

THE INTERACTIVE EXPERIENCE OF FILIGREE INLAY EXHIBITIONS THROUGH DIGITAL REALITY TECHNOLOGY



A Thesis Submitted in Partial Fulfillment of the Requirements for Master of Fine Arts Program in Design Silpakorn University Academic Year 2024 Copyright of Silpakorn University

The Interactive Experience of Filigree Inlay Exhibitions through Digital Reality Technology



วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรศิลปมหาบัณฑิต สาขาวิชาการออกแบบ แผน ก แบบ ก2 มหาวิทยาลัยศิลปากร ปีการศึกษา 2567 ลิขสิทธิ์ของมหาวิทยาลัยศิลปากร



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Title	The Interactive Experience of Filigree Inlay Exhibitions through
	Digital Reality Technology
By	Miss Ruiying LI
Field of Study	Program in Design
Advisor	Assistant Professor Dr. Gomesh Karnchanapayap

Faculty of Decorative Arts, Silpakorn University in Partial Fulfillment of the Requirements for the Master of Fine Arts

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	Dean of Faculty of
(Associate Professor Arwin Intrungsi)	Decorative Arts
Approved by	Chair person
(Assistant Professor Dr. Atithep Chaetnalao)	
	Advisor
(Assistant Professor Dr. Gomesh Karnchanapayap)	I)
	External Examiner
(Associate Professor Dr. Kriangsak Khiaomang)	
<i>่าวิท</i> ยาลัยศิลป	

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Miss Ruiying LI : The Interactive Experience of Filigree Inlay Exhibitions through Digital Reality Technology Thesis advisor : Assistant Professor Dr. Gomesh Karnchanapayap

As an important intangible cultural heritage of China, the inheritance and dissemination of the craft of filigree inlay is of great significance. The exhibition of the filigree inlay is still presented by displaying cultural relics and illustrations, while the experiential and interactive exhibitions are now more in line with people's needs. However, due to the challenge of the crafting process of filigree inlay, it is impossible to experience in a usual scene. This study explored the use of digital reality technology to deliver the experience of the craft process in filigree inlay exhibitions. The virtual information of digital reality technology was aimed to be used as a key component of this study. Firstly, the importance of filigree inlay's cultural and craft elements was studied. Secondly, to explore the use of digital reality technology for the interactive and experiential exhibition of filigree inlay. Lastly, to design, develop, and evaluate the application of digital reality technology to improve the dissemination of knowledge about the craft of filigree inlay. The study was analyzed and researched through a comprehensive research methodology of literature review, questionnaire survey, expert interviews, and fieldwork. The research results are: 1. This study summarized the technical and aesthetic content of filigree inlay and the craft steps suitable for digital experience. 2. It found AR and MR technologies suitable for filigree inlay interactive exhibitions and virtual content using learning strategies. 3. It designed and developed AR and MR experience exhibitions program and compared and tested them with traditional exhibition. The test showed that the audience's knowledge of filigree inlay craft process improved by 46%. The study discussion that AR and MR digital experience exhibitions can effectively help the audience understand the craft of filigree inlay.

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Ruiying LI

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CHAPTER 1

INTRODUCTION

Filigree inlay is a highly significant form of cultural heritage in Chinese craftsmanship, but currently have a problem. In 2008, Chinese filigree inlay was included in the second batch of national intangible cultural heritage list and the first batch of national intangible cultural heritage list announced by the State Council "Notice on the Expansion of the List of Items" (Ren et al., 2020). It represents the highest craftsmanship of Chinese gold and silver. However, there is currently an issue in its dissemination.

The inheritance of intangible cultural heritage is mainly the inheritance of handicrafts. At present, with the development of industrial technology, many filigree inlay works are batch machine production. So, the filigree inlay studio hosts over 50 gold and silver filigree exhibitions annually across China to promote this craft. Despite the numerous exhibitions, the dissemination methods still primarily focus on displaying objects rather than showcasing the craftsmanship.

The current effective way of exhibition pays more attention to the audience's experience, and the traditional experience is different (Chaumier & Chare, 2020). However, the filigree inlay technic is difficult, and requires the use of high-risk high-temperature tools for operation. It is challenging to provide audiences with hands-on experiences at the exhibition site.

Digital reality technologies expanding possibilities that are unattainable in physical spaces and enabling safer experiential modes. Enable effective interaction between audiences and exhibitions through immersive, interactive experiences(Suh & Prophet, 2018). Through case study analysis, which in turn lead to a positive learning experience (Pallud, 2017). Satisfied visitors can share the experience with other users, thus increasing the museum's visibility and "social" rating (Izzo, 2017).

The use of digital reality technologies offers the possibility of providing interactive exhibition experiences for the craftsmanship aspect of filigree inlay.(Rizvic et al., 2019) Researchers believe this can help audiences gain a deeper understanding of the artisanal techniques involved in filigree inlay.

1.1 Research Problems

The traditional object-based exhibition methods of filigree inlay no longer attract the attention of younger audiences. Exhibitions that convey knowledge through text and images fail to engage the interest of visitors (Chaumier & Chare, 2020). This study combined the theoretical framework and methodology of multidisciplinary integration of culture, science and technology, cognitive strategy, and aesthetic design to proposed innovative and concreted solutions and applications for digital reality technology to upgrade the craft experience of the filigree inlay exhibition.

1.2 Research Objectives

1. To study the important cultural and craft elements of filigree inlay were studied.

2. To explore the how to use digital reality technology to realize the interactive and experiential exhibition of filigree inlay, which can effectively realize the cognition and dissemination.

3. To design, develop and evaluate of an interactive and experiential exhibition application of digital reality technology aimed at improving the dissemination of knowledge about the craft of filigree inlay.

1.3 Research Hypothesis

1. Digital reality technology can make the audience have a deeper understanding of the knowledge of filigree inlay handicraft through interactive experience.

2. Digital reality technology can stimulate the audience's interest in the dissemination of filigree inlay.

1.4 Research Scope

This study focuses on the research of Chinese filigree inlay craftsmanship. The scope of artifact research is limited to items housed in national and provincial-level museums. All research in the digital domain is based on literature from 2018 to the present.

This study draws certain boundaries to clarify what it does not cover. First, it excludes the study of filigree inlay techniques from countries other than Chinese filigree artifacts as well as contemporary Chinese filigree inlay works. Second, the environments involved in the exhibition as well as the display space and other elements of the non-digital reality technological experience are outside the jurisdiction of this study. By describing these exclusions, the study maintains a clear focus on its well-defined objectives and ensures consistency in its methodology and findings.

1.5 Research Significance

This study has multiple significance. Firstly, this study refines and summarizes the cultural elements of filigree inlay, which provides important material value and inspiration for design and dissemination; secondly, it provides digital innovation ideas and concepts for the inheritance and display of craft-type cultures, and upgrades the dissemination mechanism of intangible cultures, which is more in line with the experiential needs of today's audience. Finally, through the overall innovation of culture, the combination of culture and today's humanistic life, the experience products of the filigree inlay exhibition are more in line with the young audience's favorite, more willing to spread and participate. This study gives a certain enhancement to the intangible culture to improve the audience's awareness, interest and dissemination.

1.6 Conceptual Framework

The core concepts of this study are the digital reality technology exhibition of AR and MR applications and the filigree inlay. Figure 1 illustrates the direct relationship between the two contents, and the combined part is the innovative part of this study. The aim is to complete the experience and learn about the content of the filigree inlay process through the study of digital technology exhibitions.



Note. Illustrated by the researchers.

1.7 Definitions

Filigree Inlay: Filigree inlay is one of the special crafts in China, in which gold, silver and copper are drawn into filigree, and various techniques are used to make various kinds of jewelry, artifacts and other decorations. In 2008, filigree inlay was included in the second batch of national intangible cultural heritage list and the first batch of national intangible cultural heritage list announced by the State Council. Filigree inlay is one of the "eight masterpieces of Yanjing", with a long history and exquisite craftsmanship. It represents the highest craftsmanship of Chinese gold and silver.

Interactive experience exhibition: The interactive experience exhibition represents the third stage in the evolution of museum exhibitions, placing significant emphasis on the visitor experience. If visitors are unable to engage with the exhibition design, the exhibition loses its intended significance. This category encompasses various types of interactive exhibitions, including those utilizing digital reality technology, multi-sensory experiences, and emotional engagement. Such exhibitions offer substantial benefits, including the enhancement of visitor interest, an increase in learning experiences, and the improvement of knowledge dissemination.



1.8 Structure of The Thesis

The structure of the thesis is outlined as follows.

Chapter 1 Introduction

This chapter provides a comprehensive overview of the present and problems of filigree inlay, describing the scope of the study and the research. The research questions, objectives and hypotheses guiding the study are stated.

Chapter 2: Literature Review

This chapter provides an in-depth examination of existing literature and related research, focusing on the culture and craft of filigree inlay, and experiential and interactive exhibitions. The key role and experiential characteristics of digital reality technology in exhibitions are examined in depth. In addition, the chapter reviews the principles of innovation regarding human cognitive strategies and cultural content design. Important references are provided for the dissemination of knowledge and enhancement of interest in digital reality technology in filigree inlay exhibition experiences

Chapter 3 Research Methodology

This chapter clarifies the methodology employed in the study, emphasizing the utilization of mixed research methods. The chapter provides a detailed explanation of the research process, including the selection of methods, tools and analytical approaches used in the study.

