Design and Implementation of Virtual Museum Learning Environment from the Perspective of Multimedia Learning Theory

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2021 International Symposium on Educational Technology (ISET) | 978-1-6654-2859-0/21/$31.00 ©2021 IEEE | DOI: 10.1109/ISET52350.2021.00063

***Abstract*—With the advancement of technology, virtual museums have attracted much attention as a new learning resource type. Under the guidance of multimedia learning theory, this study designed and implemented a virtual Tujia instrumental museum (Vtujia) based on seven multimedia design principles—coherence, signaling, redundancy, spatial contiguity, temporal contiguity, multimedia, and personalization principle. A sample of 56 students was participated in our study to experience the Vtujia. Their attitudes on the learning tool were collected. The results indicated that the students hold a positive attitude towards the virtual museum and believed that the virtual museum could effectively promote meaningful learning.**

Keywords—multimedia learning, cognitive theory, multimedia design principles, virtual museum

I. INTRODUCTION

With the rapid development of information technology, the learning environment and learning style saw significant changes in recent years. Their effects on instruction have also attracted the attention of many scholars. As a new type of informal learning environment, museum learning can promote the dissemination of scientific knowledge and promote the development of lifelong learning. Its rich and diverse resources, flexible and various learning methods, free choice, and self-oriented learning environment have become a hot topic in the field of education[1]. Virtual reality technology (VR) is a human-computer interface technology that highly realistically simulates human beings' behaviors in the natural environment, such as seeing, hearing, and moving[2]. Simulation of the museum by VR can expand the form of museum exhibitions, enrich the content of cultural relics, enhance museum exhibitions' interest, and provide people with comprehensive sensory stimulation. It is an essential direction for the development of a museum learning environment [3].

Tujia instruments have peculiar national characteristics and charm, and they are treasures of the Chinese nation. However, due to environmental factors such as the Tujia nationality's scattered settlements, cultural exchange activities are challenging to carry out, making the development and inheritance of Tujia instrumental music culture stagnant. Virtual museums undoubtedly provided great opportunities for museum visiting. It is of great significance for the heritage and protection of Tujia instrumental music culture. However, making real learning happen in the virtual museum environment, rather than just at the entertainment level, is still an issue that rare researchers focused on.

Multimedia learning theory guides how to design multimedia information that can promote meaningful learning. Based on the idea of multimedia learning and seven design principles for multimedia teaching, this study created and developed a virtual Tujia instrument museum (Vtujia). Through experiment, preliminary exploration of the application effect of the virtual venue.

II. LITERATURE REVIEW

A. Museum Learning Environment

Museum learning originated from a reform in the United States to improve learning effectiveness in science and technology museums. Science Learning in Informal Environments: People, Places, and Pursuit, published by the National Academic Press of the United States, emphasizes that all kinds of informal environments are essential places for science learning and classifies typical informal learning environments into three categories: daily living environment, design environment, and project environment. The daily life environment refers to the knowledge acquired through social communication in daily social life or family, but this kind of knowledge is relatively scattered. Design environment refers to purposeful, organized, and consciously designed public educational places, such as museums, science, technology museums, art museums, etc. Project environment refers to the learning activities with project form characteristics, which often occur in a group, such as a club, etc. Among them, the museum learning environment, especially in the science and technology museums, has been paid more and more attention because of its rich and diverse learning resources. They have become a typical application of informal learning environments [4]. During traditional physical museum visits, learners may fail to understand the exhibits deeply because of the abundance of exhibits and time limitations leading to information overload. This constraint may restrict the effects of learning on learners' cognition[5]. Research on technology-

978-1-6654-2859-0/21/$31.00 ©2021 IEEE
DOI 10.1109/ISET52350.2021.00063

assisted museum learning focuses on developing a learner-centered method and applying technology to help learners explore and learn in a museum[6].

Therefore, this research refers to the learner-centered multimedia design principles to design and implement a virtual museum(Vtujia) that promotes learners' understanding of exhibits information.

