Research on Digital Innovation of Intangible Cultural Heritage Based on Virtual Reality Technology

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Abstract. The purpose of this study is to explore the method framework and key design factors for the application of virtual reality technology in the digitization, preservation, and transmission of intangible cultural heritage, aiming to facilitate digital innovation in the realm of intangible heritage. This study combines the dynamic characteristics of intangible heritage that do not rely on physical artifacts with the immersive, imaginative, and interactive features of virtual reality technology. It proposes a digital innovation path for intangible heritage dissemination, focusing on skills, experiences, and spiritual values, using virtual reality games as a medium with a human-centered approach. Based on a four-fold classification of game elements and building upon existing game design models and user experience frameworks, this study explores the design process and method framework. Experimental work is conducted using an evaluative approach, and key factors influencing the virtual reality gaming experience are extracted using factor analysis. This research establishes a framework for the design process of virtual reality games for intangible heritage, encompassing cultural research, heritage game positioning, content and mechanism design, and interface design.

Keywords: Virtual Reality, Game Design, Intangible Cultural Heritage, Digital Innovation

1 Introduction

Virtual Reality (VR) is a computer-simulated three-dimensional virtual world that can simulate sensory experiences such as vision and hearing. Users feel as if they are transported to the virtual environment, enabling them to explore objects within the three-dimensional space in real-time and without limitations. Virtual reality is characterized by its immersive, interactive, and imaginative qualities. Currently, VR technology finds its primary applications in cultural exhibitions, gaming entertainment, and everyday life services.

Li Qingchang (2023) explores the design principles and methods of virtual reality technology in non -heritage culture inheritance, and further exerts the role of technology to improve the efficiency of non -heritage cultural heritage [1]. Chen Yingjie (2022) studied the concepts and characteristics of virtual reality technology, and proposed the idea of combining the two. Then take the traditional brewing technique of Lao Longkou liquor as an example. Through the process and methods of specific application of virtual reality technology, the feasibility and superiority of the combination of the two is verified. Finally, it summarizes the protection strategy of intangible cultural heritage in Liaoning Province based on virtual reality

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technology [2]. Li Yazheng (2022) believes that under the impact of modern waves, the inheritance of non -heritage has become more complicated, facing the dilemma of people's breakdown. With the development of information technology, the concept of non -heritage digitalization is gradually clarified, and digital technologies such as virtual reality and augmented reality are used in the protection and inheritance of non -heritage [3]. Li Yuanzhen and Xu Mei (2022) studied that the protection and inheritance of intangible cultural heritage were inseparable from human practice activities. The human social innovation practice space platform and the network, information, and virtual reality space became closer. In order to spread culture more efficient and extensively, choose innovative design digital technical means to create a virtual reality resource design library [4]. Zhang Yan, Yuan Shuai (2021) focused on the display of the cultural and space -based culture and space of the virtual reality technology of the virtual reality technology, and the inheritance of activity inheritance. After research, the virtual line beam technology is applied to the inheritance of intangible cultural heritage to make it sustainable development [5].

In summary, there are less digital protection for how the virtual reality technology is systematically applied to the intangible cultural heritage.

Intangible cultural heritage is an important part of a national or community cultural identity, including traditional skills, folk art, oral tradition, festivals and customs. These intangible cultural heritage carried historical, cultural, and social values. However, due to the changes in the times and the impact of modernization, they are facing the risk of continuous loss and decline. Therefore, the importance of protection, inheritance and promotion of intangible material cultural heritage is increasingly prominent. Although we have recognized the importance of intangible cultural heritage, its digital preservation and dissemination are facing a series of challenges. Traditional cultural protection methods are no longer enough, so you need to find innovative solutions. As a powerful digital tool, virtual reality technology provides new possibilities for protecting, inheriting and promoting intangible cultural heritage. Through virtual reality, people can experience intangible cultural heritage in a more intuitive and immersive way. This not only helps cultural heritage, but also attracts wider audiences to participate, thereby promoting cultural heritage and development.

2 Design Process and Methodology for Intangible Cultural Heritage Games Based on Virtual Reality Technology

This paper aims to digitize, preserve, and pass on intangible cultural heritage through digital innovation. It employs virtual reality technology as the technical means, with intangible cultural heritage serving as the primary subject and content of presentation. The production methods, manufacturing processes, and usage patterns of intangible cultural heritage are regarded as interactive pathways between users and the game. The five senses of humans (visual, auditory, gustatory, olfactory, and tactile) are utilized as channels for interaction in the exploration of game design methods based on virtual reality technology [6].