Chapter 4 Design Process and Research Results

This chapter describes the entire research process, from the initial prototype design to the improved and finalized design. The entire design process was designed with the research objectives in mind.

Chapter 5 Research Conclusion

This chapter summarizes the results of the study as well as the limitations of the study, along with an analysis of future research and innovations.

CHAPTER 2

LITERATURE REVIEW

This chapter explores an in-depth study of the culture of filigree inlay, covering historical development, crafting processes, and aesthetic characteristics. The focus of the study lies in accurately distilling cultural content and identifying suitable interactive experience elements. This chapter also delves into learning strategies, interactive exhibition experiences, and digital reality technologies, establishing a conceptual framework for the research.

2.1 Filigree Inlay

The filigree inlay craft possesses unique technical and aesthetic characteristics. The research was conducted through an examination of the basic introduction, historical development, aesthetic process analysis, and difficulties to pass on the filigree inlay.

2.1.1 History

Filigree inlay is one of the "Eight Masterpieces of Yanjing", with a long history and exquisite craftsmanship. Filigree inlay originated during the Han Dynasty and reached its peak during the Ming and Qing Dynasties. The filigree inlay craft can be traced back to the Han Dynasty, and it can be seen from the decorative boxes and other artifacts unearthed from the ancient tomb complexes in Zhaojiagou Village, Hui Autonomous County, that the filigree inlay craft has already shown its beginnings. After the Ming Dynasty, with the continuous migration of Persians, the ancient Arab culture and traditional filigree technology has been organically combined.

Filigree inlay began to decline in the late Qing Dynasty, with the craft being passed down through family lines. Due to years of war, social unrest, corrupt bureaucrats, each workshop gold, silver, jade and stone substrate, finished products were looted, have closed, mastering the whole work of the craftsmen far away from his hometown, filigree inlay craft from now on into a single family, father and son inheritance.

Once the filigree inlay craft transformed into family inheritance, it can be traced back to the establishment of a family workshop by Ma Zuo, Li Xirui, and Li Xifa in 1956 in Wangzhihuaitun Village, Dachang Hui Autonomous County. In response to natural disasters causing widespread starvation from 1957 to 1960, they recruited local villagers as workers to improve their income. After institutional reforms in 1998, the workshop became a private enterprise under Ma Fuliang, Ma Composition's third son, and was renamed DaChang Huizu Autonomous County Liangshengda Filigree Inlaid Specialty Art Co. in 2008 to further benefit the community.Figure 2 and Figure 3 show the Liangshengda Filigree Inlaid Specialty Art Co. exhibition hall.

Figure 2

Liangshengda Filigree Inlaid Specialty Art Co. Exhibition Hall



Note.Photographed by the researchers **Figure 3**

Photograph of the Researcher and the Inheritor Ma Weisheng



Note. Photographed by the researchers.

2.1.2 Craft Elements Analysis

The cultural content of filigree inlay craft covers a wide range, which can be divided into two plates: knowledge and craft. The knowledge includes the historical development of filigree inlay, symbolism, etc. The craft includes the process, filigree type, filigree filling pattern, color, material, pattern, etc. When analyzing traditional culture, we can't just analyze it from the perspective of painting aesthetics, but should also integrate the spiritual culture, in order to better interpret the artistic value of traditional culture, as well as to realize the meaning conveyed in visual communication design (Yixuan, 2018). Therefore, this study analyzed the type of filigree inlay works in the collection of the National Palace Museum, combined with the content of the literature, to divide the filigree inlay from the understanding of aesthetics and the understanding of auspicious symbolism in a more refined way, to provide more interesting content topics for the experience of the exhibition.

2.2.2.1 Craft Processes of Filigree Inlay

Process flow according to the information provided by Mr. Ma Weisheng, in the actual production of filigree inlay through 14 processes, as shown in the Figure 4.



Figure 4

The Detailed Production Process of Filigree Inlay



Note. The production process is provided by the filigree inlay workshop master Mr. Ma Weisheng. (2024) Illustrated by the researcher.

The process of making filigree inlay has 14 steps detailed as follows:

1.Design

First, design the blueprint.

2. Chemical material

Purchase the raw materials used to make the finished product, such as gold bricks and silver bricks, and then high-temperature melting, melting into a liquid state, the temperature of the gold bricks at about 1,600 degrees Celsius, the silver bricks at about 1,000 degrees Celsius, to remove the impurities, and purification. The process is shown in Figure 5.

Figure 5

Melt Gold or Silver into a Liquid State



Note. Image taken form Hunan TV's Intangible Cultural Heritage Program "Hundred Hearts, Hundred Craftsmen."(2018)

3. Plate and bar making

Gold and silver bricks in liquid form are poured into prepared molds for natural cooling. The plate molds are then processed using a pressure plate machine to achieve the desired thickness for tire production. For strip production, the strip molds utilize a strip-making machine, applying precise pressure step by step. Finally, wire is drawn through a silk plate and wire eye to achieve the required fineness, with the finest wires comparable to a hairline. The process is shown in Figure 6.

Figure 6

Pressing Gold or Silver into Sheets as Thin as Washi Paper



Note. Image taken form Hunan TV's Intangible Cultural Heritage Program "Hundred Hearts, Hundred Craftsmen."(2018)

4. Making the base sheet

Using previously pressed plates, the main core structure are made traditional techniques such as rushing, hammering and welding. The process is shown in Figure 7.

Figure 7

The Process of Creating the Core Structure



Note. Image taken form Hunan TV's Intangible Cultural Heritage Program "Hundred Hearts, Hundred Craftsmen."(2018)

5. Engraving

The traditional hand-engraving technique utilizes a metal burin to burn patterns onto a carcass. The burin, typically homemade from tool or spring steel, is tempered, shaped into a date-pit form (about 10 cm long), and then ground, quenched, and polished for optimal performance. Various burin types include hook, straight, double-line, and others, with additional specialized burins crafted as needed.(Dongfang, 1999(4)) The workpiece is secured on a rubber plate made from rosin, white powder, and vegetable oil, which is softened by heat to facilitate adhesion of metal workpieces like copper and silver. Engraving begins after cooling, and pieces can be detached by reheating. The process is shown in Figure 8.

Figure 8



The Metal Wire is Progressively Drawn Thinner Through a Drawing Plate

Note. Image taken form Hunan TV's Intangible Cultural Heritage Program "Hundred Hearts, Hundred Craftsmen."(2018)
6. Filigree

Following the drawings, the required pattern is pinched and bonded to the base sheet, completing the assembly prior to welding. After welding, cleaning is conducted before applying blue points. To create filigree, single wire is shaped using tools such as a rubbing board, rubbing wood, tweezers, and a brake. The rolling process involves placing multiple round filaments on the rolling board and using rolling wood to combine them into a single filament, with the direction of rolling determined by the filigree type. After rolling, the filigree is pinched, requiring precision to avoid errors known as "carving." Lines must be smooth, and careful positioning with moderate force is essential to prevent uneven arcs and transitions. The process is shown in Figure 9.

Figure 9





Note. Image taken form Hunan TV's Intangible Cultural Heritage Program "Hundred Hearts, Hundred Craftsmen."(2018)

7. Filling

Filling involves adding silk to the outline of the crafted filigree, following pinching the silk into the desired pattern as per the drawings. Using tweezers, the outer outline is filled, ensuring the silk is evenly arranged with a smooth surface and consistent density. Common fillers include Kung silk, filler roll heads, and petal fillers. Kung silk creates a continuous pattern, serving as a base or edge for ornaments. The filling process, termed "filling in the head of the scroll," requires shaping the silk with pointed tweezers and trimming it to length. Petal filling spirals the silk to form petals, incorporating patterns like cloud brocade and ancient money brocade. The process is shown in Figure 10.

Figure 10

The Process of Filling the Pattern of Filigree



Note. Photographed by the Chinese National Geographic website. (www. dili360.com).

8. Saving

Saving work refers to the assembly process in filigree, which includes flat saving, stacking saving, and parts saving. Flat saving involves connecting filigree patterns on a single plane, while stacking saving layers the same or different patterns together. Parts saving entails connecting individual components. During this process, all necessary parts for a piece are prepared and assembled according to the design specifications and drawings.

9. Welding

Welding in filigree inlay is a complex skill distinct from conventional mechanical welding, requiring precise adjustments based on the artisan's expertise in solder types, ratios, and techniques. Fluxes are classified as yellow and red, with yellow flux used for the carcass and red flux, which has superior fluidity, preferred for filigree. For high-gold-content pieces, artisans typically use a solder ratio of 97% gold to 3% other materials. The solder quantity must be carefully measured, and welding points are determined by structural conditions. Controlling heat during welding is crucial to prevent wire cracking and ensure optimal solder flow. The process is shown in Figure 11.

Figure 11





Note. Photographed by the Chinese National Geographic website. (www. dili360.com)

10. Stacking

The stacking of filigree involves a two-step process to create non-planar forms, such as gourd-shaped bottles and curved models. Flat base silk consists of layered filigree patterns for a three-dimensional effect, while three-dimensional filigree may use solid forms or charcoal ash patterns for welding.

11. Weaving

Weaving in filigree, like traditional grass and bamboo techniques, employs various silk strands made from metals such as gold, silver, and copper. The weaving process begins with selecting the appropriate silk—round plain, round flower, or flat—based on design specifications. As shown in the Figure 12. Common patterns include pigtails, crosses, screws, mat patterns, and bubbles, typically woven with three, four, or six non-flattened strands. A notable example of this craft is the well-preserved winged crown of the Wanli Emperor. The process is shown in Figure 13.