B. Multimedia Learning Theory

Multimedia learning refers to learning from words and pictures. A practical goal of research on multimedia learning is to devise design principles for multimedia presentations. There are two approaches to multimedia design - a technology-centered approach and a learner-centered approach. Technology-centered approaches start from the practical function of multimedia. Learner-centered approaches begin with an understanding of how the human mind works and asks[7,8]. As science educators claim, the museum's learning can be characterized as learner-centered, self-regulated, and actively involved peers in social interactions. Therefore, the design of Vtujia should adopt the learner-centered approach.

The learner-centered approach focuses on the learning style of human cognitive processing[7]. According to the cognitive theory of multimedia learning (CTML), to achieve meaningful learning, there must be five cognitive processing processes (as shown in Figure 1): (1) choosing related words to process in verbal working memory, (2) select relevant images and process them in visual working memory, (3) organize the selected words into a mental model of speech, (4) organize the chosen images into a visual mental model, (5) integrate verbal and visual representations with prior knowledge.

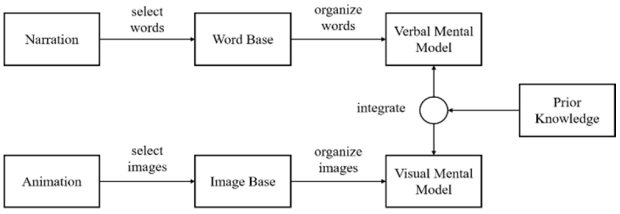

Fig. 1. The cognitive theoretical model of multimedia learning [7]

Based on CTML, Mayer derived and tested instructional design principles for promoting multimedia learning. There are three categories and 12 principles: (1) five principles for reducing extraneous processing – coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles; (2) three principles for managing essential processing – segmenting pre-training, and modality principles; (3) four principles for fostering generative processing – multimedia, personalization, voice, and image principles[9].

This study mainly refers to the seven principles of reducing extraneous processing(coherence, signaling, redundancy, spatial contiguity, and temporal contiguity principles) and the two principles of fostering generative processing(multimedia and personalization principles).

III. The Design Strategy of Virtual Tujia Instrument Museum from the Perspective of Multimedia Learning Theory

The design of the Vtujia refers to seven multimedia design principles, which were: (1) coherence principle, (2) signaling principle, (3) redundancy principle, (4) spatial contiguity principle, (5) temporal contiguity principle, (6) multimedia principle, (7) personalization principle. Table I shows the details.

IV. The Implementation of Virtual Tujia Instrumental Museum

The system architecture of the Vtujia is shown in Figure 2. It mainly includes two modules: instrumental music knowledge navigation and exhibition hall navigation. The instrumental music knowledge module mainly introduces Tujia folk culture; the system contains three exhibition halls, and each exhibition hall provides users with panoramic roaming and exhibition hall introduction. In this regard, visitors can be familiar with the exhibition hall with Tujia folk customs. Besides, Vtujia can deliver cultural knowledge of instruments through graphic hotspots, model hotspots, audio, and video hotspots.

A. Development Tool

The development tool is the Unity3D engine, which supports the cross-platform import of 3D models, related resources (e.g., images, video, and audio) in multiple formats. Photoshop, 3DMax, Premiere, and other software are used as auxiliary to support the construction of resources.

B. Implementation Process

The implementation of the Vtujia requires the collection and arrangement of materials, three-dimensional modeling of the museum and instrumental models, image processing, audio recording and embedding, video processing and embedding, roaming control, optimization, and packaging and publishing. First, materials were collected through the internet, books, physical museums, and other channels. Then, we discussed with experts and teachers to determine the content of the exhibitions, the route of the exhibits, and the exhibits' placement. Next, 3Dmax is used to construct the model and import the model into Unity. According to the multimedia design principles mentioned above, UGUI is used to layout the words, pictures, audio, and video information of Unity's instruments, as shown in Figure 3. Vtujia is divided into wind string hall, instrument hall, and percussion hall according to the types of instruments, as shown in Figure 4. Three exhibition halls introduce different kinds of exhibits. Users can click on the graphic hotspots to learn about the instruments' basic shapes and performance techniques. Click on the video and audio hotspots to enjoy the performance of the instruments. The 3D model can be rotated 360 degrees to view the instruments in detail through the model hotspots. (as shown in Table I). Visitors can control the keyboard and mouse, W, S, A, D or up, down, left, right buttons to control movement, and the right mouse button to control direction.