Drawing from Jesse Schell's fourfold classification of game elements, this study extracts the primary elements of game design, including mechanics, narrative elements, aesthetics, and technical elements. Leveraging the unique attributes of intangible cultural heritage as the design object and the distinct technical medium of virtual reality, in conjunction with the

hierarchy model of user experience elements, it reorganizes the various elements of game design to create a framework suitable for intangible cultural heritage VR games, as illustrated in Figure 2.

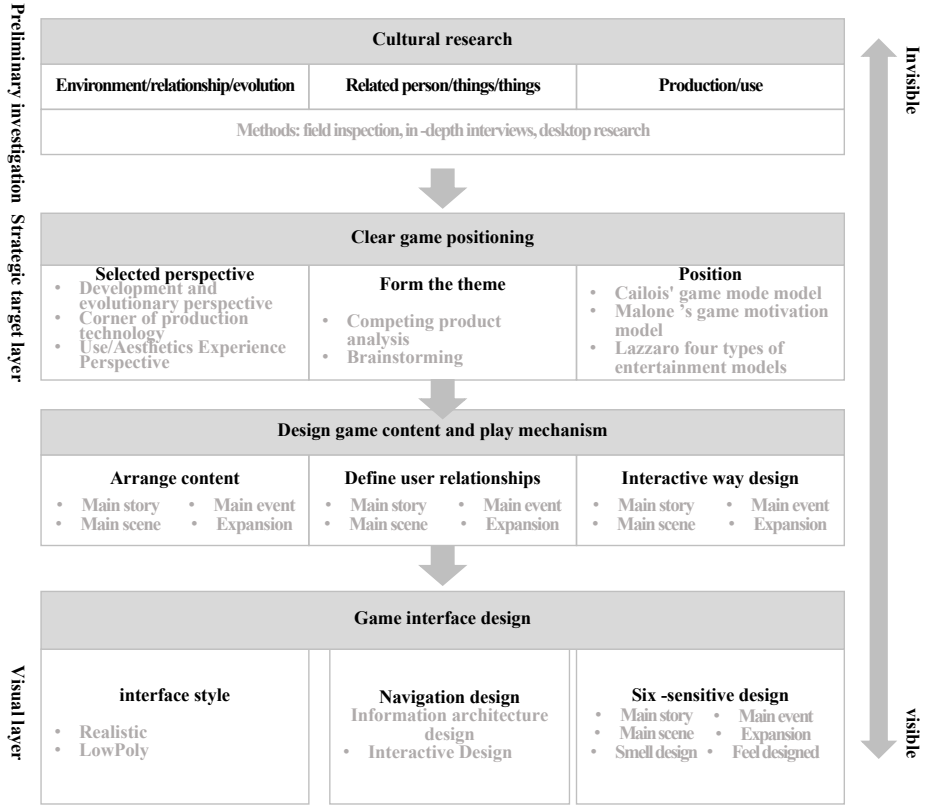

Fig.2. VR game design framework for digital protection of intangible cultural heritage

2.1 Preliminary Research

Through research methods such as field visits, in-depth interviews, and desk research, an understanding of the environment in which intangible cultural heritage exists, its relationship with the natural world, and its evolutionary processes is gained. This research also investigates the people, events, objects, production methods, and usage patterns related to intangible cultural heritage, providing materials and ideas for the design of game content and interactive elements.

2.2 Defining Game Positioning

Building on a profound understanding of intangible cultural heritage, creative design perspectives are explored through divergent thinking methods such as brainstorming. Given the attributes of intangible cultural heritage, potential design perspectives include viewing the process of intangible heritage creation from the perspective of the creators, examining the development history of intangible heritage from a timeline perspective, appreciating the

dedication of intangible heritage inheritors from their viewpoint, and savoring the beauty of intangible heritage from the perspective of its products [7]. Based on this, competitive analysis is conducted to gather insights into the implementation paths and strategies for the corresponding game themes. Subsequent design processes revolve closely around the chosen theme, utilizing as many means as possible to reinforce it.

In the exploration of game types, combinations of theme and factors from existing game models are used to determine different game positions. Notable research by scholars in the field of game models includes Caillois' game pattern model, Malone's game motivation model, and Lazzaro's proposal of four entertainment core models [8]. Caillois and others categorized game patterns into challenge, conflict, chance, randomness, role-playing, and instinctive response classes. Malone categorized game patterns into challenge, fantasy, and curiosity classes. Lazzaro's research focuses on the development and improvement of relationships between users and between users and games, and she proposed four levels of entertainment core: easy fun, hard fun, serious fun, and people fun.