Figure 12

The Process of Weaving Filigree



Note. Photographed by the Chinese National Geographic website. (www. dili360.com)

Figure 13

Winged Crown of the Wanli Emperor



Note. Photographed by The Ming Tombs website (<u>https://www.mingshisanling.com</u>)

12. Glazing

According to the drawings, various colors are dotted into the filigree on the carcass and then burnished blue, a process that takes six to ten or even a dozen times.

13. Polishing and Sanding

Using a cloth wheel, buff and polish the inner measurement of the carcass to add brightness for the final finish.

14. Inlay

Metal pieces are made into brackets and claw-type grooves, and then inlaid with pearls and gemstones. The process is shown in Figure 14.

Figure 14 *The Process of Gemstone Setting*



Note. Photographed by the Chinese National Geographic website. (www. dili360.com)



The conventional processes of the filigree process can be categorized into eight primary techniques: pinching, filling, piling, basing, weaving, saving, and welding (TangYiting, 2020). The analysis of the project is shown in Table 1.

Process	Illustration	Explain
Pinch.		Use tweezers to hold the filigree, make the outline of the pattern.
Filling		Make the filigree into a pattern and fill it in the outline of the pattern.
Pile		Three-dimensional modeling shape, pattern combination of
Build		more than.
Braid		Weave filigree like bamboo
Weave		using round filigree.
Combin on	at	Assembling each component, either flat or three-dimensional, is the basis for welding.
Weld		Welding is the most difficult step in the filigree inlay process, connecting the components.
Inlay		Inlay jewelry into gaps.

Table 1

Note. Compiled by the researchers.

2.1.2.2 Filigree Type

Filigree is a fine metal wire known for its ductility. The wire is gradually drawn through a board with varying hole diameters to achieve the desired thinness suitable for filigree work. The filigree process is categorized into two types: plain wire and filigree. Plain wire consists of a single wire, shaped into round wire through drawing and then flattened into flat wire. Filigree, on the other hand, involves two or more wires rolled together; when shaped into a round form, it is termed round filigree, while flattening results in flat filigree. The analysis of the project is shown in Figure 15.



2.1.2.3 Filigree Filling Patterns

Filigree filling patterns exhibit significant variety and creativity. This study analyzed the filigree inlay artifacts from the National Palace Museum, refining and classifying frequently used filling patterns while elucidating their application scenarios and meanings. The classification includes categories such as screws, braided silk, coin silk, curly grass silk, droplet silk, flower silk, wavy silk, fret silk, and tee silk, as referenced in the accompanying Table 2 (ShenYifei, 2020).

Table	2

Eight Common Patterns of Filigree Filling

Pattern	Picture	Line Illustration
Braided		
Coin		
Curly grass		
Droplet	200000 2000000	



Note. Compiled by the researchers.

2.1.2.4 Material and Color Concepts

The primary materials for filigree inlay are gold and silver, enhanced by precious materials such as tourmaline, jade, turquoise, and kingfisher feathers, with colors derived from their natural hues. This section analyzes the filigree inlay collection at the National Palace Museum, focusing on material usage, proportions_o

According to traditional Chinese Colors, gold symbolizes power, wealth, and nobility, while turquoise signifies tranquility, strength, and hope. Red tourmaline is associated with fire and the expulsion of evil, whereas blue tourmaline denotes courage and sanctity. Pink tourmaline represents love and longevity. Kingfisher feathers symbolize good fortune and luck, while green tourmaline conveys elegance and loyalty. Brown tourmaline signifies warmth and stability.(Hao, 2020) The analysis of the project is shown in Table 3.

Table 3

Material	Color	Meaning	Usage rate
Gold		Right; Worshipful; Beautiful	100%
Turquoise		Quiet; Strong; Hopeful	45%
Red tourmaline		Drive away evil;Fire	43%
Bule tourmaline		Brave; Noble; Divine	40%
Pink tourmaline		Love; Beauty; Longevity	38%
Kingfisher feather		Auspicious; Wealthy Luck	30%
Pink tourmaline		Elegance; Loyalty; Nobility	13%
Brown tourmaline		Warm; Stable; Natura	6%

Materials and Color Usage Ratios in Filigree Inlay

Note. Compiled by the researchers. Ranked by rate from High to Low.

2.1.2.5 Patterns and Symbols

The motif subjects of filigree inlay can be categorized into five groups: divine animals, natural animals, plants, characters, and religious symbols (ShenYifei, 2020). The analysis of the project is shown in Table 4.

Table 4

Filigr<u>ee Motif</u>





Note. Compiled by the researchers.

The five traditional Chinese symbols of good luck are fortune, prosperity, longevity, joy and wealth (Vivien, 2014). According to the book "Five-fold happiness" by Vivien sung for pattern classification as the basis for the National Palace Collection of filigree inlay works for the pattern theme classification, and then according to the symbolism of the generalization of the five symbols on behalf of the pattern. The analysis of the project is shown in Table 5.

Table 5



Filigree Patterns Categorized by Meaning

Note. Compiled by the researchers.

Analyzing the craft processes, aesthetic qualities, and the spiritual content conveyed by the culture better assist us in fostering cultural innovation.

2.1.3 The Difficulties to Pass on the Filigree Inlay

Demonstration and dissemination of complex and high-risk craft

With the advancement of industrial technology, many handicrafts, including the intricate technique of filigree inlay, have been increasingly replaced by machines. Currently, flat and simple three-dimensional openwork filigree objects can be produced mechanically, achieving stylistic expressions like handmade items. As illustrated in the images, non-specialists often find it difficult to distinguish between machine-produced and handcrafted products. The mass production of machine-made items has broadened market access, familiarizing more people with the aesthetic of filigree inlay. However, filigree inlay is recognized as intangible cultural heritage primarily due to its artisanal characteristics. Although machine-produced items may closely resemble filigree inlay, they do not qualify as genuine works of filigree inlay. Thus, the preservation of filigree inlay focuses on maintaining the craft itself.

Filigree inlay studio said that the exhibition is the main way to broadcast. Each year, filigree inlay exhibitions in the whole of China to display as many as more than 50 occasions. The current exhibition is mainly in the form of objects. As shown in the Figure 16 and Figure 17, for the 2024 filigree inlay exhibition in Xiamen. This way of display, lack of interest and for the craft of the display of publicity.

Exhibitions have evolved into a third paradigm that is now more concerned with the audience's experience, which, unlike the traditional experience, is accomplished

through the audience's participation by stepping into a designated role in the exhibition (Chaumier & Chare, 2020). The third paradigm is now more focused on the audience experience, as opposed to the traditional experience, through the audience entering a designated role in the exhibition and completing the participation (Chaumier & Chare, 2020). However, the filigree inlay process is complex, technically difficult, and requires the use of high-risk, high-temperature tools to operate. Therefore, it is not possible to demonstrate the process on site.

Figure 16 *Filigree Inlay Exhibition*



Note. Photographed by the researcher. Photographed in 2024, Xiamen, China.

Figure 17 *Filigree Inlay Exhibition*



Note. Photographed by the researcher. Photographed in 2024, Xiamen, China.

Filigree inlay art modeling is not suitable for today's people's daily style. From the point of view of the artistic style of the exhibition materials, there is a lack of innovation. Therefore, it is difficult to attract the attention of young groups. From the Figure 18 and Figure 19, the researcher photographed the real scene in the filigree inlay workshop, with more than 20 craftsmen and only one young craftsman.

Figure 18

Liangshengda Filigree Inlaid Specialty Art Co. Workspace



Note. Photographed by the researcher (2024)

Figure 19

Liangshengda Filigree Inlaid Specialty Art Co. Workspace



Note. Photographed by the researcher (2024).

This explains why only a small number of young people engage in filigree inlay work. To address this, researchers conducted a survey to investigate the needs of younger generations regarding traditional cultural practices.

2.1.4 Young People's Demand for Traditional Culture

Researchers have found that there is significant potential for a shift in the interest of younger audiences towards exhibitions of intangible cultural heritage, with a high degree of feasibility for implementation. (Yao, 2022)The researcher investigated 455 age groups of 18-35 years old for the degree of interest in the non-heritage, according to the questionnaire content can be seen, 30.11% of the neutral attitude occupies the most, followed by a little interest in occupying 25.05%, the group is not interested in just only occupies only 12.09%. As shown in the Figure 20. So that the part of the young people's group for the non-heritage bias interest, the difference is the interest degree of the difference lies in the degree of interest. Therefore, there is a strong

possibility of shifting young people's attitudes towards exhibitions of intangible cultural heritage from neutral to interested or very interested.(Lupo, 2023)

Figure 20

Survey on Interest Levels in Intangible Cultural Heritage Exhibitions



Young consumers' attitudes towards traditional cultural products are determined by their perceptions of the development of traditional culture. The perceived novelty and sustainability of traditional culture can significantly improve young people's attitudes and perceptions of traditional culture. This is because culture is not static, but tends to encourage more innovative design thinking and convey cultural vitality (Zhenzhen et al., 2019).

Use innovative modes of thinking and create a more attractive way of presenting traditional culture, so that it can effectively disseminate the knowledge of traditional culture while being loved by more young people. Therefore, it is necessary to find out the difficulties of cultural innovation and dissemination.

