Balancing authenticity and creativity: a VR system design for assisting ceramic creation

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Abstract
Culture-based product designers are facing the challenge of balancing authenticity and creativity: designers need to maintain tradition in materials, craftsmanship and cultural factors, while product design values innovation in form, function and user experience, which requires both indigenous knowledge and creative design methods. This paper describes our attempt to develop a VR system to help culture-based product designers learn indigenous knowledge and translate it into ceramic creation. The system includes a ceramic repository module, a design case library module, and a rapid prototyping module. The effectiveness of the VR system was assessed through a design workshop where eight participants were randomly divided into two groups, one working with the VR system and the other working with paper-based approach. Experts scored their design work by assessing authenticity through appearance, craftsmanship and culture, and creativity through aesthetics, technology and uses. Results showed that the VR group had a better general performance, specifically in terms of culture, and were more open to creative experimentation in terms of technology and uses.

Author keywords
Virtual reality; Culture-based product design; VR Ceramic creation; Culture heritage

Introduction
Cultural-based creative products support handcrafted, intangible cultural heritage tourism by attracting tourist interest and promoting the development of the tourism economy (Liyan, Xuanqi, Hesen, Yue, & Jian, 2019; Partarakis, Zabulis, Antona, & Stephanidis, 2020). To do so, designers must extract local design elements while avoiding deviation or stagnation to balance authenticity and creativity in the design process (Qiu, 2020; Wu, Zhang, & Xu, 2018), which means they need to maintain tradition in materials, craftsmanship and cultural factors, while product design values innovation in form, function and user experience. This requires a thorough understanding of both indigenous knowledge and creative design (Suib, Van Engelen, & Crul, 2020).

To meet this challenge, some studies have explored new ways of learning indigenous knowledge. Ch'Ng et al. (2020) investigated the process and method of using VR technology for cultural heritage learning and identified the positive significance of using VR technology for experiential learning. Zhang, Wan, Huang and Cao (2022) used VR technology to design a reading system for ancient Chinese books to help readers overcome cultural and language barriers through VR scenes. Some studies also explored new ways of creative design. Unfold design studio and Knapen (2010) create a ceramic design system working with AR named "l'artisan electrique" for users, even without ceramic creation knowledge, to create, influence or hack tools that further their design practice. Guan, Wang, Chen, Jin and Hwang (2021) created a VR-based pottery making system and found it enhanced student's creativity and learning engagement. Chen, Chang and Chuang (2021) used VR application for engineering design and found VR had marked effects on the novelty and usefulness aspects of creative performance on engineering design creativity. Yang et al. (2018) experimented with using VR drawing for design and explored the effects of VR on an individual's creativity and revealed VR's ability to boost creativity by maintaining stable focus or attention.

This research shows how we use VR technology to enhance cultural-based product design by immersing designers in a digital environment to learn about indigenous knowledge and creative design examples, using the example of Changsha Kiln ceramic creation in Changsha, China. The research aims to understand the potential of VR technology to support culture-based product design processes and revitalize intangible cultural heritage.

Design of the VR ceramic creation assistance system
The VR ceramic creation assistance system is designed based on the traditional ceramic creation skills of Changsha kiln in Changsha, China, which is a colored ceramic creation technique. The Changsha kiln ceramics were one of the main commodities traded along the maritime Silk Road during the Tang Dynasty. The system is developed using the Unreal Engine and is accessible through the Meta Quest2 , a VR headset, aims to provide an immersive and interactive experience in designing creative ceramic products from the Changsha kiln.

We reconstructed a virtual design studio scene in VR to provide a sense of familiarity, safety and privacy and eliminate negative experiences in VR environment, which contains three main modules (Figure 1.): a) *ceramic repository module*, which includes indigenous ceramic knowledge presented as scenes of appearance, techniques and cultures to clarify domain and relationship between each other to help designers use knowledge purposefully in the design process, (b) *case library module*, which contains design cases organized with narrative theory to enhance users' personal experience of the design process, and (c) *rapid prototyping module*, which is a modelling function in VR environment that makes it easier to review and modify design proposals. Users will be entrusted as a designer to help the Changsha kiln elf (a virtual character designed to guide the user) to finish its design by learning indigenous knowledge and creative design cases in ceramic repository module and design case library module, and further develop their own design attempts through the rapid prototype module.