2.3 Game Interface Design

Based on the user experience element framework, VR game design includes information architecture design, interface design within the three-dimensional space, interaction flow design, and visual presentation design, progressing from the bottom to the top. For VR interface design, it begins with UV layout design, creating and combining basic textures, images, and text, similar to information architecture design and navigation design. Subsequently, 3D modeling and animation are created in 3D software, connecting models and animations to design key interfaces. A logical flowchart (interaction flow design) is established within the game engine, and the design version is iterated through usability testing.

3 Exploration of Key VR Game Design Factors

3.1 Indicator Selection

In this paper, we extract the dimensions and design indicators of virtual reality games from two perspectives: game design and virtual reality application design.

In the field of virtual reality application design, representative achievements include the desktop system for virtual appliance maintenance engineering developed by Barrett et al., which evaluates virtual reality technology based on dimensions such as realism, usefulness, operational efficiency, and subjective satisfaction [9][10]. For usability assessment in the virtual reality training system for astronauts, Liu Peng et al. proposed indicators such as ease of learning, usability, interactivity, learning effectiveness, comfort, satisfaction, sense of presence, side effects, and task performance. Li Dandan introduced aesthetics, immersion, exploration and collection, and challenge as usability indicators for virtual reality games [11].

In summary, based on a review of literature from domestic and international scholars on the comprehensive evaluation of games and virtual reality, we have eliminated redundant semantic indicators and, in some cases, modified the names of certain indicators to make them clearer in meaning. For example, "beauty" has been changed to "visual effects." Ultimately, 11

common indicators have been selected as variables for further experimentation. The sources of these indicators are shown in Figure 3.

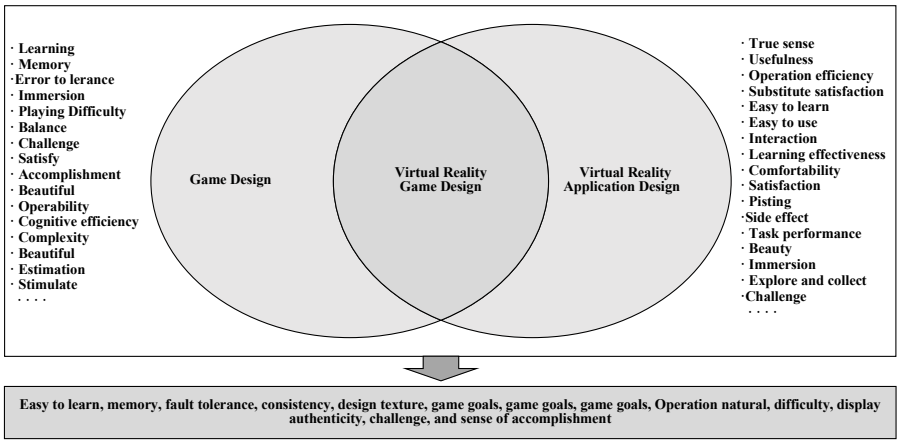

Fig.3. Indicator extraction of virtual reality games

3.2 Experimental Process

All VR game materials used in the experiment were obtained from two virtual reality gaming platforms, STEAM and Viveport. We selected 14 VR games that align with the theme of this study and have a high daily activity and download ranking. Each participant completed the entire experiment in approximately 1 hour. The experiment involved 11 participants and spanned 2 weeks, resulting in the collection of 33 questionnaires.

Questionnaires were designed based on validated scales, with answers given using the Likert five-point scale, where 1 represents "not important at all" and 5 represents "extremely important." Data analysis was conducted using IBM SPSS 24.0. Factor analysis was employed to extract a few latent common factors from numerous observable variables, allowing these factors to comprehensively summarize and explain the essence of the original observed variables, thus elucidating the nature of the original phenomena.

3.3 Factor analysis

It can be seen through Alpha's trust test, KMO sampling appropriate test, and Bartlite spherical test, and data is suitable for factor analysis. According to the turning point of the gravel diagram, try to extract 2, 3, and 4 factors for analysis, and finally extract 4 factors. The accumulated interpretation variance is 78.2%. See Table 1 through the rotating component matrix through the main component analysis method. The 11 indicators are classified and named the factors. The four key factors of the virtual reality game design are authentic, gaming, availability and emotion.