The cultural content of filigree inlay encompasses a diverse range of themes. When addressing the cultural elements of filigree inlay, it is crucial to simplify the information to align with the audience's learning preferences (Izzo, 2017). Therefore, researching the learning strategies to different types of information is a critical step in the processing of filigree inlay information.

2.2 Learning Strategies for Filigree Inlay

Researching learning strategies involves categorizing and simplifying complex knowledge content. The knowledge in filigree encompasses various aspects, including language, spatial design, patterns, processes, objects, and meanings. Given the complexity of this information, it is essential to identify appropriate communication methods that align with learning strategies. (Dudley & Kristensson, 2018)Therefore, the researcher investigated learning strategies to discern these characteristics, facilitating the processing of filigree inlay content and enhancing the effectiveness of learning outcomes.

2.2.1 Learning Strategies Types

Learning strategies that facilitate human generative learning have been categorized into eight categories based on research: summarizing, mapping, drawing, imagining, self-testing, self-explanation, teaching, and enacting (Logan & Richard, 2015). The characteristics of the corresponding learning strategies for the learning materials are summarized in Figure 21. For example, summarizing appears to be most effective when the material to be learned consists of short descriptive texts and these texts are not highly spatial by nature. When the material is highly spatialized, drawing or enacting learning strategies may be more appropriate (Fiorella & Mayer, 2016).

Figure 21

Eight Categories of Learning Strategies



Note. Illustrated by the researcher. The three large circles represent the three commonly used types of learning strategies.

The three types of learning strategies selected for this study that are more appropriate for filigree inlay content are summarizing, drawing, and enacting, which be explained in the following section.

1. Summarizing

The nature of the learning material plays an important role in summarizing the learning strategy of stating the main ideas of the lesson in concise language-that is, summarizing may be most effective in restating relatively simple ideas or concepts.

2. Drawing

Drawing learning in which learners draw pictures by hand or using computer tools to describe course content, drawing as a learning strategy is effective but the act of drawing may produce irrelevant processing if the learner must focus on tedious drawing techniques rather than course content. Therefore, when teaching the implementation of drawing, first we recommend that students be provided with very specific drawing instructions, including what parts should be included. Second, we suggest minimizing the requirement for drawing skill, perhaps by pre-painting the background and placing simple elements around the edges that can be easily replicated (Leutner & Schmeck, 2014).

3. Enacting

Enacting learning involves engaging in task-related actions during the learning process, for example by manipulating objects or making gestures in conjunction with course content. The main contribution of learning by doing is to emphasize the use of one's own body to facilitate generative processing and learning. In order to effectively implement learning by doing, research evidence suggests that students need explicit instruction on how to perform specific actions designed to facilitate learning so that these actions can be mapped to events to be reflected upon (Cook et al., 2008).

Based on the analysis of the three commonly used learning strategy methods, we can categorize and match the cultural content of filigree inlay to identify suitable learning approaches.

2.2.2 Classification of Learning Materials for Filigree Inlay

Based on the three learning strategies of summarizing, drawing, and enacting, the researcher matched the content analysis of filigree inlay to these three types of learning strategies, as illustrated in the Figure 22. This approach divided the various content into distinct learning materials, facilitating the design of appropriate learning methods tailored to the characteristics of the learning materials in a subsequent stage.(Pietroni & Ferdani, 2021)

Figure 22

Classification of Learning Materials for Filigree Inlay



Note. Illustrated by the researcher.

After categorizing the content of filigree inlay, it is necessary to conduct research on the exhibition and integrate the content into appropriate exhibition formats.

2.3. Exhibitions

Through the study and enhancement of exhibitions, filigree inlay can utilize those effective modes of dissemination. The researcher analyzed and summarized three aspects of the exhibition: the evolution of the exhibition, the interactive experience exhibition cases and the exhibition user experience.

2.3.1 Evolution of Exhibitions

Chaumier, Serge and Chare Nicholas in the study, it is mentioned that Exhibitions have undergone four stages of development, transitioning from their early purpose of displaying objects to their current roles in knowledge dissemination, education, and commemoration. They have undergone four developmental stages. As shown in the Figure 23. The first stage, the object museum, focuses solely on displaying items. The second stage, the Museum of Thought, emphasizes conveying a central idea alongside object display. The third stage, the experience museum, prioritizes visitor engagement, asserting that without meaningful interaction, exhibitions lack purpose. The fourth stage, the action museum, emerges with advancements in network technology, aiming to address cultural differences in visitor perceptions and fostering a more inclusive and public-oriented exhibition experience. These stages do not replace one another but rather reflect evolving demands, often coexisting within exhibitions to enhance their overall impact (Chaumier & Chare, 2020).

Figure 23

Evolution of Exhibitions



Note. Illustrated by the researcher.

Exhibition space is not only a container for objects but also a place of entertainment. (Vi et al., 2017)The audience groups for exhibitions are constantly changing. Exhibitions need to be easy to use and provide an interactive experience. These technological dimensions in turn trigger emotional responses such as immersion, curiosity, enjoyment and authenticity, which in turn lead to a positive learning experience (Pallud, 2017). By studying the types of experiential exhibitions, we can analyze the effects of different experiential methods.

2.3.2 Interactive Experience Exhibition Types

Interactive experience exhibitions and summarized three types: Digital reality technology interactive exhibitions; Multi-sensory experience interactive exhibitions; Emotional experience exhibitions.(Garrett, 2011) As shown in the Table 6. These three types could be integrated to some extent. The researcher analyzed and summarized four aspects: interactive experience methods, experience characteristics, and experience limitations.

Туре	Method	Characteristic	Limitation
			S
Digital reality	Constructing links	Immersive experience	Limitations of
interactive	between the real and the	Increase participation.	technology.
experience	virtual through digital	-Realize experiences that are	Exhibition content
exhibition	reality technology.	not possible in the physical	needs to be matched
	Creating for the user a	world $_{\circ}$	with technology to
	virtual element in the real	Sharing support for visitors	be realized
	world superimposed on		
	the physical world that		
	cannot be realized.		
Multisensory	Enhances the visual	The multi-sensory	May narrow the
interactive	experience through	enhancement of art can	visitor's experiential
experience	touch, taste, smell and	provide both opportunities for	perspective: can
exhibition	sound. Help visitors	interpretation.	only be experienced
	understand art and	Multi-sensory stimulation	within a defined
	create stories.	enhances visitors'	feeling
		memorization of exhibition	
		content.	
Emotional	Emotional experience	It can provoke visitors to	The degree of
interactive	interaction relies	empathize with or morally	immersion achieved
experience	primarily on the creation	engage with the events and	is a crucial
exhibition	of physical objects or	characters depicted in the	limitation to the
	environments to provide	exhibition.	emotional
	real experiences for		experience of
	visitors. to stimulate the		interactive
	imagination to evoke an		exhibitions.
	emotional response.		

Table 6Interactive Experience Exhibitions Three Types

Note. Compiled by the researcher.

Through the analysis of three types of experiential exhibitions, it has been determined that interactive experiential exhibitions are more suitable for the engagement of filigree inlay cultural content. This approach addresses the safety concerns associated with craft operations and allows audiences to immerse themselves in historical culture across different eras.(Han et al., 2017) After confirming the use of interactive experiential exhibitions as the preferred format, this study continues to investigate user experiences in museums, aiming to ensure alignment between exhibition expectations and outcomes.

2.3.3 Museum User Experience

Izzo and Filomena said the most crucial aspect of user experience in museums is achieving perceptual alignment between designers and audiences, which refers to the consistency between the content being conveyed and the content being received. This misalignment often arises from exhibitors' unclear understanding of visitor needs, leading to ineffective information processing and unsuitable exhibition formats.(King et al., 2023) To address this, this study utilized the MEUX model, thereby enhancing information education and communication.

The MEUX model serves as an assessment methodology that establishes user experience goals from both museum and visitor perspectives. As shown in the Figure 24. It encompasses exhibit features that collectively define desired characteristics, ultimately aligning museum objectives with visitor needs. The model analyzes requirements through three primary segments: first, exhibition characteristics, including content, design, and audience participation; second, influencing factors, examining motivations and potential impacts from both visitor and exhibitor perspectives; and third, benefit feedback, which assesses visitor and exhibitor goals in terms of knowledge, emotions, and operational aspects.





Note. Illustrated by the researcher.

Under the guidance of the MEUX model, the effectiveness of interactive experiential exhibitions can be effectively controlled from the outset. By aligning with the anticipated outcomes of interactive experiences, we can better integrate digital reality technologies.(Peter & John, 2010) This integration enhances the experiential effects through the study of digital reality technologies.

2.4 Digital Reality Technology

Digital reality technologies provide advanced innovative methods for enhancing experiential engagement. Digital reality technology evolves alongside advancements in computer technology, incorporating elements such as headsets, motion capture, and tracking devices to enhance multi-sensory interaction through voice, eye tracking, and motion feedback. This fosters a more realistic virtual experience for users. (Bekele et al., 2018) Understanding the characteristics and applications of digital reality technology allows for improved traditional cultural exhibitions, making display forms more innovative while enhancing educational and promotional interactions. (Gilbert, 2018) The experiential function of digital reality primarily showcases three key features: immersion, audiovisual interaction, and conceptualization (Chao, 2022). This study mainly analyzes the two main features of immersion and audio-visual interaction.

