

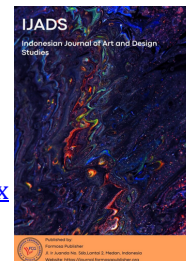


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## Learning the construction techniques of San Jiang Dong wooden architecture via virtual reality application

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### ABSTRACT

This paper explores the theme of learning the techniques of Dong wooden building construction in San Jiang, Guangxi through virtual reality (VR) applications. The Dong wooden building construction techniques are an important part of China's intangible cultural heritage but are facing the crisis of loss and extinction. To preserve and inherit this skill, this paper designs and develops an immersive VR application based on head-mounted display (HMD), which allows users to experience and manipulate the process of Dong timber-frame building construction in a virtual environment and provides related cultural and historical knowledge through a multimedia approach. This paper evaluates this VR application using both program observation and literature research, collecting and analyzing data in terms of user experience, learning effects, learning behaviors, and learning motivation, respectively, and comparing and discussing with existing theories and practices. The findings show that the VR application can significantly increase the level of users' knowledge and interest in the Dong wood construction techniques and facilitate their exploratory and collaborative learning. The paper concludes that using VR technology to learn and preserve intangible cultural heritage has potential value and significance and suggests some design recommendations and future research directions.

### INTRODUCTION

Intangible cultural heritage is an intangible cultural heritage that represents an important part of the history, culture, and tradition of human society (Huang & Tal, 2012). This cultural heritage is inherited and interpreted by human beings through oral traditions, performing arts, social practices, and knowledge skills, and its rich and varied contents reflect the lifestyles and cultural habits of different peoples, regions, and times.

Among them, knowledge skills are one of the core elements of intangible cultural heritage (Liu, 2012). Knowledge and skills refer to various techniques, methods and experiences that people

have mastered and used in production, life and social interaction. These skills have not only practical value, but also aesthetic value. For example, Chinese skills such as calligraphy, paper-cutting, folk instrument making, and porcelain making have both practical value and are known worldwide for their unique artistic value (Wei, 2022).

The transmission and protection of intangible cultural heritage is a common responsibility of all countries in the world. UNESCO (United Nations Educational, Scientific and Cultural Organization) established the Convention for the Safeguarding of Intangible Cultural Heritage in 2003, aiming to promote the safeguarding and transmission of

intangible cultural heritage in all countries and to preserve the diversity of humanity and cultural diversity. This Convention defines intangible cultural heritage as "the product of the creative activity of humankind in the form of language, literature, music, dance, drama, games, legends, crafts, festivals, etc." (Ma et al., 2019).

However, intangible cultural heritage is facing serious threats and challenges due to globalization and modernization. In this context, countries should strengthen the protection and transmission of intangible cultural heritage, as well as integrate intangible cultural heritage into cultural education so that the younger generation can better understand and transmit intangible cultural heritage in order to preserve and promote the unique cultural traditions of humanity. (Huang & Tal, 2012)

San Jiang County in Guangxi is one of the central territories where the Dong people gather in southern China and has the largest Dong population among the five Dong autonomous counties in China. The county has eight natural villages, including Maanzhai, Ping zhai, Yan zhai, Pingtan, Zhizhai, Cheng yang Village, Ping pu and Ji chang, with an area of 12.55 square kilometers and a total of 9,701 residents in 2,197 households. According to 2006 statistics, the total population of the county is about 360,000, of which seven ethnic groups, including Dong, Miao, Yao, Zhuang, Hui, Mu lao, and Han, live together, and the Dong population accounts for about 57% of the total population (Yue et al., 2022). (Fig. 1)

As an important representative of the Dong traditional culture, the Dong wooden building construction technique in San Jiang County, Guangxi is not only beautiful and unique in shape, but also excellent in craftsmanship, reflecting the wisdom and creativity of the Dong people. The building process of this technique involves many aspects, such as selecting materials, processing, connecting, and decorating, which not only demonstrates the adaptability and utilization of the Dong people to the natural environment, but also reflects the reflectiveness and shaping of the Dong people to the social structure and values. Cheng yang Village, as one of the important carriers of Dong culture in San Jiang County, has preserved many Dong traditional cultural elements, such as Dong songs and dances, Dong handicrafts, and Dong festivals, and has made positive contributions to the inheritance and

promotion of Dong culture (Guo Ying & Zhao, 2012). (Fig. 2)