Tab.1. Component matrix after rotation

Index	Element			
	Authenticity	Gameplay	Usability	Emotion
Natural nature	0.837			

Show authenticity	0.836			
Design texture	0.779			
consistency		0.838		
Gaming goal		0.762		
Memory		0.646		
Fault tolerance			0.872	
Learning			0.852	
Difficulty			0.511	
Sense of accomplishment				0.809
challenge				0.731

Among the four dimensions of authenticity, gameplay, availability and emotion, users are most concerned about the expression of authenticity and gaming, and the weights are 28.579%and 26.520%, respectively. Insense, it shows that in virtual reality games, whether users can have immersive immersion and natural smooth interaction are the top priority of the design of virtual reality games. Under the premise of ensuring the above authenticity and gaming, appropriately improve the availability and meet the emotional needs of users through a certain design method through a certain design method.

4 Design Implementation

To validate the effectiveness of the virtual reality game design framework and strategies mentioned above, this study conducted a digital innovation exploration of intangible cultural heritage based on virtual reality games, using Inner Mongolia's intangible cultural heritage, Daur folk field hockey, as a prototype.

4.1 Content and Game Mechanism Design

Based on Daur customs, the game offers three main scenes: A'nie Festival, Mahei Festival, and Thousand Lantern Festival, with corresponding content based on these festivals. In the "A'nie Festival" scene, players can experience traditional festival activities such as cleaning the courtyard, pasting New Year paintings, throwing meat, rice, and pastries into the fire to pray for a bountiful harvest, making wooden balls for Daur field hockey, and playing field hockey. The latter two activities belong to Mode 2, where users enter an endless track and accumulate points by throwing food items or hockey balls into designated targets.

In the "Mahei Festival," traditionally aimed at protecting people from ghosts and ensuring safety amid conflicts, players experience the act of applying black ash to children's foreheads to challenge the ghosts.

In the "Thousand Lantern Festival," players encounter various lanterns, help villagers light them, engage in prayers at the temple, and participate in fireball making. Lighting lanterns and playing fireball defense are part of Mode 2, where lighting lanterns requires players to illuminate various lanterns on the temple's path, and fireball defense involves defending against balls thrown by AI opponents. This scene is set at night.

4.2 Game information architecture and interactive process design

The information architecture is a navigation of users roaming in digital products. The design of the information architecture of this game adopts a flat level, which is divided into three

levels. It is the homepage, list page and detail page in turn, see Figure 4. The interface is a medium that connects and communicate between users and various functions. The interface prototype and interactive process are shown in Figure 5.

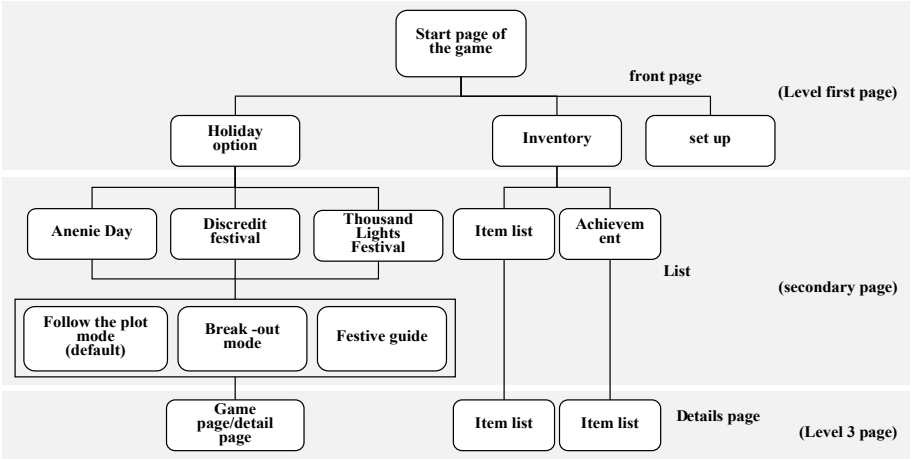

Fig.4. Information architecture (IA)