2.4.1 Analysis of Immersive Features of Digital Reality Technology

Immersion is the typical feature of digital reality technology.(Kim & Hong, 2020) With the continuous improvement of science and technology, the definition of immersion, technology needs, influence process and factors have changed, through the literature review comprehensive understanding of the current immersion in the realization of digital reality technology, to find the important factors affecting immersion, immersed in the design of the immersive be better used.(Chittaro et al., 2010)

1. Definition of immersion

Immersion can significantly influence an individual's perception of objects and experiences. Can be interpreted through a synthesis of theoretical perspectives that encompass both psychological states and objective technical aspects. It refers to a profound mental experience where an individual feels deeply engaged with their current environment. In this state, users' cognitive processes shift their attention continuously, sometimes leading to a temporary dissociation between their consciousness of the virtual world and the physical world ("Defining Immersion: Literature Review and Implications for Research on Immersive Audiovisual Experiences," 2019).

The realization of immersion needs two components, technical support as well as content support. technology provides diversified interaction methods and brings more possibilities for the technical carriers to stimulate and attract users;(Concur, 2017) content support needs to allow users to satisfy more emotional needs in their experience, and to find more sense of presence, participation and creativity from user experience.(Ferdani et al., 2020)

2. Carrier requirements for realizing immersion

Digital technologies for immersive experiences, such as Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR). Research across various sectors—education, business ,entertainment , exhibitions, and healthcare—demonstrates that these technologies enhance engagement, experience, and creativity. AR merges real and virtual environments, while VR offers a fully virtual space; XR integrates aspects of both.(Apostolakis et al., 2020; Rauschnabel et al., 2022) Immersion should be assessed not solely by the levels of real versus virtual use, but by the transformative experiences these technologies provide (Suh & Prophet, 2018).

3. Immersion influencing factors

The immersion experience is best understood as a process rather than a static state, requiring users to engage fully for it to be considered immersive. This process consists of two layers: the first layer involves existence and flow, focusing on user experience, while the second layer encompasses empathy and embodiment, allowing for tailored experiential choices. As shown in the Figure 25. These two layers are interconnected, ultimately leading to genuine user participation and enhanced experience quality (Shin, 2018). Delivering information and generating a good interactive experience through the immersion of digital reality technology should be developed to allow users to generate two levels of flow of participation content, the experience of the device technology alone is not enough to satisfy the immersive feeling (Shin, 2018).

Figure 25

Two Layers of Immersion



Note. Illustrated by the researcher.

Virtual characters significantly impact emotional engagement in user experiences. Avatars, which can represent humans, animals, or other designs, must possess specific traits, such as gender, body size, and personality. Edler in his research on audiovisual mentioned indicates that when avatars closely resemble users, attention shifts away from the avatar itself, enhancing focus on information delivery. Thus, to maximize immersion, it is crucial for virtual characters to closely reflect the realism of the user's likeness (Edler et al., 2019). To achieve deeper immersion, it is essential to align closely with user needs, enabling greater creativity and choice during the experience. This approach addresses the diverse feedback resulting from individual differences, fostering a sense of identity and cognition for the user. Ultimately, this alignment enhances the user's understanding of the content, allowing immersion to play a more significant role in the experience.

Cognitive differentiation among users arises from varying educational backgrounds, life experiences, and aesthetic preferences, necessitating a more focused experience in digital reality environments. Prioritizing knowledge about the upcoming experience over immersion enhances user interest, ultimately fostering a more immersive experience when engagement with the content is established (Lee et al., 2020). Therefore, we need to leverage the second key characteristic of digital reality technologies 'audiovisual interaction' to reduce experiential discrepancies.

2.4.2 Characterization of Audiovisual Interaction

Audiovisual interactive experiences refer to the interaction between visual and auditory elements and are the most fundamental and important components of digital reality technologies.

1. Visual interaction analysis

The visualization of data and information processing is a key objective of visual design. Research indicates that visually processed information yields better acquisition and dissemination outcomes. Since early human civilization, such as wall paintings, visual information processing has evolved alongside advancements in science and technology.(Concur, 2017) As the medium of information changes, a progressive visual symbolic system is required. Understanding the fundamental cognitive logic of the visual system is essential to meet the demands of information visualization in a technological context.

Vision is the primary human perceptual impulse, The study of visual arts includes the study of visual culture and the analysis of conceptual elements of the visual world (Chao, 2022; Liu, 2021.) Visual system is divided into three categories: color, text and layout. Colors can be used to connect important blocks and distinguishing blocks; different fonts provide different tones for the interface and content blocks; in the interface layout, according to the order of reading from left to right, important blocks are placed on the top left and secondary blocks are placed on the bottom right (Tong et al., 2018). According to the learning principles derived from cognitive load theory, digital storytelling more educationally efficient if the following conditions are met:

- Use both text and images, but only text (multimedia principle).
- Temporary integration of text and pictures (the principle of distraction).
- Graphic content is used with narration rather than written text (modal principle).
- One type of information is not presented in two or more forms (principle of redundancy).
- Key messages are emphasized in the organizational structure of the message (signalization principle).
- Exclude unnecessary material (principle of coherence).
- The material is presented in segments and the user can control them instead of a linear structure (segmentation principle).
- For beginner users, a variety of organizers are offered.
- The app is easy to use (Edler et al., 2019).

2. Auditory interaction analysis

We can categorize the sounds in digital reality technology into four types: abstract sound, speech, music, and soundscape (Edler et al., 2019). As shown in the Figure 26. Abstract sound typically consists of simple tones used to indicate specific changes or characteristics. Speech sounds are applied in educational interactions to convey intellectual information and provide guidance. Music represents a complex rhythmic system that facilitates emotional transmission and motivation due to its cultural attributes. Soundscape encompasses the sound elements that convey emotions to users. A key distinction between sound events and films in VR is the emphasis on interactivity, where user actions—such as walking, hitting, or throwing—generate corresponding sounds(Serafin et al., 2011 ;(Serafin et al., 2018). Simulating sound events in VR poses additional challenges compared to movies or games (see the sidebar "Sound Source Modeling" for more information). One essential difference is that the user is surrounded by the environment.(Feng, 2020) In VR, sound can help direct the user's attention and enhance the sense of place and space (Cao et al., 20).

Figure 26

Four Types of Sounds in Digital Reality Technology



Note. Illustrated by the researcher.

The above constitutes an analysis of the components of visual and auditory interaction within digital reality technologies. Researchers have analyzed and summarized how these characteristics are applied and implemented in specific case studies.

2.4.3 Digital Reality Application Case Study

The researcher selected six globally implemented cases of digital reality technology, focusing primarily on exhibitions, culture, and handicrafts. Through an analysis of the applied technologies and their interactive functions, different suitable scenarios for various digital technologies were identified, leading to the development of interactive experiences tailored for the filigree inlay craft.

1. Restoration of Augustine Church

This case employs VR technology for the digital reconstruction of the Augustine Church, facilitating the restoration of damaged church murals and presenting a fully restored view of the church within a virtual space. This approach aims to protect cultural heritage that has already suffered damage (Soto-Martin et al., 2020). The analysis of the project is shown in Table 7.

Table 7

Restoration of Augustine Church Case Analysis



Note. Compiled by the researchers.

2. Pleistocene Crete

The Pleistocene Crete exhibition is a digital interactive experience that allows museum visitors to immerse themselves in the multisensory world of the fauna that inhabited Crete during the Pleistocene epoch. This presentation aims to showcase lifelike animations and life-sized reconstructions of animals that roamed the island approximately 800,000 years ago (Apostolakis et al., 2020). The analysis of the project is shown in Table 8.

Table 8

Pleistocene Crete Case Analysis

3. Footbal	l Club Café		
Picture		Technology	Interactive Function
	A R	VR	1. Visitors can navigate to
30 Asimda			view text, images, or audio.
Hobbind after scientific date. Animated according to classes extent relations.	Realine EDPC		2. They can wander through
	entreal interactions 30 Spatial Mapping &		virtual spaces representing
	Understanding Avaid callinians with anvironment and with humans.		natural habitats.
In Printing Binistabel Reality Realistication and consistent consistent consistent and consisten		MA	3. The "timeline" feature
and replaces the resonance of the second sec	Angunented Min BOOTH	PA	allows users to traverse
	the photographs		different periods of each
6		5	animal's life, observing
Γ		(GAD)	changes over time.
			(5)
9	73		
the second	nitur /	AR	1. Visitors can view various
	-	2	animals featured in the
	-		exhibition on the display.
	4		2. Users can take photos with
20		Sec. 1	the animals roaming nearby
			and receive these pictures via
Carl Street and Street			email or social media as
			souvenirs of their visit.
-	the mit		
Jaco .	F AS	-	

Note. Compiled by the researchers

A small exhibition at a café in Japan aims to create an interactive experience centered around a collection of historically significant jerseys. The design objective is to develop a mixed-reality experience that provides users with deeper insights into the jerseys themselves, while avoiding the installation of any additional permanent physical facilities within the venue (Cheng & Furusawa, 2018). The analysis of the project is shown in Table 9.

Table 9



Football Club Café Case Analysis

Note. Compiled by the researchers

4. Terracotta Warriors AR

The Franklin Institute is utilizing augmented reality (AR) to enhance its Terracotta Warrior exhibition, which is on display in Philadelphia until March 2018. Visitors can scan items with their smartphones to visualize rich AR content, providing deeper insights into the fascinating history behind the majestic sculptures. The analysis of the project is shown in Table 10.