Fig. 1 main Dong people's settlements in China



Fig. 2 Song and Dance of Dong Nationality in Sanjiang

The Dong wooden building construction technique is one of the important components of China's intangible cultural heritage and the most outstanding ethnic folk traditional cultural expression in San Jiang County, Guangxi (Liu, 2022).(Fig.3) Dong wooden architecture, represented by wind and rain bridges and drum towers, is not only beautiful in shape, but also a masterpiece of craftsmanship, showing the wisdom and creativity of the Dong people (Xu, 2015). The Dong wooden building construction techniques involve a wide range of knowledge and skills, including material selection, processing, joining, and decoration, and they reflect both the adaptability and utilization of the natural environment and the

reflection and shaping of the social structure and values of the Dong people (Peng et al., 2006). (Fig. 4)



Fig. 3 The Dong wooden building

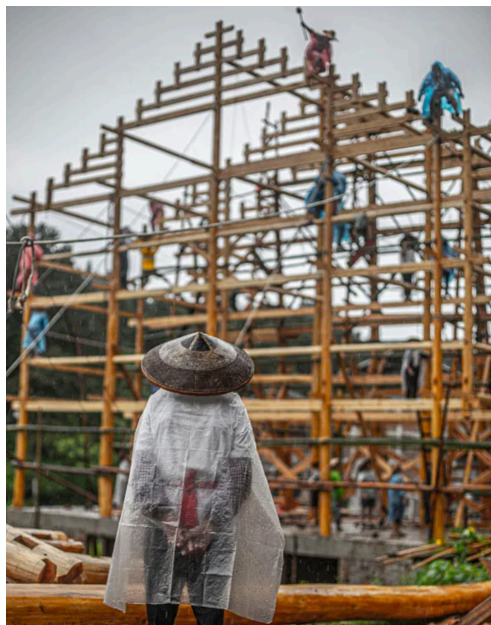


Fig. 4 Dong architectural construction

The Dong wooden building construction technique is an important traditional handicraft technique, a traditional cultural expression closely related to the life of the Dong people, and a cultural resource of great value that brings together the unique temperament, building techniques and practical experience of the Dong people. At present, San Jiang has the most complete, the most numerous and the most concentrated Dong architecture group in China, with 110 wind and rain bridges and 168 drum towers. The skill of building wooden structures of the Dong people in San Jiang has been passed down through generations for more than two hundred

years. (Zhou, 2017) The Dong wooden architecture is completed by the process of cutting and drilling the mortise and tenon, piercing the beams and connecting the arches, and erecting the columns and square, which has a strict structure, exquisite craftsmanship, majestic and spectacular appearance, and is extremely rich in the local characteristics of minority groups. (Guo Shanmin, 2021) (Fig. 6)



Fig. 6 San Jiang Dong wind and rain Bridge

The San Jiang region in Guangxi is located in the subtropical zone and belongs to the Lingnan humid climate zone, where the climate is humid and rainy, and the summer is hot and humid, so the local craftsmen use the dry-rail building structure when creating the residential buildings. This structure can achieve the purpose of heat removal and ventilation, making the interior of the building cooler and more comfortable. In San Jiang area, the Dong people live in deep mountains and transportation is not easy, so the transportation cost of building materials such as bricks and tiles is high and very difficult to obtain. However, natural woods and stones all over the mountains become the cheapest and easily available building materials. In addition to the common cedar wood, Dong timber construction also requires the use of bamboo, tung oil, white clay, glutinous rice and kiwi vines. Bamboo plays a very important role in wood construction. It is mainly used to make model samples, tenon poles and bamboo nails. These small samples and DD poles are important parts of wood frame construction and can be used to determine the shape and size of the building, while bamboo nails can be used to connect the wood members. Tung oil is also an important material in Dong wooden construction, which can effectively protect the building from corrosion and insects. White clay, on the other hand, is used to make the tiles on the roof, which is characterized by strong adhesion and high

hardness after firing. While glutinous rice and kiwi vine are special materials used in Dong architecture to make decorations on wooden structures (Yue et al., 2022b). It is worth mentioning that the Dong timber frame construction technique is a complex traditional craft. To build a complete timber frame building, at least six steps are required: making a small sample, making a DD pole, taking and processing wood, drawing lines, making components, and assembling. This involves thousands of complex processes, and some steps are inseparable from the actual building experience of the individual architect. These craft details make the Dong wooden architecture not only practical but also a cultural and artistic expression, which makes one marvel at the wisdom and skills of the Dong people (Bian, 2020). (Fig. 7)



