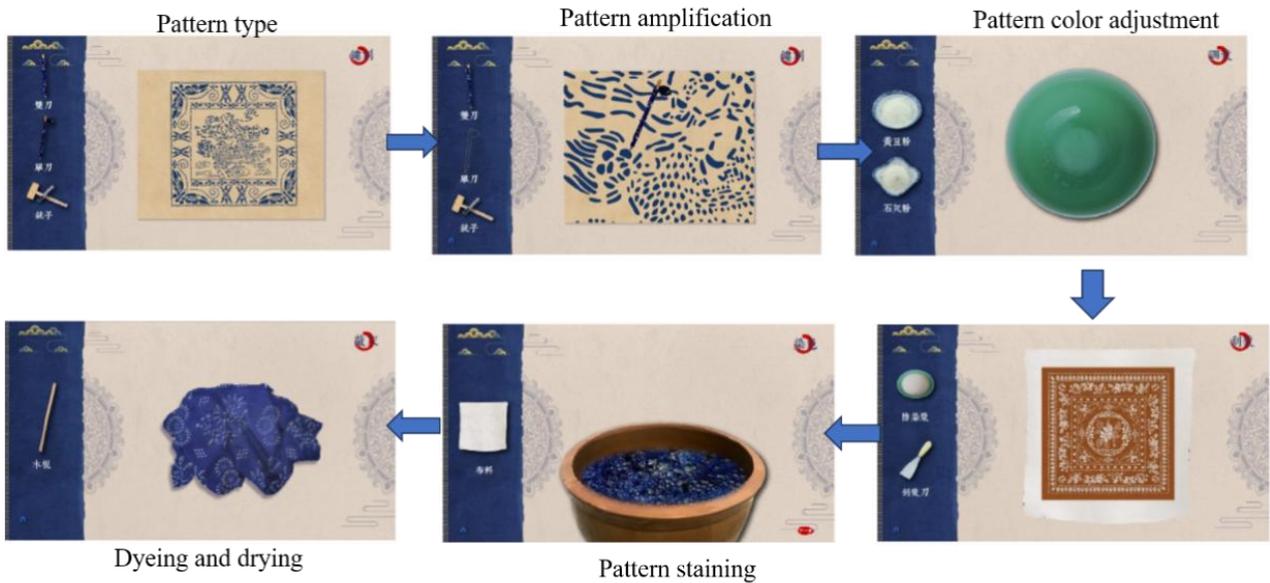

Figure 10. Pattern Design Process

Availability Testing

In order to verify the feasibility and rationality of the user research and interaction design strategy for blue calico pattern in this project, the user testing method was selected to conduct usability testing on the above design practices. Satisfaction surveys were conducted to verify whether the design guided by the user research and interaction design model meets user needs.

Test Object

Randomly recruit 6 ordinary users (Yu & Li, 2014), invite 1 interaction designer to conduct usability testing, and number them according to A–F. All test participants have been using touch screen devices such as mobile phones and tablets for a long time and are familiar with touch screen operations. The information on the test object is shown in **Table 1**.

Table 1. Test Object Information Table

Number	Age	Gender	Category
A	24	Woman	Ordinary users
B	26	Man	Interaction Designer
C	53	Man	Ordinary users
D	35	Man	Ordinary users
E	28	Woman	Ordinary users
F	13	Woman	Ordinary users

Testing Process

This test mainly adopts on-site testing methods, observing users' performance in executing testing tasks, conducting user interviews, and evaluating the SUS usability scale after the test is completed. Observing and recording users' performance and problems encountered during testing tasks from an objective perspective without interfering with the testing process.

Analysis of Test Results

Based on the observation of users during the usability testing process and interviews with users after the testing, it can be understood that the users participating in this usability testing were able to complete the testing

tasks according to the operating prompts, and the testing experience was relatively good. The following will analyze the evaluation results of SUS usability testing. Through research, scholar Jeff Sauro analyzed the curve grading range of SUS scores, as shown in **Table 2**.

Table 2. Curve Grading Range of SUS Scores

SUS	Grade	Percentile Rank	SUS	Grade	Percentile rank
84.1-100	A+	96-100	71.1-72.5	C+	60-64
80.8-84	A	90-95	65-71	C	41-59
78.9-80.7	A-	85-89	62.7-64.9	C-	35-40
77.2-78.8	B+	80-84	51.7-62.6	D	15-34
74.1-77.1	B	70-79	0-51.7	F	0-14
72.6-74	B-	65-69			

SUS scores, learnability scores, and usability scores are obtained by converting the evaluation results into scores, as shown in **Table 3**.

Table 3. Analysis of Evaluation Results

	SUS	Ease of Learning Score	Availability Score
A	90	100	87.5
B	87.5	87.5	87.5
C	80	87.5	78.13
D	85	87.5	84.38
E	87.5	100	84.38
F	77.5	75	71.88
Average value	84.58	89.58	83.33

From the above table, it can be seen that the overall usability score of the blue calico pattern demonstration application is 84.58, with a rating of A+; The ease of learning score is 89.58, rated A+, and the usability score is 83.33, rated A, all of which can better meet user needs.

CONCLUSION

This article takes traditional handicrafts as the research method, mainly studying the design and application of an interactive cultural heritage education gamification system. Through investigation, it was found that the public's learning efficiency of traditional museum cultural heritage could be higher, indicating the shortcomings of traditional museum education methods. The blue calico pattern as the background, a gamified learning process for the blue calico pattern, was designed, to demonstrate the impact of gamification on cultural inheritance. The main conclusions are as follows:

1. This paper analyzes the reasons for the low efficiency of a traditional museum learning culture, summarizes the theoretical basis of game-based learning, and indicates that game-based knowledge will contribute to the spread of cultural heritage.

2. Designed the interactive process and behavior for the display and application of blue calico pattern; Usability testing was conducted on the design scheme, and the test results showed that the design scheme could meet user needs and achieve the display and dissemination of blue calico technology.

RECOMMENDATION

It has been proven that traditional display forms can no longer meet the needs of the current dissemination and exchange of traditional Chinese culture. The joint cultural exhibitions in China mainly rely on physical and visual displays based on a specific principle of placing exhibits on a dedicated display platform and attaching brief text for explanation. This display mode has the advantages of transparent background and realism but has significant limitations. From the perspective of display methods, it is almost impossible to interact with static

objects. Instrumental explanations are dull and tedious and create a strong sense of distance among the audience, affecting people's enthusiasm for understanding, hindering the learning initiative of visitors, especially young people, and even hindering the dissemination of culture.

Nowadays, with the support of science and technology, people have long become accustomed to interactive and exciting forms of information reception, so interactive and exciting display methods can attract more public attention. In addition, using virtual reality for display does not require the support of venues. It minimizes the consumption of building materials, which can be considered a significant driving force for China's sustainable development. At the same time, virtual reality display has the advantage of not being limited by space and time and can provide audiences with a high-quality display experience across regions. It will have vital reference significance for the display of cultural heritage while also taking into account the correct dissemination of traditional culture, paying attention to the audience's feelings with a gamified design concept, creating an immersive and exciting experience for the audience, allowing them to experience the charm of traditional culture during the experience process, continuously deepening their emotional passion and rational understanding of culture, which is of great significance and feasibility.

CONFLICT OF INTEREST

We declare that we have no financial, personal, or professional affiliations that could be construed as a conflict of interest in the preparation and completion of this research. We confirm that the content of this research is the result of independent, unbiased scholarship.

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