Table 10

Terracotta	Warriors AR	Case Analysis

Note. Compiled by the researchers.

5. Weaving Machine Training

This design addresses the interactive experience between humans and the tools used in craftsmanship. It provides a visualization method for the craft process within a virtual environment, facilitating an enhanced educational experience ("University of Bremen Researcher Publishes New Studies and Findings in the Area of Acute-Phase Proteins (Transferring Traditional Crafts from the Physical to the Virtual World: An Authoring and Visualization Method and Platform)," 2022). The analysis of the project is shown in Table 11.

Table 11



Weaving Machine Training Case Analysis

Note. Compiled by the researchers.

6. Mixed-Reality Demonstration and Training of Glassblowing

This design is intended for the exhibition and educational experience of glass bottle craftsmanship at the French School of Fine Arts (Carre et al., 2022). The analysis of the project is shown in Table 12.

Table 12

Mixed-Reality Demonstration and Training of Glassblowing Case

Note. Compiled by the researchers.
7. Case Study Analysis

In analyzing the above cases, the researcher has summarized the characteristics and interactive features of various digital reality technologies. The analysis of the project is shown in Table 13.

Table 13

VR AR M	R Case	e Summary	Analysis
---------	--------	-----------	----------

Technology	Characteristics
VR	1. VR typically establishes surrounding environments, making it.
	suitable for scenarios involving damage, danger, or
	inaccessibility.
	2. VR usage requires the wearing of head-mounted devices.
	3. Most VR applications operate in expansive spaces that
	necessitate. movement or controller-based navigation.
	4. VR is designed for deep immersion, focusing on the
	experiential. aspects of spatial environments.
AR	1. Requires screen-based devices for effective display.
	2. Suitable for real-time presentation of virtual information
	related to, physical objects.
(3. Applicable for showcasing supplementary and explanatory.
	information.
	4. Facilitates social sharing and dissemination.
MR	1. Enables semi-immersive experiences.
	2. Allows for hands-free interaction.
	3. Suitable for interactions that resonate with the real
	environment and approximate hand-held engagement.
	4. Applicable for interactive displays that link virtual and
	physical information.

Note. Compiled by the researchers.

Based on the analysis, the researcher divides the digital reality interactive experience of filigree inlay into three components. The analysis of the project is shown in Figure 27.

1. Educate part

Utilizing AR to introduce the filigree inlay process, this segment does not restrict devices and accommodates multiple users simultaneously, facilitating a fundamental understanding of the craft.

2. Customized experience part

Employing MR for a DIY experience with filigree inlay products, this phase enables interaction between the virtual and real worlds, achieving a secondary immersion experience.

3. Publicity part

Leveraging AR technology, this aspect enhances the ease of dissemination on social media platforms.

Figure 27

The Three Components of Digital Experience



2.5 Other Related Studies

Digital reality technology has been widely used in various places, including museums. The Silk Museum in Krefeld, Germany, applies digital reality technology to demonstrate the clothing production process by categorizing and selecting clothing styles. In the 3D clothing collection, the process is mainly done by the virtual craftsman with motion capture to restore the real production action of the artisans. To a certain extent, the study is more inclined to restore the virtual content of the display(Hauser et al., 2022).

Moreover, studying batik craft in Malaysia and Indonesia has also developed AR architecture to help elementary school students, vocational students, and students with special needs understand the local knowledge and philosophy of batik. Tosida also researched AR technology to increase students' interest in learning, and the study has developed different learning crafts through different levels of learning needs(Syed Shaharuddin et al., 2021).

Recently, Guan conducted a study by applying virtual reality (VR)-based ceramics production methodology to technology education in a middle school to examine its impact on student creativity and engagement in learning. Two groups of students were assigned to learn using the VR-based method, while two other groups were assigned to be the control group, in which 30 students learned using the paper-and-pencil method and 33 students learned using the clay-based method. The results showed that the students who learned using the VR-based method were not only more creative with their products but also had higher cognitive engagement than the control group(Guan et al., 2023).

Interactive virtual reality can also be applied to many learning scenarios, such as the study of bamboo weaving virtual experience, which consists of three elements: information display, scene roaming, and learning module. The content of Dongyang bamboo weaving inheritors and bamboo weaving craft was displayed by hearing and vision. The users can experience the scenes of bamboo weaving in different periods through scene restoration and scene reproduction combined with the characteristics of the virtual reality environment. The process of bamboo weaving is redesigned, omitting the cumbersome steps of material processing and retaining the exciting steps of weaving, which is easy to disseminate. The study is diversified for the presentation aspect of bamboo weaving culture, and the interaction of three types of contents: history, life, and learning is accomplished by way of switching modes(Zhang et al., 2023).

Moreover, the study was for designing and developing a mixed reality installation at the Marble Craft Museum on the island of Tinos, Greece, which allows visitors to take on the role of a crane operator. The system allows users to operate tangible controllers, and digital workers perform their operations in a rich 3D environment. The study used a way of realizing interaction by manipulating the virtual through natural physical objects. This approach enhances visitor interest and engagement compared to non-interactive media or purely digital environments(Vosinakis et al., 2020). From this finding, it can be said that the use of virtual reality is suitable for challenging environments like the study of Antonya and Butnario, who revealed that A virtual reality environment was developed in which the user's perception could deliver positive feedback for the development and support the use of virtual tools(Antonya & Butnariu, 2022).

2.6 Analysis Summary

This study summarizes four analytical processes and organizes them into a visual format. These processes include exhibition analysis, content extraction analysis, content type analysis, and digital reality design analysis. The goal is to effectively adapt filigree inlay content within this framework, facilitating better integration of digital technology and maximizing its value.

2.6.1 Exhibition Design Analysis

This analysis evaluates the process of filigree inlay experiential content from the perspectives of both visitors and organizers, culminating in the final feedback. As shown in the Figure 28. Once identified, human cognitive strategies are applied to differentiate the content's cognitive characteristics and align them with suitable strategies. Digital reality technology is then integrated to improve these cognitive strategies, with specific design applications discussed in the digital experience framework. Finally, a MEUX feedback test evaluates whether the exhibition outcomes align with the expectations of visitors and organizers.

Figure 28

Exhibition Design Analysis



Note. Illustrated by the researchers.

2.6.2 Content Extraction Analysis

This section summarizes the analysis of the needs of both the curators and visitors regarding the filigree inlay exhibition. As shown in the Figure 29. Starting from the filigree inlay exhibition, it was firstly divided into two sections: museum expectations and visitor expectations. Separately from the content of the exhibition, demonstration, functionality, interactivity in three directions combined with the questionnaire form, to determine the characteristics of the exhibition. The characteristics of the exhibition can be divided into "how to let visitors know", "how to let visitors feel" and "how to let visitors do" (Kyriakou & Hermon, 2019). Which summarizes the content of the filigree inlay exhibition.



Note. Illustrated by the researchers.

2.6.3 Content Analysis

This section summarizes the methods for matching filigree inlay content with human cognitive strategies. As shown in the Figure 30. Based on the steps, the content of the filigree inlay exhibition can be categorized into narrative, visual, and operational content.(Sidenmark & Gellersen, 2019; Zhao et al., 2022) Narrative content primarily employs summarization as a cognitive strategy to simplify and reiterate information. Visual content utilizes drawing strategies, minimizing drawing techniques while incorporating predefined elements.(Afshan et al., 2019) Operational content relies on action-based cognitive strategies, designing iconic actions that correspond to specific events. Through these processes, the filigree inlay content can be effectively aligned with suitable cognitive strategies.(Tong et al., 2018)





2.6.4 Digital Experience Design analysis

This section summarizes the analysis of the methods for achieving secondary immersive experiences using digital reality technologies. As shown in the Figure 31. Augmented reality (AR) facilitates broader visitor engagement without equipment limitations, enhancing communication through efficient interactive education and enabling a primary level of immersion. (Hilken et al., 2020; Zhang et al., 2020)Virtual reality (VR) allows visitors to make secondary identity choices and customized experiences, leading to a deeper level of immersion and creating promotional attributes with experiential relevance.(Holly et al., 2021) Consequently, the first stage focuses on generative content, the second on interactive content, and the third on customized content, guiding design from visual and auditory perspectives.(Ke et al., 2019)



Digital Experience Design Analysis



Note. Illustrated by the researchers.

2.7 Design Methodology

The design method of this study follows the principles of cultural innovation class design (Sun Deming, 2015). The first step is to deconstruct the cultural elements; the second step is to add the modernization context.

2.7.1 Deconstructing Cultural Elements

Culture is the conceptual symbol of social ideology. It includes three levels: material culture, institutional culture and spiritual culture. The first level of material culture mainly includes the four elements of form, color, material and texture. The second level of institutional culture mainly includes the two elements of traditional skills and folk customs. The third level of spiritual culture mainly includes the three elements of religious beliefs, values and legends.

2.7.2 Adding Modernization Contexts

Regarding the design of cultural innovation must be human-centered, design according to the needs of modern people, and increase the modern people's sense of identity with traditional culture. Therefore, the key to think about is the lifestyle and aesthetic value of modern people. During the design process, we need to determine the expression of modern context through two parts: modern design style and modern civilization.(Sun, 2023)

Modern design styles evolved from the sophisticated 20th century Art Nouveau styles to the styles that are fashionable today. We can categorize them into ten Bauhaus, Minimalism, Decorative Arts, Pop Art, International Typography, Psychedelic, Postmodernism, Demagoguery, Flatten, and Contemporary. Each of the eleven modern designs characterized from the following Table 14.

