Design and Research on the Virtual Simulation Teaching Platform of Shanghai Jade Carving Techniques Based on Unity 3D Technology

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Abstract. As one of the four major schools of Chinese jade carving, Shanghai style jade carving is a manifestation of Shanghai's unique regional culture and Shanghai style cultural spirit. And it has extremely high cultural and commercial value. However, in the teaching process of jade carving, there are problems such as high teaching cost, lack of teachers, and limited time and place. In order to solve these problems, we have designed a virtual teaching platform that combines Shanghai style jade carving skills with virtual simulation technology. We used Rhino and 3ds Max to model in a virtual environment. Based on Unity 3D development engine, we used C# scripting language to realize the human-computer interaction function of the system, and completed the design of teaching cognition, training of carving techniques, selection of carving tools, and teaching assessment. In addition, the research elaborates on the technical route, system framework and implementation process of the virtual teaching system in detail. Fifteen students of jade carving skills tested this system and verified the reliability and effectiveness of the system from their interviews. The system utilizes the immersive, interactive and imaginative functions of virtual technology. Therefore, it can effectively reduce the cost of jade carving training and improve learning efficiency, so that jade carving learners can't be limited by space, time, and materials. Moreover, it plays an important role in promoting the application of virtual reality technology in education and training.

Keywords: Unity 3D · Shanghai style jade sculpture · Virtual simulation · Intangible cultural heritage · Human-computer interaction

1 Introduction

As one of the most important traditional handicrafts in Shanghai, Shanghai style jade carving is a manifestation of unique regional culture and spirit. It possesses high cultural and business value, and therefore, it is of great significance to spare efforts to inherit jade carving [1]. However, due to long period of learning and complicated carving procedures, currently it is inevitable that some beginners do irreversible damage to raw materials in the practice of jade carving when they have not completely mastered the skills. This

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results in unnecessary replacement of raw materials, not only consuming the practice time, but causing excessive loss of supplies.

At present, the teaching mode of Shanghai style jade carving is also very simple. Most of them are based on the traditional ways of "master leads apprentice, father leads child" or inheritance in studio. These modes would take a long time and have low efficiency, which has made Shanghai style jade carving encounter a bottleneck in development and inheritance. However, there is no denying that it is well recognized by the market. After realizing the huge talent gap in the jade carving industry, some companies and individuals actively meet market demand and establish vocational training schools in industrial areas, such as Shanghai Jade Carver Training Class. In addition, some local universities like Shanghai Art & Design Academy also focus on the cultivation and inheritance of jade carving skills. All of these provide market opportunities for the virtual simulation teaching system of Shanghai style jade carving [2].

Aiming at a series of practical problems in the inheritance and development of Shanghai style jade carving, this thesis designed and actualized a virtual simulation system based on the status quo of actual teaching mode. The immersive experience allows jade carving beginners to efficiently master the procedures without the restriction of space, time and material and thereby increasing the popularity of craft, pushing the sustainability of the talent training, and also serving as a reference for other intangible cultural teaching methods in China.

2 The Design of the Virtual Simulation Teaching System for the Craft of Shanghai Style Jade Carving

2.1 Shanghai Style Jade Carving Craft and Features

Shanghai style jade carving is an artistic style mainly based on Shanghai style but also developed from the characteristics of Suzhou, Yangzhou and court style, which can be described as "All rivers run into sea". Shanghai style jade carving is known for "fineness". Apart from fine carving, it also has vigorous and supple lines, and clear structures. Meanwhile, it is featured by the exquisiteness of furnace or bottle vessels and the vividness of characters or animals. Natural shape and color of jade can be well utilized. Now it has ranked in the four major jade carving art styles in China.

2.2 Functional Requirements Analysis of the Virtual Experience System

(1) The situations of material damage, collapse, and breakage that jade carving learners may face during the process are simulated, which boosts the users' learning efficiency and prevents the waste of materials.
(2) The technologies of VR, human-computer interaction application, etc. are used to break through the limitation of time and space, and enhance the authenticity and experience feeling in the jade carving practical training. The teaching procedures such as demonstration, prompting, and identification of jade carving are added to attract interest.

(3) The virtual simulation system is divided into three modules: teaching, training, and assessment. It allows experiencers to master the procedures, skills and precautions of identification, painting, carving, and grinding. During the assessment, the system automatically scores them, bringing the beginners an overall feeling of their own capability.
(4) In accordance with the characteristics of Shanghai style jade carving craft, the training of detailed model carving is added, so that the trainees can perceive its unique charm and features.
(5) There is a visualized data management center in the system maintenance module. The management platform can monitor the real-time dynamic data of the users' operation in the virtual environment. All data during the operation can be visualized in three dimensions. Users can view all of them by VR helmet.