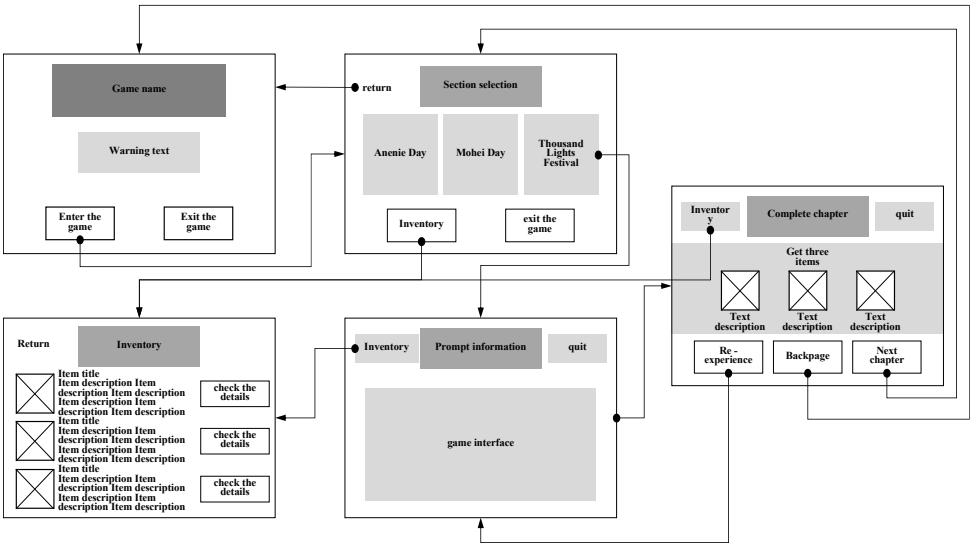

Fig.5. UI flow

5 Conclusion

Virtual reality technology, integrating cutting-edge human-machine display and interaction techniques, boasts three distinct characteristics: immersion, interactivity, and creativity. It stands as one of the most suitable technologies for creating immersive displays and interactive

experiences related to intangible cultural heritage. It provides excellent technical support for the digital preservation and inheritance of intangible cultural heritage. Therefore, this paper takes virtual reality gaming as a breakthrough in the digital innovation of intangible cultural heritage. It explores the framework for game design from various aspects, including preliminary research, game positioning, content and mechanism design, and interface design. Additionally, it puts forward four critical design factors affecting user experiences in virtual reality games, encompassing authenticity, playability, usability, and emotions, along with their corresponding design strategies. As human-machine display and interaction technologies continue to mature, coupled with ongoing improvements in design processes, methods, and standards in related fields, the integration of virtual reality games with the preservation of intangible cultural heritage is bound to deepen further.

References

[1] Li Qingchang. The design research of virtual reality technology in the inheritance of non-heritage culture [J/OL]. Packaging Engineering: 1-6 [2023-09-26].

[2] Chen Yingjie. The application research of virtual reality technology in the protection of intangible cultural heritage in Liaoning Province [J]. Governance and development, 2022 (01): 141-146.

[3] Li Yazheng, Zhou Xuan. The application of virtual reality in the protection and inheritance of intangible cultural heritage [J]. Science and Education Wenhui, 2022 (16): 132-134.

[4] Ruffino P A, Permadi D, Gandino E, et al. Digital technologies for inclusive cultural heritage: The case study of serralunga d'alba castle[J]. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2019, 4: 141-147.

[5] Cui Huijiao, Cheng Muhua. Digital media art teaching strategies based on virtual reality technology [J]. Journal of Shanxi University of Finance and Economics, 2022,44 (S2): 125-127.

[6] Cui Lingyi. Digital media technical exploration based on "virtual reality+" [J]. Journal of Shanxi University of Finance and Economics, 2022,44 (S2): 188-190.

[7] Madan. About digital technology virtual reality space immersive experience form [j]. Digital technology and application, 2022,40 (10): 52-54.

[8] Yin Li. Based on virtual reality technology and digital media technology integration creation first explore [J]. Tomorrow's fashion, 2022 (16): 183-186.

[9] Selmanović E, Rizvic S, Harvey C, et al. Improving accessibility to intangible cultural heritage preservation using virtual reality[J]. Journal on Computing and Cultural Heritage (JOCCH), 2020, 13(2): 1-19..

[10] Kim S, Im D, Lee J, et al. Utility of digital technologies for the sustainability of intangible cultural heritage (ICH) in Korea[J]. Sustainability, 2019, 11(21): 6117.

[11] Gonçalves A R, Dorsch L L P, Figueiredo M. Digital tourism: an alternative view on cultural intangible heritage and sustainability in Tavira, Portugal[J]. Sustainability, 2022, 14(5): 2912.