Table 14	4			
Modern	Design	Styles	Analysis	

Art style	Photograph	Specificities
Bauhaus (German school of modern architecture and design)	BAUA In a state of the state of	Prioritize functionality in your design. Sans serif fonts. Geometric shapes. Grid systems. Contrasting colors.
Minimalist	AMNESTY INTERNATIONAL	Simple. Clean lines. Avoid matching colors. Straightforward typography with white space
Decorative arts		Geometric shapes. Rich colors. Luxurious splendor. Symmetrical compositions.
Pop art (loanword)		Contrasting colors. Popular culture images. Humor and satire. Simple bold lines.
International Typographic Style	Pesign is is	Sans serif fonts. Grid system. Asymmetric composition typography.



Contemporary style



Experimental fonts. Fusion of digital graphics and hand-drawing. Sustainable socially conscious design.

Note. Compiled by the researchers.

In the age of communication, traditional culture must actively embrace modern civilization if it is to be recognized by more people. Inspiration can be sought from modern people's clothing, food, housing, transportation, hobbies, and fashion trends.

The visual content of this study deconstructs and redesign the cultural elements of filigree inlay, identifying the spiritual and cultural needs that align with contemporary life. (Jeff, 2014)Ultimately, the works designed in a decorative arts style.



2.8 Summary

The study on the literature review can be summarized as the conceptual framework shown in Figure 32. The three segments of filigree inlay, digital reality technology and theoretical learning constitute the conceptual research framework. The concepts of the three segments were learned to find a suitable design solution for learning and interaction of filigree inlay interactive experience, and the framework helped the researcher to clearly organize the relationship of the research concepts, which laid the foundation for the subsequent practice.

Figure 32

Conceptual Framework



Note. Illustrated by the researchers

CHAPTER 3 RESEARCH METHODOLOGY

This study was conducted using a mixed-method approach. Firstly, the qualitative research method, including literature review, cultural relics analysis, and on-site research, was used to study the aspects of filigree inlay, digital reality technology, design principles, human cognitive strategies, and museum user experience. Then the qualitative and quantitative research methods were applied to interview filigree inlay experts and digital reality technology experts, and the quantitative research method was applied to collect questions through questionnaires to survey the audience. The collected data are collated and fed back to obtain the results of the real role of digitization for filigree inlay exhibitions.

3.1 Research Methodology

The study research methodology as shown in the Figure 33. Comprehensive research methodology using questionnaires, expert interviews. The study was carried out in three stages: prototyping, testing and modification, and final testing.



Figure 33

Research Methodology



Note. Illustrated by the researcher.

To elaborate more clearly on the findings and processes obtained in the four phases, the researchers explained each of the four phases in terms of the following.

3.1.1 Phase 1: Conceptual Framework Phase

In the first phase, a conceptual framework was developed by collecting research content through literature review, fieldwork and case studies.

1. Literature inclusion criteria

The main content of the literature is mainly categorized into research on Chinese filigree inlay and digital reality technology as well as comprehensive theories. The knowledge of Chinese filigree inlay primarily comes from renowned Chinese academic journals and materials provided by Master Ma Weisheng from the Liangshengda Filigree Inlaid Specialty Art Co. The literature on comprehensive theories is selected from globally renowned academic journals published from 2015 to the present. The literature on digital technology is drawn from leading academic journals worldwide, covering the period from 2018 to the present.

2. Fieldwork inclusion criteria

The fieldwork was conducted at the Liangshengda Filigree Inlaid Specialty Art Co., founded by a certified Chinese intangible cultural heritage inheritor of filigree inlay. The company integrates a filigree inlay factory, exhibition space, and office space, providing a comprehensive understanding of the development, production, and promotion of filigree inlay.

3. Case study inclusion criteria

This study applies the method of case study in the section of filigree inlay pattern classification and application of digital reality technology. The cases in the filigree inlay section are selected to analyze the filigree inlay works in the collection of the Palace Museum. Filigree inlay craft belongs to the palace craft, the Forbidden City, as the largest palace complex in China, is the museum with the most concentrated collection of palace artifacts. Cases of digital reality technology applications, selected from applications after 2018. As far as possible, multiple countries are covered.

The collection of research content in the first phase helped the researcher to obtain sufficient research information to support the content and theory of the subsequent research.

3.1.2 Phase 2: Investigation and Prototyping Phase

The second stage is mainly to collect the experts' opinions through interviews and the public's views through questionnaires.

1. Interview inclusion criteria

In this study, three experts were selected for interviews. The interview panel included an artist and developer with five years of experience in VR art; A certified

Chinese filigree inlay intangible cultural heritage inheritor; And an associate professor with ten years of experience in the field of visual arts.

2. Questionnaire inclusion criteria

The questionnaire collected people aged 18-35 years old in all regions of China. The number of questionnaires was 455, randomly distributed to 47% men and 53% women. The questionnaire was sent via <u>www.wjx.cn</u> website.

The data collected in the form of interviews and questionnaires in the second phase applied to the development of the design prototype, which provide a more precise and informative material for solving the research problem.

3.1.3 Phase 3: Innovation Enhancement

1. Audience inclusion criteria

Audience Suggestion Form: Invite the audience to experience the design prototype and make suggestions on the experience and the direction of upgrading.

Audience Observation Form: The researcher conducts real-time observation while the audience participates in the interaction with the design prototype, which mainly observes whether the audience interacts with the design within the predefined scope and achieves the predefined effect. It is an important indication for upgrading the program.

2. Expert inclusion criteria

Experts from different fields experience the design prototypes in this session and give their opinions on the corresponding fields. Experts in filigree inlay give advice on the accuracy of the message conveyed and the direction of education and dissemination of the exhibition; experts in digital reality technology suggest upgrades from the perspective of the use of the technology; and VR painting artists give advice on aesthetic ideas from the visual sense of virtual reality.

The third phase of testing adjustments play a crucial role from the perspective of upgrading the design. It helps the design to be more effective in real use sessions.

3.1.4 Phase 4: Results Assessment Phase

1. Traditional Exhibitions

Pre-test and pro-test standard

Fifty visitors were selected to visit a traditional filigree inlay exhibition and were given a questionnaire to answer questions related to filigree inlay after the visit. The questions in the questionnaire were categorized into three levels: easy, medium and difficult.

2. Expert assessment

Three experts were involved in this phase, namely experts in the field of filigree inlay, digital reality technology artist developers, and VR painting artists. Innovative and effective suggestions for the dissemination of non-heritage culture were made through multidisciplinary analysis.

3. Digital Reality Exhibition

Pre-test and pro-test standard

Fifty visitors were selected to visit the Digital Reality Filigree Inlay exhibition and were given a questionnaire to answer questions related to filigree inlay after the visit. The questions in the questionnaire were categorized into three levels: easy, medium and difficult.

4. Expert assessment

A total of three experts participated in this stage, namely experts in the field of filigree inlay, digital reality technology artist developers and VR painting artists. Through multi-disciplinary analysis of digital reality to help the dissemination of non-heritage culture has what effective significance and did not put forward the views of future upgrading.

The fourth phase of the test evaluation effectively and intuitively get the direct effect of the digital reality on helping the filigree inlay exhibition. It be able to effectively reflect the strengths of the innovation as well as the directions to be upgraded.

3.2 Research Sample Groups

The study divided into six sample groups, which expanded upon below.

3.2.1 Group 1: Volunteer Team (Phase 2)

The volunteer team had no prior knowledge of filigree inlay and had not received any training on the subject before the test. They were not professionals in fields related to filigree inlay.

- Sample Scope: 18-35 year old group

- Sample Size: 455

3.2.2 Group 2: Expert Team (Phase 2, 3, & 4)

Evaluation of the study by experts in different relevant fields to ensure the feasibility of the study.

- Sample Scope: Expertise in the field of filigree and digital reality technology.

- Sample Size: 2

Experts were selected through Purposive Sampling based on their qualifications and

expertise in.

- Filigree Inlay Inheritor.
- Ma Fuliang, Hebei province first class arts and crafts maestro
- Digital Artist.
- Kevin Ang, artist/developer
- Visual Design.
- Wu Wenyong, Associate Professor/Visual Designer

3.2.3 Group 3: Audience Team 1 (Phase 3)

Audience Group 1 was mainly involved in testing the prototype design and suggesting effective modifications. The audience group was mainly focused on people over 18 years old.

- Sample Scope: Adult audiences over 18 participating in innovation display experiences.

- Sample Size: 30

3.2.4 Group 4: Audience Team 2 (Phase 4)

Audience Panel 2 was primarily involved in the results of attending the Traditional Filigree Inlay exhibition.

- Sample Scope: Adult audiences over 18 participating in innovation exhibition experiences.

- Sample Size: 50

3.2.5 Group 5: Audience Team 3 (Phase 4)

Audience Panel 3 was primarily involved in attending the results of the filigree inlay exhibition after the digital reality upgrade.

- Sample Scope: Adult audiences over 18 participating in innovation exhibition experiences.

- Sample Size: 50

3.2.6 Group 6: Questionnaire Evaluation Expert Team (Phase 2)

Experts evaluated research tools' effectiveness and proposed improvements.