Fig. 7 Dong Village, San Jiang County

According to the information I have, Dong wooden architecture is a typical architectural form of Dong dwellings, which attracts tourists and culture lovers with its unique architectural style and craft skills. In Liuzhou City, there are 38 representative inheritors of Dong wood construction techniques, including 2 national representative inheritors, 3 autonomous region representative inheritors, 11 municipal representative inheritors (2 of them have passed away), and 22 county representative inheritors. Most of these inheritors live in San Jiang Dong Autonomous County. At present, there are only about 1,800 craftsmen engaged in the construction of Dong wooden structures, of which only about 300 have the qualification of "ink master". The so-called "ink master" refers to the master who controls the ink line, that is, the "chief engineer" who presides over the whole construction when building houses traditionally. On average,

there are only 1-2 ink masters in each village, so there is a great scarcity of people who can master this skill. (Guo Shanmin, 2021) (Fig. 8)



Fig. 8 Dong ink masters, San Jiang County

However, in today's socio-economic development and globalization, the Dong wood construction techniques are facing the crisis of loss and extinction. On the one hand, in terms of resources and environment, traditional timber resources such as "primitive forest", "natural forest" and "old trees" are decreasing or prohibited to be harvested; on the other hand, in terms of social On the other hand, in terms of culture, "old craftsmen", "old artisans" and "masters" are old or have passed away, and "new craftsmen The successors such as "new craftsmen", "new artisans" and "new masters" lack interest or are unable to take responsibility; furthermore, in terms of market economy, "low cost", "high "high efficiency", "fast construction" new construction materials and methods have replaced the "high cost", "low efficiency", "slow construction The "low-cost", "high-efficiency" and "fast-construction" new construction materials and methods have replaced the "high-cost", "low-efficiency" and "slow-construction" traditional construction materials and methods (Luo et al., 2012). These factors have led to great difficulties and

challenges in the inheritance and conservation of Dong wood construction techniques.

As an important part of Dong traditional culture, Dong wooden architecture has gone through thousands of years, showing unique architectural style and craft skills, and is well loved by people. However, in the face of the rapid development and influence of modern technology, economy and information society, the preservation and inheritance of these ancient Dong buildings are facing serious challenges. San Jiang Dong Autonomous County is one of the most concentrated areas of Dong wooden architecture, but the culture of the Dong people in the county is accelerating towards extinction, according to the China News Service. With modernization, many young people are leaving the countryside for better living and working opportunities in the cities, resulting in fewer and fewer talents in these traditional crafts. At the same time, the rapid development of modern construction and industrialized production has also impacted on the traditional handmade way of making Dong wooden structures, and many people have gradually lost their interest and enthusiasm for traditional culture. (Luo et al., 2012)

Architecture is not only the crystallization of a nation's wisdom, but also contains endless cultural, scientific, and economic values, and is a treasure trove to be explored. However, with the rise of modern construction techniques, traditional Dong wooden architecture is often neglected by the public (Zhou, 2017). The traditional teacher and family mode of inheritance is the main mode of inheritance of Dong wood construction techniques, which are mostly passed down from folk artisans or village residents by word of mouth, leaving no systematic and complete written information, making the construction techniques themselves informal and unstable (Liu, 2022). With the change of the times, modern emerging technologies are more attractive to the young people of today, and fewer and fewer people are willing to devote themselves to traditional craftsmanship, while the older generation of masters who mastered the skills of Dong wooden construction are also old, and the skills are in the hands of only a few people and on the verge of being lost. In addition to the difficulty in passing down the construction techniques, it is also difficult to preserve the Dong wooden architecture itself (Guo Shanmin, 2021). In addition, the all-wooden

structure of Dong architecture itself is weak against disasters, and floods and fires can bring fatal damage to these wooden structures, especially the fire hazard is so great that a single accidental fire can turn these precious cultural heritages into ashes.(Bian, 2020). (Fig. 9)



Fig. 9 A fire broke out in a Dong village in Guizhou.

Faced with the impact of the development of the times, brick houses have replaced the hanging wooden houses, the demand for traditional wooden buildings has been decreasing sharply year by year, and the amount of works undertaken by the inheritors has been relatively reduced. The increase of brick houses has also squeezed the soil for the survival of traditional wooden architecture and threatened the protection of traditional villages. (Guo, 2021) The archiving of architectural data information of "Dong wood frame building construction techniques" is one of the key points of research in the field of architectural conservation, but there are many drawbacks in the archiving of architectural data information. In the past, the archiving of architectural data of "Dong wooden architecture" in China was mainly done through drawings, tables, texts, images and so on. However, there are many drawbacks in these archiving methods, such as the large amount of data processing work, the abstract and imprecise expression of information, and the difficulty in finding information. (Zhou, 2017)