Figure 1. Virtual design studio scene.

Ceramic repository module

The ceramic repository module includes a *virtual pattern scene* full of patterns from Changsha Kiln and *virtual roaming scenes* showing indigenous ceramic knowledge (Figure 2).

In the virtual pattern scene, each pattern contains knowledge related to Changsha Kiln. By clicking on a pattern, users can view the knowledge description it refers to in the form of text and pictures in the information panel. We organized and divided it into three layers for explanation to make the content of different knowledge more organized: (1) *appearance*, which includes the form properties of Changsha Kiln artifacts, such as material, decorative patterns, and shapes; (2) *craftsmanship*, which includes the techniques and production methods used in the ceramic creation of Changsha Kiln, such as underglaze painting, applique (applique involves adding low-relief clay forms to slurred, scored leather-hard surfaces for embellishment); (3) *culture*, which includes the local culture activities related to ceramic production in the Changsha Kiln, such as the custom of offering sacrifices to the kiln god and burning pagoda made with porcelain chip. We visualized the relationship between the knowledge it represents through the visual effects of the pattern, such as color coding for different layers and lighting effects that hint the connection between knowledge.

Virtual roaming scenes contains our reconstructed virtual environment of historical context related to the knowledge of Changsha Kiln. By clicking on a pattern in the virtual pattern scene with a shortcut key, users can explore and experience the scenarios it reflects and access more detailed information including indigenous cultural elements involved in Changsha Kiln-based design cases (one part of the design case library module). For example, users can observe how people build a pagoda out of porcelain chips, the way they scatter grains for good luck and the scene of people gathering around the pagoda to pray. Such immersive experience would help users gain an intuitive understanding of the knowledge related to Changsha Kiln.

Design case library module

The design case library module consists of four sets of case combinations. Each set contains existing cases and a Changsha Kiln-based design case. The existing cases include culture-based creative product design cases on the Internet, which are reviewed, classified and summarized by experts and presented in the form of text and pictures. They are used as design case references for users, and can be viewed at any time through the information panel (Figure 3).

The Changsha Kiln-based design cases were created by project team members according to inspiration from existing cases using the cultural elements of Changsha Kiln. They come with text explanations and interactive 3D models, but cannot be viewed at first. They are set in the story as the design that the Changsha Kiln elf wants to complete, which requires the user to follow the avatar's led to view existing design cases and to think and find out the indigenous cultural elements needed for product design in Ceramic repository module to unlock them. The indigenous cultural elements are hidden in specific virtual roaming scenes. In order to find it, users need to analyze existing cases and think from three layers (appearance, craftsmanship, culture, as indigenous cultural elements used to unlock the Changsha Kiln-based design case is set according to this structure), and actively explore in the Ceramic repository module. Each time a particular element is found, the user is prompted through the information panel. which makes the user clearly understand the selection of the Changsha kiln elements.

Figure 3. The existing cases (left), the Changsha Kiln-based design cases (middle), the user experience of ceramic repository module and design case library module (right).

Rapid prototyping module

The rapid prototyping module is a VR modeling system that allows users to quickly iterate and test their design prototypes. The system includes basic clay modeling, some basic shapes, and a variety of pre-designed components. Designers can shape ceramic products through clay modeling by mov-

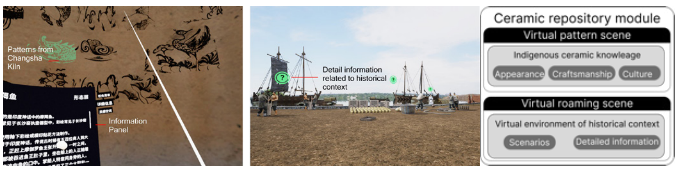


Figure 2. Virtual pattern scene and information panel (left), Virtual roaming scene (middle), and the structure of ceramic repository module (right).