2.3 Technology Roadmap of System Design

Field surveys were conducted to obtain the physical mapping drawings or design drawings of jade carving tools and jade materials. Rhino and 3DMax software were used for modeling and exporting the model in FBX format, and then importing the Unity3D engine to build a 3D virtual jade carving environment. Based on the know-how of operation tools, materials, techniques, etc., relevant expanded knowledge such as jade material identification was added to the system. Use Unity 3D to build scenes, integrate model resources, and use C# scripting language to realize human-computer interaction, including physical grabbing, rotation, zooming and other functions, to improve user experience, and finally release and test the program. The system development flow chart is shown in Fig. 1.

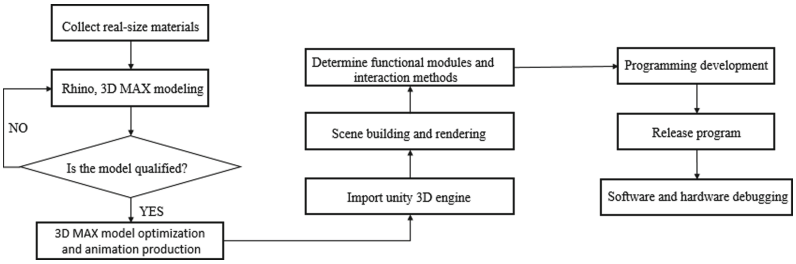

Fig. 1. The system development flowchart

2.4 System Frame Diagram

The system takes the production scene of Shanghai style jade carving as a prototype and uses Unity 3D technology to restore the carving production process. Four major modules are divided: system setting module, learning and cognition module, simulation training module and virtual assessment module. The core module is the simulation training, and

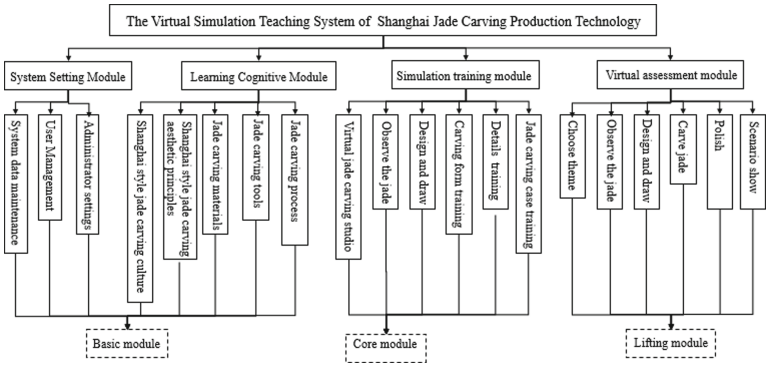

Fig. 2. The system framework

the promotion module is the virtual assessment. The system module controls user login and data maintenance, etc. The system framework is shown in Fig. 2.

Learning and Cognition Module

In learning and cognition module, the trainees aim to learn the process and tools of jade carving craft, etc. The learning modules include Shanghai style jade carving culture and aesthetic principles, jade carving materials, jade carving tools, etc., among which, tools are the most complex one. It includes mechanical tools, grinding head tools, grinding tools, polishing tools, etc. Trainees can refer to the graphics and texts of the interface to learn the selection and use of tools, the steps, evaluation criteria and key points of jade material identification. The learning module of Shanghai style jade carving culture and aesthetic principles is mainly pictures and texts, supplemented by case analysis. The jade carving production process is automatically played in the form of 3D animation.

Simulation Training Module

This module is a practical training course that simulates the actual jade carving production process, and the trainees aim to practice that process. According to the sequence of jade carving, this module is divided into jade identification training, drawing and sketching training, carving form training and case creation training. Virtual training can be carried out conveniently, and the system will provide tips on the operation steps in practical manipulation. In the case creation training, users can adjust the difficulty level on UI controller menu through VR handle to experience the complete process of jade carving works from identification, drafting, rough carving, fine carving to polishing. During this period, the system will give prompt to trainees for wrong operations. As Shanghai style jade carving keeps high demand for the carving of detailed models, a variety of fine techniques such as “hook”, “push up” and “press” are added to the training module to clarify the details of the jade.