In conclusion, despite many conservation and development measures taken by local governments, effective conservation and inheritance cannot be achieved due to the limitations of traditional conservation means and inheritance modes (Dai, 2015). Therefore, in the era of modern Informationization and networking, it is important to strengthen the study of ancient Dong wooden

architecture and use modern technology to protect and inherit these ethnic architectural heritage cultures, while modern civilization such as 3D virtual reality technology and network interaction technology provide more and better means of protection and dissemination of culture, which can effectively realize the protection and inheritance of these cultures. (Luo et al., 2012)

To effectively preserve and inherit the Dong wooden building construction techniques, various measures and tools are needed, among which digital technology is a powerful tool (Peng et al., 2006). Digital technology can preserve and transmit intangible cultural heritage by recording, storing, displaying, and transmitting (Huang, 2015). Digital technology can not only improve the visibility and accessibility of ICH (Zhang, 2019), but also promote the interaction and innovation of ICH with contemporary society (Ji, 2020). Among the many digital technologies, virtual reality (VR), as an emerging interactive medium, has great potential in the field of ICH preservation.

Virtual Reality (VR) was first proposed in the early 1980s by the American scientist Raoul, a modern design method and technology based on computer simulation, which is generated by using computer simulations to provide users with realistic simulations of the visual, auditory, tactile, and other sensory worlds. (Luo et al., 2012) (Fig. 10)



Fig. 10 Virtual reality technology

Virtual reality technology not only makes the user feel immersive, but also breaks through the limitations of time and space to realize the experience that the user cannot experience in the real world. The key technologies of virtual reality are data acquisition technology, 3D modeling technology, stereo display technology, stereo sound synthesis technology, human-computer interaction technology, and system integration technology (Bachvarov et al., 2019). Data acquisition technology mainly uses acquisition equipment to obtain data such as spatial location relationship, image information and sound information of the scene; 3D modeling technology uses measurement data and captured images to build virtual scenes and character models; stereo display technology mainly uses special display devices such as light-valve eyes and digital helmets to achieve the visual effect of three-dimensional space; stereo sound synthesis technology mainly mixes direct sound, echoes and surrounding noises to achieve realistic sound sensation. The human-computer interaction technology uses feedback devices such as digital gloves and mechanical feedback devices to enable the user in the virtual environment to respond with live feedback information through their own voice, gestures and other actions (Mortara & Catalano, 2018). System integration technology is the process of integrating information models, display effects, sound effects, etc. in virtual environments. (Zhang, 2019)

VR is a technology that uses computers to generate simulated environments or situations and allows users to immersively experience and participate in them (Bozzelli et al., 2019). VR can make users feel like they are in a virtual environment and can perform various actions with it by creating a sense of realism, presence, interaction, and other psychological effects (Okanovic et al., 2022). VR can not only simulate real-world scenarios that are difficult or dangerous to reproduce, but also create imaginative spaces beyond the real world (Deng et al., 2021). Therefore, VR can be used as an effective educational tool for users to learn various aspects of knowledge, skills, and attitudes in a virtual environment (Gonizzi Barsanti et al., 2015). (Fig. 11)



Fig. 11 Researchers are conducting virtual reality application tests.

There are several advantages of using VR technology to learn Dong wooden construction techniques: first, VR can provide a realistic and vivid virtual environment, allowing users to feel the natural landscape, social atmosphere, cultural connotation and other multiple elements involved in the process of Dong wooden construction (Pieraccini et al., 2001); second, VR can support users to perform various operations and interactions in the virtual environment (Li, 2020). Second, VR can support users to perform various operations and interactions in the virtual environment (Li, 2020), allowing users to experience the various knowledge and skills of selecting materials, processing, connecting, and decorating that are needed in the process of building Dong wooden structures; Third, VR can provide relevant cultural and historical knowledge through multimedia and personalize it with users' own interests and needs (Mortara & Catalano, 2018) ; fourth, VR can facilitate collaboration and communication among users in a virtual environment and stimulate their sense of exploration and innovation in the Dong wood construction techniques (Fanani et al., 2021).

Based on the above analysis, this paper designs and develops a head-mounted display (HMD)-based immersive VR application that allows users to experience and manipulate the process of building Dong wooden structures in a virtual environment and provides related cultural and historical knowledge through a multimedia approach. This paper evaluates this VR application using both program observation and literature research, collecting and analyzing data in terms of user experience, learning effects, learning behavior, and learning motivation, respectively, and comparing and discussing with existing theories and practices. This paper focuses on answering the following three research questions:

1. What is the user experience when using the VR application?
2. What are the cognitive, affective, and behavioral changes in users' perceptions of Dong wood construction techniques after using the VR application?
3. What kind of learning behaviors and motivations do users exhibit when using the VR application?