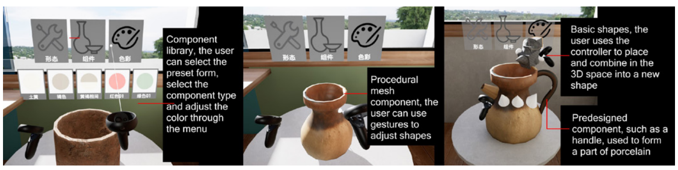


Figure 4. Rapid prototyping module.

ing the handle controller, and select the basic shapes and pre-designed components in the corresponding interface, and use the controller to place them in 3d space (Figure 4). Through the combination of shapes in space, the user can test their ideas about design.

Experimental design

We performed a one-day rapid design workshop to evaluate the feasibility and effectiveness of the VR ceramic creation assistance system. By analyzing design results, we were able to identify the effectiveness of the system in learning indigenous knowledge and promoting creative design.

Participant

The study recruited eight participants with similar design backgrounds, six with no prior knowledge of Changsha Kiln and two with basic ceramic creation experience. They were all students in cultural and creative design and were randomly divided into two groups (each group has one participant with basic ceramic creation experience): a control group that work with paper materials and an experimental group that work with the VR system (Figure 5).

Figure 5. Control group (left), and experimental group(right).

Experimental procedure

Both groups were asked to design creative ceramic products for tourists, based on the culture and techniques of Changsha Kiln. The designs were organized in a standardized format, including the name, function, and physicality (shape, color, and material) of the work, and presented in the participant's preferred method (sketching, modeling or physical prototype). The designs were then evaluated by three experts using an adapted scoring scale, to qualitatively and quantitatively assess the authenticity and creativity of the designs. The scale includes three terms used for authenticity and three terms used for creativity (Table 1.), adapted from the study of the authenticity of tourism crafts (Revilla & Dodd, 2003) and the research of creativity (Cropley & Cropley, 2008). Following the design activity, participants were invited to semi-structured interviews to gain insight into their creative process and to clarify experience with the VR system.

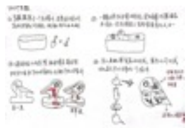
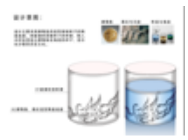
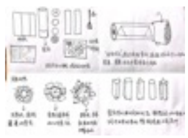
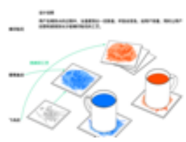
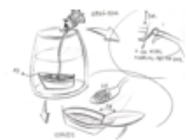
Result and discussion

The expert scores of the design outcomes (Table 1.) show that compared with the control group, the experiment group showed different preferences for product authenticity, the authenticity of the control group products was more reflected in the appearance and craftsmanship, while the experimental group focused more on the culture aspect of the product, especially the extraction of local ceramic customs and stories. The experimental group also had significantly better performance in creativity and were more willing to try new things in terms of technology and uses.

Table 1. Rating scale and scores (Full score of 5).

Dimensions	Factors	Interpretation	Control group	Experimental group
Authenticity	Appearance	Refers to the appearance of a product, such as shape, color.	3.5	3.5
	Craftsmanship	Refers to the crafts, materials used to create the product.	4.0	3.5
	Culture	Refers to the elements that reflect the local culture	2.25	3.75
Final score of authenticity		The mean of the three factors of authenticity.	3.25	3.58
Creativity	Aesthetics	Refers to the aesthetic effects on other people	3.25	4.0
	Technology	Refers to the technology used and how it is used	2.75	3.5
	Uses	Refers to the usage scenario and method of the product.	2.5	4.0
Final score of authenticity		The mean of the three factors of creativity.	2.83	3.83

Table 2. Design outcomes and explanations.