Virtual Assessment Module

In this module, trainees can make self-assessment of their learning process within a specified time. The system will no longer give any prompt about steps, so it is all relied

on personal operation. Starting from material identification, trainees need to comprehensively sort the ten given jade materials by texture, gloss, and fineness. The system sets the ten jade materials with a grade difference, which is convenient for further grading. In the engraving stage, trainees choose the carving tools, parts and forms on their own, and the system will score based on their operations. In the virtual assessment, errors are allowed for each step but not allowed to exceed five times totally, otherwise the jade material will collapse and the trainee will fail the assessment. After the assessment, the system automatically demonstrates the results and operation reports, which can be viewed through the function menu "Score". For those who fail the assessment, the system automatically enters the repeated learning mode.

2.5 System Core Functions and Key Techniques

Scene Roaming of Virtual Jade Carving Studio

In order to enhance the on-site experience of jade carving craft, this system actualizes the scene roaming. It is mainly aimed at the virtual jade carving studio in the training module. The construction of the scene will improve the learning interest of the trainee and make the trainee interact with the scene and devices in the system in the first person. It is also controlled by the VR handle.

The virtual jade carving studio is divided into areas, including "working area", "tool area", "works show area", etc. Users can roam through each area on demand. This is shown in Fig. 3. Take "working area" as an example, after users enter the virtual studio and choose this area, they can enter the next virtual scene for carving techniques training. The buildings, props and other models are all created by 3DMAX and Rhino. During the process, the atmosphere of the jade carving studio is restored as much as possible, so that the trainee can get more authentic experience.

Fig. 3. Virtual jade carving studio system interface design rendering

The Display and Selection Module of Jade Carving Tools

Different tools can be selected through the UI controller menu in the display and selection module of jade carving tools. The first-level menu divides the tools into "mechanical tools", "grinding tools", "grinding head tools", "polishing tools", and " Other tools". The second-level menu includes "ball", "point needle", "hook mound" and other practical

tools. In the tool display and selection area, VR handle is available to grasp, view, rotate, and zoom the tools, so as to further observe the three-dimensional tools in all directions. In order to enable every beginner to learn jade carving tools as soon as possible, the system provides a text introduction of the corresponding tool at the same time as each tool is displayed, including "brief introduction", "features", "main functions", "instruction", etc. The users can select different text introduction information through the VR handle to deepen the user's understanding of jade carving tools. In addition, after the user learns the tool, the system can conduct a small test on the user, and let the user choose the tool through voice questions. After the error is selected, the system will jump to the pop-up window to prompt the error, so as to consolidate the user's familiarity of the tool. The interface is shown in Fig. 4.

Fig. 4. Jade carving tool interface design rendering

Carving Technique Training Module

The carving technique training is set in the training mode of the system, which is divided into three-dimensional carving, semicircular carving, relief carving, openwork carving, hollow carving, line carving and other forms. The trainee can choose the "working area" in the "virtual jade carving studio" and choose different carving techniques with the equipped VR handle. As shown in Fig. 5 (a).

After choosing a technique, the trainee needs to select the needle in the "Jade Carving Tool Storage Box" according to the prompts, and then complete the installation of the needle and the operating handle. The system interface will prompt information such as the characteristics of the tool. As shown in Fig. 5 (b). After the installation is the training of carving techniques. To make the virtual environment closer to reality, the trainee can wear a VR helmet and then control and select the position point with the VR handle and optical orientation device. The system will give simple vibrate feedback according to different carving techniques. At the same time, the interface will display the application key points of different carving forms in practical operation. This training is designed to lead users to experience the procedures of different carving techniques. Since the system will prompt for operation, it is necessary to highlight the parts on the virtual simulation model. The details are shown in Fig. 5 (c). In the training mode, if the trainee operates improperly, the system will prompt an error with a pop-up dialog box for further corrections, as shown in Fig. 5 (d).

The detail carving training is designed for one feature of Shanghai style jade carving, namely "high quality in fineness". The trainee can observe the details through the "microscope" and adjust the parameters of size in unity3d software to achieve zooming. A variety of fine techniques such as "hook", "push up" and "press" can be learned to clarify the details of the jade. As shown in Fig. 5 (e). Through the training about detailed modeling, such as subtle patterns, hair of the characters, bird feather and dragon scale, etc., the trainee can understand the craft and characteristics of Shanghai style jade carving. As shown in Fig. 5 (f).