The structure of this paper is as follows: the first part introduces the background and purpose of the study; the second part introduces the research methodology, including the design principles, development process, and evaluation methods of VR applications; the third part introduces the research results, including data analysis of user experience, learning effects, learning behaviors, and learning motivation; the fourth part conducts a discussion of the results, including comparison with theory and practice, advantages and limitations of VR applications; the fifth part summarizes the conclusions of the study and puts forward some design suggestions and future research directions.

## METHODS

This study uses a mixed-methods design that combines both program observation and literature research to evaluate VR applications. Procedural observation is a method for collecting data on user experience and behavior in a natural environment (Roumana et al., 2022). Literature research is a method to obtain user cognitive and affective data by analyzing existing textual material (Theodoropoulos & Antoniou, 2022). The program observation and literature study of this study was conducted in a higher education institution in Nanning, Guangxi, with the participation of 10 students.

During the procedural observation, we used a VR application and recorded various behaviors and reactions of the participants during the use of the VR application, such as the number of clicks, dwell time, visual attention points, body movements, and so on. At the same time, we evaluated and improved the VR application by recording the participants' feedback and suggestions. During the literature study, we systematically collected and analyzed relevant literature, such as academic papers, market research reports, user evaluations, etc., to obtain users' cognitive and affective data about VR applications

and evaluated and improved VR applications based on the analysis results of the literature.

The mixed-method design of this study aims to obtain more comprehensive and objective user experience and cognitive data to evaluate and improve VR applications. Based on the results of the study, we found some problems with VR applications in terms of user interactivity, usability, cognitive level, usage experience, and satisfaction. Therefore, we improved and optimized the VR application to improve its interactivity and user experience.

**Design and development of VR applications.** This study designs VR applications based on the following principles: (1) user-centered, considering users' needs, interests, and backgrounds; (2) task-oriented, providing challenging and meaningful tasks; (3) context-supported, building realistic and rich contexts; (4) interaction-mediated, enhancing users' participation and immersion; and (5) multimedia-assisted, presenting diverse and enriched information. Based on these principles, this study developed a head-mounted display (HMD)-based immersive VR application using the Unreal Engine to enable users to experience and manipulate the process of building Dong wooden structures in a virtual environment and to provide relevant cultural and historical knowledge through multimedia. The VR application includes the following modules: (1) navigation module, which guides users to different scenes; (2) wind and rain bridge module, which allows users to participate in the process of building wind and rain bridges; (3) drum tower module, which allows users to participate in the process of building drum towers; (4) knowledge module, which provides knowledge about the building techniques, history, and culture of Dong wooden architecture; and (5) evaluation module, which tests users' understanding of the building techniques of Dong wooden architecture. (5) Assessment module, which tests the user's understanding of Dong timber construction techniques.

**Learning observation through VR program.** This study conducted program observation at a higher education institution in Nanning, Guangxi, with 10 students participating. Each student was randomly assigned to a group and used an HMD and a joystick to operate the VR application. Each group consisted of two students who could collaborate or compete to complete the task. Each group was

assigned to use the VR app for 30 minutes and fill out a questionnaire before and after use. The questionnaire consisted of the following sections: (1) basic information, which collected information about the user's age, gender, and education level; (2) usage experience, which used the SUS scale to assess the user's perception of the ease of use and satisfaction of the VR application; (3) learning effect, which used the Likert scale to assess the user's cognitive, emotional, and behavioral changes in the Dong wood construction techniques; and (4) learning effect, which used the Likert scale to assess the user's cognitive, emotional, and behavioral changes in the Dong wood construction techniques. (4) Learning behaviors, using a self-administered scale to assess users' exploratory and collaborative behaviors in the VR application. In addition to the questionnaire, this study also videotaped and observed users' use of the VR application to collect more qualitative data.

**A literature learning study.** This study was conducted as a literature learning study at a higher education institution in Nanning, Guangxi, with 10 students participating. Each student was randomly assigned to a group and used a computer browser to access a webpage containing knowledge about the techniques, history, and culture of Dong wooden building construction. Each group consisted of two students who could discuss or share the information on the webpage with each other. Each group was assigned to use the webpage for 30 minutes and to fill out a questionnaire before and after using it. The questionnaire consisted of the following sections: (1) basic information, which collected information on the age, gender, and education level of the users; (2) usage experience, which used the SUS scale to assess the users' feelings about the ease of use and satisfaction of the webpage; (3) learning effect, which used the Likert scale to assess the users' cognitive, affective, and behavioral changes in the Dong wood construction techniques; (4) learning motivation, which used the Likert scale to assess the users' cognitive, affective, and behavioral changes in the Dong wood construction techniques; and (5) learning experience. (4) in the learning motivation section, the ARCS model was used to assess users' attention, relevance, self-confidence, and satisfaction in the web pages. In addition to the questionnaire, this study also conducted screen recordings and interviews of users' use of the webpage to collect more qualitative data.