In the virtual museum, users can systematically understand Tujia instruments' knowledge, which is conducive to the inheritance and development of Tujia culture. What's more, visitors are free to arrange their visit time without temporal limitations. The exhibits' presentation follows the principle of multimedia design to reduce the external cognitive load as much as possible and bring visitors an extraordinary experience.

TABLE I. VTUJIA DESIGN UNDER THE GUIDANCE OF MULTIMEDIA DESIGN PRINCIPLES

<table>
<tr><th colspan="4">Design principles and concrete implementation</th></tr>
<tr><td rowspan="5">Principles for reducing extraneous processing</td><td colspan="3">Coherence principle: People learn better when extraneous material is excluded rather than included.</td></tr>
<tr><td colspan="3">Signaling principle: People learn better when cues that highlight the organization of the essential material are added.</td></tr>
<tr><td colspan="3">Redundancy principle: People learn better from graphics and narration than from graphics, narration, and printed text.</td></tr>
<tr><td colspan="3">Spatial contiguity principle: Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.</td></tr>
<tr><td colspan="3">Temporal contiguity principle: Students learn better when corresponding words and pictures are presented simultaneously rather than successively.</td></tr>
<tr><td rowspan="2">Concrete implementation</td><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Navigation prompts are given to reduce the external cognitive processing.</td><td>Click the button to display the text, pictures, video, and audio information of the exhibits, present relevant information as required to reduce redundancy.</td><td>Only necessary information is presented in the video.</td></tr>
<tr><td rowspan="2">Principles for fostering generative processing</td><td colspan="3">Multimedia principle: People learn better from words and pictures than from words alone.</td></tr>
<tr><td colspan="3">Personalization principle: People learn better from multimedia presentations when words are conversational rather than formal.</td></tr>
<tr><td rowspan="2">Concrete implementation</td><td colspan="2"> 
</td><td> 
</td></tr>
<tr><td colspan="2">Exhibit information is presented in the form of pictures, text, video, and audio, and both pictures and text are presented at the same time.</td><td>Describe the exhibits in conversation-style words.</td></tr>
</table>

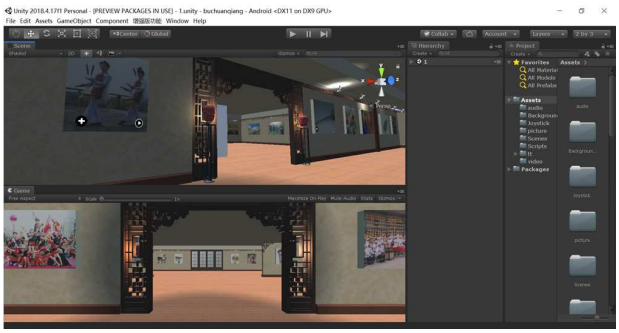

Fig. 2. The system architecture of the virtual Tujia instrument museum

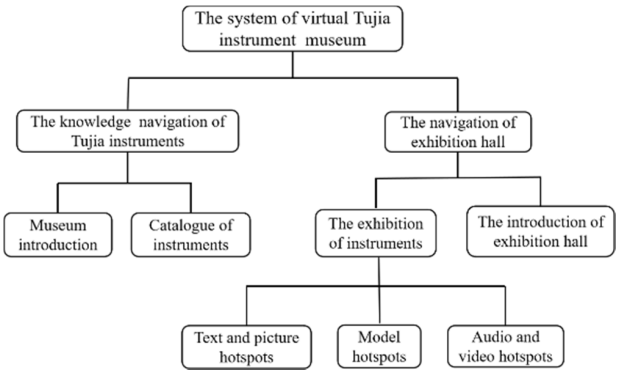

Fig. 3. Using Unity to build the virtual Tujia instrument museum

Fig. 4. Three Exhibition Halls

V. EXPERIMENTAL DESIGN

In order to understand the use-value of the Vtujia, after the completion of the development of the Vtujia, the experiment was carried out to understand people's attitudes towards it.