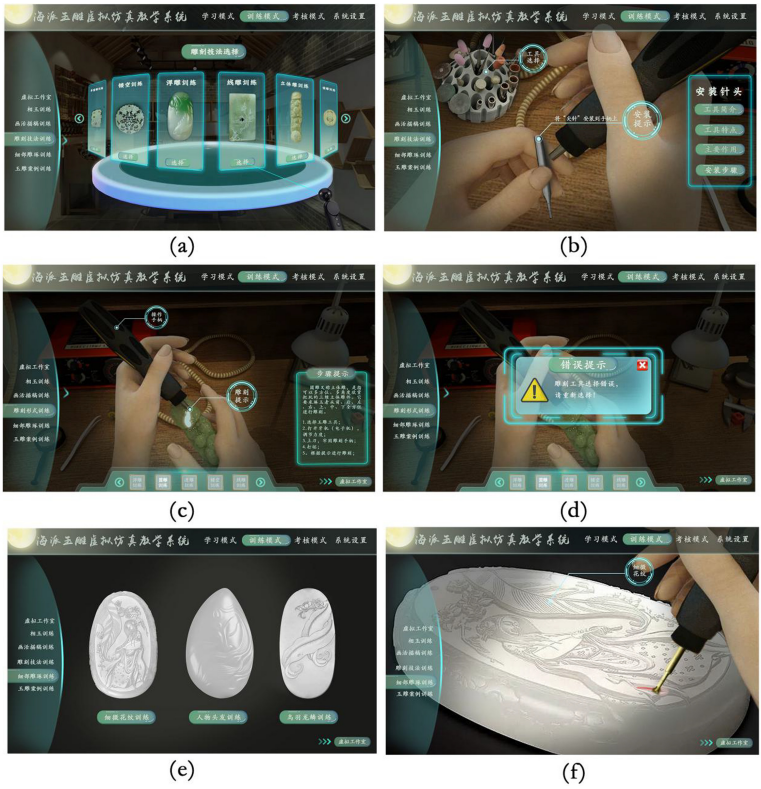

Fig. 5. Jade carving technique training system interface design renderings

3 System Evaluation

To evaluate the performance of the virtual jade carving teaching system, 15 students majoring in jade carving were invited for the system evaluation experiment. This experiment adopted the method of system experience test experiment combined with a Likert scale questionnaire. Before the experiment, it is necessary to explain the general process and requirements of the virtual teaching system to the participants. In the experiment,

participants need to wear VR helmets, use VR handles for experience, grasping and observation, and perform according to the voice prompts. After the experiment, they need to fill in a questionnaire based on the 5-point Likert scale to evaluate the system performance.

During the experiment, though a few participants encountered some problems, the majority of participants successfully completed the entire process of virtual jade carving skill teaching, as shown in the Fig. 6 (Table 1).

Fig. 6. The experimental diagram of the virtual teaching experience

Table 1. Questionnaires and evaluation results of the experience of the Shanghai jade carving virtual teaching system

Purpose	Dimension	Number	Question	Score
Learning motivation	D1 attention	Q1	I think this way of learning jade carving skills is very interesting;	4.64
	D2 concentration	Q2	I can immerse myself in the experiment of the virtual jade carving teaching system and complete the experiment with full concentration;	4.36
	D3 confidence	Q3	I feel relaxed and confident in the virtual jade carving teaching system experiment;	4.36
System user experience	D4 System authenticity	Q4	I think this jade carving simulation experiment basically restores the scene of a jade carving studio or classroom. Through this experiment, you can understand the equipment, tools and operation steps required for jade carving;	4.14

(*continued*)

Table 1. (*continued*)

Purpose	Dimension	Number	Question	Score
	D5 System operability	Q5	I can easily grasp the system's UI interface, VR equipment and other operation methods, and I have not affected my learning because I can't operate it	4.36
System teaching effect	D6 Systematic learning modules	Q6	I can get a preliminary understanding of jade carving skills through the animation display and text description in the learning module;	4.29
	D7 Understanding of operating steps	Q7	The system operation steps are clear, and the error prompts are clear. I can complete the corresponding jade carving steps according to the system's prompts;	4.29
	D8 Explore after system operation	Q8	I have a certain grasp of the process and steps of jade carving, as well as the selected tools and jade texture;	3.86
		Q9	This system can help beginners have a preliminary understanding of the process and steps of jade carving skills;	4.43
		Q10	The system can help learners of jade carving to strengthen the process and steps of jade carving skills;	4.21
		Q11	I hope this system can be adopted by school teaching;	4.43
System feedback	D9 System feedback	Q12	What do you think are the shortcomings of the teaching system? What can be improved?	