Describe your research findings according to the research problem and purpose of the study. Discuss your findings according to the perspective of theory, concept, or previous findings. Should describe this section in a comprehensive, simple, and detailed manner. The author can make subchapters in this section.

Data analysis and discussion. In this study, the data collected from program observations and literature research were statistically and content analyzed, and the results obtained from the two methods were compared and discussed. This study focuses on the following questions: (1) What are the similarities and differences between VR applications and web pages in improving users' awareness of Dong wooden building construction techniques? (2) What are the similarities and differences between VR applications and web pages in stimulating users' interest in the techniques of Dong wooden architecture? (3) What are the similarities and differences between VR applications and web pages in promoting users' exploratory and collaborative learning? (4) What are the similarities and differences between VR applications and web pages in terms of influencing users' motivation to learn? This study presents some conclusions and insights based on the results of the data analysis, and points out some limitations and shortcomings.

In this study, the data will be displayed by means of graphs and textual descriptions. For the questionnaire data, we will use tables and graphs to show the statistical results. For the content analysis of the interview data, we will use thematic word clouds and categorical summaries to display the analysis results. Also, we will cite images and videos from the experiment to present the user's experience in the virtual reality environment.

## **RESULTS AND DISCUSSION**

**Research Findings** The purpose of this study is to learn the techniques of building Dong wooden structures in San Jiang, Guangxi through a virtual reality (VR) application. To achieve this objective, we designed and developed a head-mounted display (HMD)-based immersive VR application that allows users to experience and manipulate the process of Dong timber-frame building construction in a virtual environment and provides relevant cultural and historical knowledge through a multimedia approach. We evaluated the VR application using

both procedural observational learning and literature research learning methods, collecting, and analyzing data in terms of user experience, learning effects, learning behaviors, and learning motivation, and comparing and discussing them with existing theories and practices.

Our study found that the VR application was able to significantly increase users' level of knowledge and interest in Dong wood construction techniques and facilitate their exploratory and collaborative learning. Specifically, our study found that:

**User experience:** Users rated the user experience of this VR application highly, including the psychological effects of the virtual environment such as realism, presence, and interaction, as well as the cultural and historical knowledge provided by the multimedia approach.

**Learning effect:** Users' knowledge and interest in the Dong wooden building construction techniques increased significantly after using the VR application. Specifically, after using the VR application, users gained a deeper understanding of the history, culture, and craftsmanship of Dong wooden building construction techniques, as well as a better understanding of the shape, structure, and decoration of Dong wooden buildings.

**Learning behaviors:** Users exhibited exploratory and collaborative learning behaviors while using the VR application. Specifically, users were able to freely explore and manipulate the process of creating Dong wooden architecture in the virtual environment, and collaborate and communicate with other users, thus facilitating the learning effect.

**Motivation:** Users showed high motivation to learn when using the VR application. Specifically, users showed interest and curiosity in the techniques of Dong wooden architecture construction, as well as interest and curiosity in virtual reality technology when using the VR application.

**Discussion** The results of this study suggest the potential value and significance of using VR technology to learn and preserve intangible cultural heritage. Specifically, the use of VR technology can improve the visibility and accessibility of intangible cultural heritage and promote interaction and innovation between intangible cultural heritage and contemporary society. Meanwhile, there are several

advantages of using VR technology to learn the Dong wooden building construction techniques:

First, VR can create a sense of realism, presence, and interaction, allowing users to experience and manipulate the process of building Dong timber structures in a virtual environment to better understand and master this skill.

Second, VR can provide cultural and historical knowledge in various media forms, such as text, pictures, audio, and video, so that users can comprehensively understand the cultural background and historical origins of Dong wooden architecture; and

Third, VR can facilitate exploratory and collaborative learning for users, allowing them to explore and interact freely in the virtual environment so that they can better utilize their creativity and imagination. Therefore, there is potential value and significance in using VR technology to learn and preserve intangible cultural heritage.

## CONCLUSION

The purpose of this paper is to explore the theme of learning the techniques of building Dong wooden structures in San Jiang, Guangxi through a virtual reality (VR) application. In this paper, a head-mounted display (HMD)-based immersive VR application is designed and developed to enable users to experience and manipulate the process of Dong timber-frame building construction in a virtual environment and to provide relevant cultural and historical knowledge through a multimedia approach. This paper evaluates the VR application using both program observation and literature research, collecting and analyzing data in terms of user experience, learning effects, learning behavior, and learning motivation, and comparing and discussing with existing theories and practices. The findings show that the VR application can significantly increase users' level of knowledge and interest in Dong wood construction techniques and facilitate their exploratory and collaborative learning. The paper concludes that the use of VR technology for learning and preserving intangible cultural heritage has potential value and significance and suggests some design recommendations and future research directions.