	Control group	Interpretation
1		This is a nail organizer for playing the lute, made with traditional Changsha kiln skills.
2		The refrigerator sticker made of Changsha Kiln skills and image.
3		The building blocks made of Changsha Kiln skills can be built freely to restore the shape and pattern of Changsha kiln products.
4		Changsha Kiln Capricorn fish image cup, trying to show the Capricorn fish in the water.
5		This is a kaleidoscope, can be customized Changsha kiln patterns, users can see the Changsha kiln patterns constantly changing.
6		The design of the coaster using heat transfer technology can present the brown spot pattern of Changsha kiln according to the temperature.
7		The pagoda shaped wind chime, which is composed of tiles from Changsha Kiln, which users can choose and place freely.
8		Changsha Kiln Capricorn fish image of tea bag, restore the legend of the Capricorn fish trying to swallow ships/

The VR scene enhanced the presentation of cultural activities, resulting in the experimental group paying more attention to culture aspect in authenticity than the control group. VR simulates highly detailed realistic environments through 3d perspective, which makes it easier to understand knowledge that is difficult to be transmitted in the form of pictures in paper documents (Yang et al., 2018), especially highly comprehensive knowledge such as cultural activities. For example, there is a local custom of using ceramic shards to build pagodas and burning them to pray for good luck. In VR environment, the construction method of pagoda is obvious, while it would have been confusingly complex in paper documents. It explains why the experimental group designed relevant schemes (Table 2, design No.7) while the control group ignored the extraction of such local customs.

Besides, learning in VR is more enjoyable and attractive to participants, which they concluded as "learning by roaming in an immersive environment". Compared with fragmented documents full of appearance and craftsmanship knowledge, exploring cultural activities in the VR environment is more impressive and contributes to the user's sense of discovery (Obeid & Demirkan, 2020), which made the control group more willing to do their design based on culture aspects of Changsha Kiln. In contrast, paper documents were regarded as materials to be used in the creative process by participants in the control group, which explained why the control group paid more attention to the extraction of appearance and craftsmanship.

The mechanism of unlocking design cases through exploration enhances participants' motivation and provides an opportunity for self-reflection and design critiques, which leads to a better creative performance. Participants in experimental group reported they tended to perceive surpassing existing design solutions as a challenge. In the process of gradually unlocking the design cases, they continue to criticize and reflect on the design cases, which promotes the construction of knowledge related to authenticity and the generation of new ideas. Strong motivation and self-reflection developed through design critiques was beneficial for enhancing creativity (Demirbas & Demirkan, 2007; Obeid & Demirkan, 2020).

The realistic restoration of space in VR environments enhances users' ability to understand space, and the introduction of rapid prototyping modules aids in the generation of more creative solutions (Pandey, Luthra, Yammiyavar, & Anita, 2015). Participants were able to test their solutions in 3D space more efficiently and were encouraged to try different structures, these extra bold attempts often gave birth to new ideas (Zhang, Wan, Huang, & Cao, 2022). For example, both groups used images of Capricorn fish for their designs (Table 2, design No.3 and No.7). The experimental group initially had similar ideas to the control group, but after many attempts through the VR system, he combined the legend of the Capricorn fish swallowing ships to design an interactive tea bag, rather than just extracting the image of Capricorn fish. The virtual pattern scene also directly stimulated one participant in the experimental group to design Changsha Kiln pattern themed kaleidoscopes (Table 2, design No.5). "The way you show patterns in the VR system reminds me of kaleidoscopes, that's why I made this design." As he claims.

Conclusion

This research explores the potential of VR technology in balancing authenticity and creativity in cultural-based product design process by enabling designers to immerse themselves in a digital environment to learn about indigenous knowledge and creative design cases. We developed a VR ceramic creation assistance system based on Changsha Kiln and conducted experiments to see how VR technology can help design ceramic creative product based on intangible heritage.

The results showed that the 3D perspective provided by VR enhanced the presentation of cultural activities, and the way of " learning by roaming in an immersive environment " changed designers' attitude towards indigenous ceramic knowledge, treating it as personal experience rather than material to be used in design process. Mechanisms that unlock design cases through exploration also promote original ideas by providing stronger motivation and opportunities for self-reflection and design critiques.

There are still some limitations to this study. The rapid prototyping module is too simple to enable more detailed visual effects, and better VR modeling methods have the opportunity to lead to stronger creativity. While our system is designed for a single user, the future should yield richer results through multi-user exploration and communication in VR environments. Incorporating an AI-based dialogue system is also a good way to generate more creative design.

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