A. Participants

Fifty-six volunteer college students (21 males and 35 females) aged 20-22 participated in the experiment. They were asked to experience the Vtujia and fill in the questionnaire.

B. Experimental Process

Before learning, participants will be organized to be familiar with the virtual museum's basic operating methods. Then, participants learned the exhibition contents and introductions in the Vtujia. After the learning is completed, each participant needs to fill in a questionnaire concerning the acceptance of the Vtujia to investigate the participant's experience of using the Vtujia. The experimental process is shown in Fig 5.

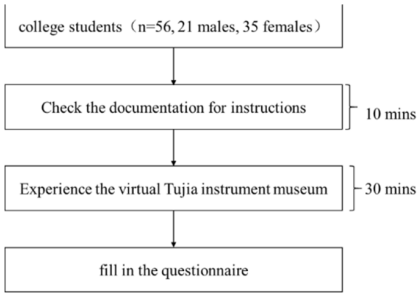

Fig. 5. Experimental process

C. Measurement Tool

The measurement tool of this study mainly investigated the students' acceptance of the Vtujia, including four dimensions: perceived usefulness (PU) (four items), perceived ease of use(PE)(four items), attitude toward using(AU)(four items), continuance intention to use(CU)(three items). PU aims to measure a person's feelings that the system has improved performance, and PE refers to the degree to which the person believes in using the system easily. These two dimensions refer to the TAM scale developed by Davis [10]. AU refers to the subjectively positive or negative feelings experienced by users when using the system, and CU measures students' continuous willingness to use the Vtujia. AU and CU refer to the TAM scale developed by Moon [11]. A 5-point Likert rating scheme was exploited in the questionnaire here, where 1 and 5 expresses strongly disagree and strongly agree, respectively. The Cronbach's alpha values for PU, PE, AU, CU were .835, .867, .896, respectively, indicating acceptable reliability of the scale.

D. Assessment Results

The results are shown in Table Ⅰ. The participants' CU is the largest value from the table, and the difference is the smallest, which reflects the participants are willing to use the Vtujia for learning. The AU results suggest that it is a good idea for people to use Vtujia for learning. Participants' feedback on the PU of Vtujia is low. There may be two reasons for this result. The first reason may be some participants have not been in contact with the virtual museum before. They are not entirely clear about this type of virtual museum's role, and most people have experienced physical museums. The second reason may be that participants may not have an excellent experience with Vtujia. To this end, the resource design and content of the Vtujia need to be improved. Participants' feedback on the PE of Vtujia is quite different. Some participants may not be familiar with operating in a virtual learning environment, which affects their learning experience and result. The average values of the four dimensions are all greater than 4.0, which tends to the option of agreement, indicating that participants have a positive attitude towards the use of Vtujia.

TABLE II. STATISTICAL RESULTS

Dimension	N	Max	Min	Mean	SD
PU	56	5	3	4.110	0.390
PE	56	5	3	4.196	0.446
AU	56	5	3	4.183	0.406
CU	56	5	3	4.232	0.359

VI. CONCLUSION AND FUTURE WORK

Under the guidance of multimedia learning theory, this study has designed and implemented a virtual museum of Tujia instruments that integrates pictures, words, audio, video, and other multimedia expressions. Vtujia provides an intuitive, omnidirectional, and multi-perspective visit mode. The museum can be applied to the Tujia intangible cultural heritage website, combined with physical museums, or as an additional learning tool for Tujia instrumental music in the classroom. It promotes the protection and inheritance of Tujia's instrumental music culture. Experimental results showed that experimenters agree with the virtual museum's usefulness and are willing to use it. In the following research, the application strategy of the virtual museum will be studied in depth. For example, we can design specific and detailed teaching activities combined with STEAM teaching concepts to give full play to the virtual venue's teaching function. Contribute to technological innovation teaching.

ACKNOWLEDGMENT

This work was supported by Fundamental Research Funds for Central Universities of China (NO.2020YBZZ037), Ministry of Culture and Tourism of China (No.20201194075), Wuhan Science and Technology Plan (No.2020010601012190), and Graduate Teaching Reform Research Project of Central China Normal University(No. 2019JG25).

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