This paper concludes that VR technology can be effective in increasing users' level of knowledge and interest in Dong wood construction techniques,

and in facilitating their exploratory and collaborative learning. The VR application was evaluated through both program observation and literature research, and data were collected and analyzed in terms of user experience, learning effectiveness, learning behavior, and learning motivation, and compared and discussed with existing theory and practice. The findings show that the VR application can significantly increase users' level of knowledge and interest in Dong wood construction techniques and facilitate their exploratory and collaborative learning. This paper concludes that there is potential value and significance in using VR technology to learn and preserve intangible cultural heritage. In the future, the application of VR technology in the field of intangible cultural heritage preservation can be further studied, the combination of VR technology with other digital technologies can be explored, and more intelligent and personalized VR applications can be developed to meet the needs of different users.

## REFERENCES

- Bachvarov, A., Chotrov, D., Yordanov, Y., & Uzunova, Z. (2019). Conceptual model of the VR module for "Virtual plaza for interactive presentation of Bulgarian cultural heritage." 090008. <https://doi.org/10.1063/1.5133585>
- Bian Jichen. (2020). Brief Analysis on the Construction Techniques and Inheritance of Dong Wooden Architecture in Sanjiang, Guangxi. *China Writers and Artists*, 07, 46–47.
- Bozzelli, G., Raia, A., Ricciardi, S., De Nino, M., Barile, N., Perrella, M., Tramontano, M., Pagano, A., & Palombini, A. (2019). An integrated VR/AR framework for user-centric interactive experience of cultural heritage: The ArkaeVision project. *Digital Applications in Archaeology and Cultural Heritage*, 15, e00124. <https://doi.org/10.1016/j.daach.2019.e00124>
- Dai Junbo. (2015). Research on the Construction of Digital Exhibition Hall of Manchu Intangible Cultural Heritage Based on Virtual Reality Technology. *Journal of tonghua normal University*, 36 (01), 48–52. <https://doi.org/10.13877/j.cnki.cn22-1284.2015.01.009>.

- Deng, X., Kim, I. T., & Shen, C. (2021). Research on Convolutional Neural Network-Based Virtual Reality Platform Framework for the Intangible Cultural Heritage Conservation of China Hainan Li Nationality: Boat-Shaped House as an Example. *Mathematical Problems in Engineering*, 2021, 1–16. <https://doi.org/10.1155/2021/5538434>
- Fanani, A. Z., Hastuti, K., Syarif, A. M., & Harsanto, P. W. (2021). Challenges in Developing Virtual Reality, Augmented Reality and Mixed-Reality Applications: Case Studies on A 3D-Based Tangible Cultural Heritage Conservation. *International Journal of Advanced Computer Science and Applications*, 12(11). <https://doi.org/10.14569/IJACSA.2021.0121126>
- Gonizzi Barsanti, S., Caruso, G., Micoli, L. L., Covarrubias Rodriguez, M., & Guidi, G. (2015). 3D Visualization of Cultural Heritage Artefacts with Virtual Reality devices. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XL-5/W7, 165–172. <https://doi.org/10.5194/isprsarchives-XL-5-W7-165-2015>
- Guo Shanmin. (2021). Study on the Protection and Inheritance of the Wooden Architecture of Dong Nationality in Sanjiang from the Perspective of Intangible Cultural Heritage. *China National Expo*, 09, 57–59.
- Huang Yonglin, & Tan Guoxin. (2012). Research on Digital Protection and Development of China's Intangible Cultural Heritage. *Journal of Huazhong Normal University (Humanities and Social Sciences Edition)*, 51 (02), 49–55.
- Huang Yonglin. (2015). Protection and Utilization of Intangible Cultural Heritage under Digital Background. *Cultural Heritage*, 01, 1-10+157.
- Ji Yang. (2020). Research on the Application of Virtual Reality Technology in the Inheritance and Dissemination of Intangible Cultural Heritage [Master, University of Science and Technology Liaoning]. <https://doi.org/10.26923/d.cnki.gasgc.2020.000252>
- Li, L. (2020). Application of VR Technology in Intangible Cultural Heritage Protection. In C. Huang, Y.-W. Chan, & N. Yen (Eds.), *Data Processing Techniques and Applications for Cyber-Physical Systems (DPTA 2019)* (Vol. 1088, pp. 29–34). Springer Singapore. [https://doi.org/10.1007/978-981-15-1468-5\\_5](https://doi.org/10.1007/978-981-15-1468-5_5)
- Liu Mengying. (2022). On the Inheriting Characteristics of Dong's Architectural Skills from the Perspective of Master Mo. *Journal of Guangxi University for Nationalities (Philosophy and Social Sciences Edition)*, 44 (04), 137–144.
- Liu Tuo. (2012). Overall protection of traditional architectural techniques in China. *Scientific Research on Cultural Relics in China*, 4, 54–58.
- Luo Xinghua, Peng Guobin, & Zhao Qinheng. (2012). Thoughts on 3D Virtual Exhibition Design of Sanjiang Dong Ancient Architecture. *Hundreds of Artists*, S2 vo 28, 170-172.
- Ma, X., Tu, L., & Xu, Y. (2019). Development status of the digitization of intangible cultural heritages. *SCIENTIA SINICA Informationis*, 49(2), 121–142. <https://doi.org/10.1360/N112018-00201>
- Mortara, M., & Catalano, C. E. (2018). 3D VIRTUAL ENVIRONMENTS AS EFFECTIVE LEARNING CONTEXTS FOR CULTURAL HERITAGE. *Italian Journal of Educational Technology, IJET-ONLINE* FIRST. <https://doi.org/10.17471/2499-4324/1026>
- Okanovic, V., Ivkovic-Kihic, I., Boskovic, D., Mijatovic, B., Prazina, I., Skaljo, E., & Rizvic, S. (2022). Interaction in eXtended Reality Applications for Cultural Heritage. *Applied Sciences*, 12(3), Article 3. <https://doi.org/10.3390/app12031241>
- Peng Dongmei, Pan Lusheng, & Sun Shouqian. (2006). Digital protection-a new means of intangible cultural heritage protection. *Art Research*, 01, 47-51.