The survey results show that the majority of students agree with the statements listed in the questionnaire. A small number of students believe that individual problems need to be further optimized. In addition, the students gave feedback on the deficiencies of this teaching system. The results are summarized in Table 2. The students put forward suggestions for improvement mainly from the software interface, interaction method and fluency, etc., which also provide a direction for the later iteration of the system.

Table 2. System feedback form

Main aspects	Problems
UI interface	Font design size and display slope issues
	The size of the prompt box
	Cumbersome switching between interfaces
Fluency	Lower resolution
	Slow response of operating equipment
Interaction method	Voice prompt interaction is not timely
	Insufficient guided interaction
	Grabbing and observing objects do not conform to human-machine

Main aspects Actual problems UI interface font design size and displayed slope The size of the prompt box Cumbersome switching between interfaces Fluency, lower resolution Slow response of operating equipment Fluency Voice prompt interaction is not timely Can add guided interaction Grabbing and observing objects do not conform to human-machine.

4 Conclusion

The virtual simulation teaching system of Shanghai style jade carving establishes virtual studios and tools, working platforms, jade, and other models by 3Dmax and Rhino. Then Unity 3D is adopted to develop the interactive functions in the system to achieve the following goals. 1. For amateurs and beginners in the field of jade carving, they can achieve an overall recognition of Shanghai style jade carving culture and production process; 2. In the tool learning module, they can learn about the characteristics, main functions and usages of different jade carving tools; 3. In the training of jade carving forms, they can master the skills and steps of different forms, as well as how to select tools; 4. In the training of jade material identification, they can distinguish the high or low quality of jade carving materials through standards like different gloss and transparency. This teaching system effectively improves the problems of time, space, consumables and teachers in the teaching application. It not only enhances the learning efficiency of jade carving beginners, but also provides reference for the teaching and inheritance of other traditional Chinese crafts.

References

1. Shen, Y., Fu, R.: Exploration of the training model of Shanghai-style jade carving talents. Enterp. Res. (04), 119–121+124 (2012)
2. Li, X.: The status quo, problems and countermeasures of Nanyang jade carving talent training. Nandu Xuetan **37**(01), 123–124 (2017)
3. Sun, J.: The historical development and intangible cultural heritage protection of Haipai jade carvings. Jilin University (2015)

4. Han, S.: Research on the style of Shanghai style jade carving. Anhui University of Finance and Economics (2014)
5. Li, B., Zhang, X., Wei, T., Huang, J., Wei, Y., Sun, Y.: Research on abdominal surgery simulation system based on virtual reality. Med. Health Equip. **41**(08), 19–24+44 (2020)
6. Sun, Y., Zhao, H., Sun, D.: Design of MTS virtual simulation experiment system based on Unity3D. Lab. Res. Explor. **39**(07), 98–100 (2020)
7. Zeng, Y.: Interaction design and implementation of Chu guqin based on Unity 3D. Wuhan Textile University (2020)
8. Zhao, R.: Design and implementation of game function module based on unity. Shandong University (2020)
9. Hu, F., et al.: The virtual simulation system of medicinal botany training based on Unity3D. Comput. Syst. Appl. **29**(01), 266–270 (2020)
10. Shi, H.: Development and design of ceramic VR display game based on Unity3D. Nanchang University (2019)
11. Liang, S.: The design and realization of the situational virtual experience system of the terracotta warriors and horses firing process. Tianjin University (2018)
12. Zhu, X.: The design and implementation of the coloring experience system of painted Qin figurines based on virtual reality technology. Tianjin University (2018)
13. Sun, Y., Yang, Q., Wang, X., Li, L., Chang, C.: Design and development of virtual simulation experiment system for rolling principle. Exp. Technol. Manag. **37**(08), 133–136 (2020)
14. Xiao, Z., Yuan, C., Jiao, H.: The virtual simulation system of Xinjiang Kazakh embroidery skills based on Unity3D. Mod. Electron. Technol. **42**(10), 179–181+186 (2019)
15. Xie, M.: Virtual museum roaming and virtual reality technology research based on Unity3D. Shanxi Normal University (2019)
16. Xu, X., Cheng, M., Shi, Y., Chen, L.: Design and implementation of virtual simulation based on Unity 3D mud movable type printing. J. Beijing Inst. Graph. Commun. **25**(02), 35–38 (2017)
17. Wang, D., Jiang, Y.: Ancient architecture three-dimensional virtual modeling and virtual-real interaction software realization. Comput. Appl. **37**(S2), 186–189 (2017)