- Pieraccini, M., Guidi, G., & Atzeni, C. (2001). 3D digitizing of cultural heritage. *Journal of Cultural Heritage*, 2(1), 63–70. [https://doi.org/10.1016/S1296-2074\(01\)01108-6](https://doi.org/10.1016/S1296-2074(01)01108-6)
- Roumana, A., Georgopoulos, A., & Koutsoudis, A. (2022). DEVELOPING AN EDUCATIONAL CULTURAL HERITAGE 3D PUZZLE IN A VIRTUAL REALITY ENVIRONMENT. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLIII-B2-2022, 885–891. <https://doi.org/10.5194/isprs-archives-XLIII-B2-2022-885-2022>
- Theodoropoulos, A., & Antoniou, A. (2022). VR Games in Cultural Heritage: A Systematic Review of the Emerging Fields of Virtual Reality and Culture Games. *Applied Sciences*, 12(17), 8476. <https://doi.org/10.3390/app12178476>
- Wei Lili. (2022). Study on the environmental design and strategy of minority villages — Taking Bazhai Village in Chengyang, Sanjiang, Guangxi as an example. *Urban Architectural Space*, 29 (09), 223–225.
- Xu Ganli. (2015). Internal Logic of Spatial Production and National Culture — Taking Dong Village Settlement as an Example. *Journal of Guangxi University for Nationalities (Philosophy and Social Sciences Edition)*, 37 (04), 74–80.
- Yamy, & Zhao Xiaoning. (2012). A Summary of Research on Intangible Cultural Heritage and Tourism in China. *Chinese Culture Forum*, 3(03), 91-99.
- Yue Zhen, Liang Xianfei, Wei Shuyi,&Shi Nini. (2022a). Research on the Dilemma and Countermeasures of the Protection and Inheritance of the Intangible Cultural Heritage in Sanjiang, Guangxi — Taking the wooden building construction skills of the Dong people as an example. *Urban Architectural Space*, 29(03), 139-142+146.
- Yue Zhen, Liang Xianfei, Wei Shuyi,&Shi Nini. (2022b). Research on the Dilemma and Countermeasures of the Protection and Inheritance of the Intangible Cultural Heritage in Sanjiang, Guangxi — A Case Study of the Wooden Building Construction Techniques of the Dong Nationality. *Urban Architectural Space*, 29(03), 139-142+146.
- Zhang Xiaofei. (2019). Research on the application of virtual reality technology in the protection of Tibetan intangible cultural heritage. *Sichuan Drama*, 04, 40-44.
- Zhou Wei. (2017). Countermeasures for the Protection and Inheritance of "Dong Wooden Building Construction Skills" Based on BIM Technology. *Popular Science and Technology*, 19 (04), 15–18.