- Sample Scope: Experts in design with research capabilities relevant to the study.

- Sample Size: 3

Experts were purposively selected based on their expertise in visual design and digital art.

- Asst. Prof. Paniti Keowsawat, Phetchaburi Rajabhat University

- Asst. Prof. Thammasak Aueragsakul, Rangsit University

- Professor Wattana Jutavipard, Rangsit University

These sample groups were integral to conducting a comprehensive and multi

faceted study, ensuring robust evaluation and refinement of the research objectives across different phases.

3.3 Variables of The Study

In this study, several key variables have independent, dependent, and control variables.

3.3.1 Independent Variables

Filigree Inlay Exhibition knowledge with AR and VR

3.3.2 Dependent Variables

Visitors' understanding of the content of the filigree inlay exhibition

3.3.3 Control Variables

This study examined the impact of AR and VR technologies on the cognitive effects of audience visits to a filigree inlay exhibition, while controlling for changes in basic knowledge across different filigree inlay exhibition approaches.

The Figure 34 below shows the key variables examined in this study. AR and VR technology displays were identified as an independent variable that influenced the results of the study. Different forms of exhibition methods for knowledge dissemination were used as a control variable to influence the level of awareness of the audience during the visit. Together, these variables contribute to a comprehensive analysis of the research objectives.

Figure 34

Variables of the Study



Note. Illustrated by the researcher.

3.4 Research Tools

During the research, several research tools were used to achieve the objectives of each stage of the research. For this purpose, the following was done for the preparation of the research tools.

3.4.1 Preparation of Research Tools

The research tools were prepared to help understand how content knowledge in exhibitions is conveyed through digital technology. The researcher used questionnaires and interviews as the main research tools, following the steps below:

1. Identification of relevant literature studies

The literature query centered on filigree inlay exhibition content and digital reality technology content, with content processed through learning strategies, exhibition user experience and aesthetic theory.

2. Define Scope and Structure of Research Tools

Determine the scope and structure of the research tools based on the hypotheses and research objectives outlined in the study.

3. Draft Research Tools and Seek Advisor Feedback

Develop an initial draft of the research tools and solicit feedback from an advisor or mentor.

4. Discuss Draft with Instructor and Revise

Present the initial draft of the research tools to the instructor for discussion, and review, and necessary corrections.

5. Expert Review of Research Tools

Engage three experts for an evaluation of the research tools.

Experts include Asst. Prof. Paniti Keowsawat, Assis. Prof. Thammasak Aueragsakul, and Assoc. Prof. Dr. Wannaporn Chujitarom. The Figure 35 shown the researcher presenting the study's content to experts.

These steps ensure that the research tools are robust and aligned with the study's

objectives, providing a solid foundation for data collection and analysis in the subsequent phases of the study.

Figure 35

IOC Review Session



Note. Photographed by the researcher. (2024)

The refined research tool underwent evaluation by three experts to ensure the precision of its content. Experts assessed the Index of Item Objective (IOC) values to determine the alignment of questions with the research objectives. Experts assessed the Index of Item Objective Congruence (IOC) values to determine the alignment of questions with the research objectives. The scoring criteria for IOC evaluation are as follows.

ยาสัยค

+1: Question is deemed consistent with the research objectives.

0: Uncertainty regarding the consistency with the research objectives.

-1: Question is determined to be inconsistent with the research objectives.

The table presents the IOC evaluation scores from three experts across six IOC files. Based on these scores, the research tool was found to be accurate and effective in its design. Based on these scores, the research tool was found to be accurate and effective in its design. Detailed documents of the experts' IOC reviews are available in

the appendix, providing comprehensive insights into the evaluation process. Detailed documents of the experts' IOC reviews are available in the appendix, providing comprehensive insights into the evaluation process.

Table 15

Experts l	Review	IOC A	ssessment	Resul	ts
-----------	--------	-------	-----------	-------	----

Expert Name	Questionnaire	Expert	Pre-Test	Post-Test	Evaluation IOC
	IOC Score	Interview	Questions	Questions	Score
		IOC Score	IOC Score	IOC Score	
Asst. Prof.	14÷14=1	35÷	15÷	15÷	5÷5=1
Paniti		35=1	15=1	15=1	
Keowsawat					
Assis. Prof.	13÷14=0.93	35÷	15÷	15÷	5÷5=1
Thammask)er	35=1	15=1	15=1	
Aueragsakl	19	225	AIR)		
Asst. Prof.	14÷14=1	35÷	15÷	1 5÷	5÷5=1
Wannaporn		35=1	15=1	15=1	
Chujitarom					
Final	0.98	I	11	1	1
Average Score	الاسام	D'	MAD	n	
Note. Comp	iled by the research	ners.		5	

3.4.2 Research Tools for Assessing the Research Gap

The researchers used structured questionnaires and in-depth interviews to gather audience perceptions of non-heritage cultural exhibitions such as filigree inlay, including perceptions of the visuals, the way the experience is conducted, and the content of interest. These methods, along with expert interviews and a comprehensive literature review, enabled the researchers to effectively characterize and define existing research gaps.

• Questionnaire

The questionnaire used in this study was divided into three sections:

Part 1: General information questions survey questions about demographic information about the respondent.

Part II: Issues in the exhibition of China's intangible cultural heritage.

Part III: China's Intangible Cultural Heritage Combined with Digital Interactive Experiences.

• Interview

Open-ended interview questions provide an in-depth understanding of filigree inlay specialty content and XR technology related content.

3.4.3 Research Tools for Enhancing Innovation Prototype

Methods for collecting data to enhance innovation prototypes encompassed interviews, questionnaires.

• Interview

After experiencing the test prototype, interviews are conducted with those who experienced it. Suggest corrective actions on the upgrade direction of the test from the viewer's and expert's point of view.

• Questionnaire

After the prototype is designed, volunteers are tested and their experience feedback. Collected their suggestions use the questionnaire.

3.4.4 Research Tools for Evaluating Innovation

In evaluating innovation prototypes, multiple data collection methods were employed, including questionnaires and interviews.

Questionnaire

The questionnaire was categorized to assess two forms of testing. Pre-Test Knowledge Questionnaire and Post-Test Knowledge Questionnaire, designed to assess the effectiveness of knowledge acquisition after innovative use.

• Interview

Interviews were conducted through the experience followed by participant comments and feedback on what they knew and how they felt about the experience.

3.5 Research Process

Identify research gaps. Organize the contents from the content of filigree inlay, the user experience of museum exhibition, the application of digital reality technology, the analysis of audience learning strategy, and the principles of cultural design in non-heritage category. Find the research gap needs through fieldwork, filigree inlay factory research and other methods.

Creation of a detailed research plan. Including preparation for Index of Item Objective Congruence (IOC) evaluation

Data collection and analysis. The NRM exhibition was tested through 455 questionnaires, collected from people aged 18-35, about the way of interest as well as the content of interest. As well as the opinions of three experts in the field.

Prototype testing. During the prototype testing phase 30 audience members were selected to experience and give feedback, and 3 experts gave their opinion on the areas of use.

Exhibition Feedback Test. Two groups of 200 audience members were selected to conduct two sets of experimental tests to provide real-life comparative feedback on the specific effects of the study.

Conclusion. The conclusions and limitations of this study are summarized through feedback with the experts and the audience, and more effective upgrades are proposed.

3.6 Data Collection (Phase 2-4)

During phases 2 to 4 of the research, the data collection process followed structured steps as outlined below.

3.6.1 Questionnaire Data Collection (Phase 2)

The questionnaire is used to collect questions through basic information type questions, degree level ranking questions, and intention to choose questions. The questionnaire was released online to reach a wider range of people.

3.6.2 Expert Interviews Data Collection (Phase 2)

The interview questions of the experts were focused on practical applications in more fields, the experience of the experts, and the needs of the field for the collection of questions.

3.6.3 Audience Evaluation Data Collection (Phase 3)

The audience in this phase participates in the experience of the design by invitation. The audience is guided to give authentic feedback after the experience is completed. Advice on upgrading and improvement is given in terms of experience and knowledge acceptance.

3.6.4 Expert Evaluation Data Collection (Phase 3)

At this stage, experts are invited to experience and suggest improvements in terms of practicality and innovation in the field.

3.6.5 Pre-Test & Post-Test Questions Data Collection (Phase 4)

The same pre- and post-tests were prepared for both groups of exhibition visitors at this stage. The test questions categorized knowledge of filigree inlay as beginner, intermediate and advanced. Objective evaluation criteria were achieved for both groups of visitors.

3.6.6 Expert Evaluation Data Collection (Phase 4)

At that stage, we fed back the audience's test results to the experts for reference. The experts are informed of the testing objectives for the final phase of this study, which combined with real feedback from the experts' experience. Provide final evaluation feedback on the study, as well as feedback for improvement.

3.7 Data Analysis (Phase 2-4)

In phases 2 to 4 of the study, the researchers employed various methods to analyze the collected data.

3.7.1 Analysis Method

• Analyzing Questionnaires (Phase 2)

After collecting the questionnaires, the following steps were taken to analyze the data:

1. Validate the completeness of each questionnaire response.

2. Statistical analysis of demographic information using percentages provides a basis for discussion of research findings.

3. Descriptive statistics were used to analyze respondents' questions related to the NRM exhibition, focusing on frequency and percentage distribution. A 5-point Likert scale was used to measure the level of agreement, ranging from "strongly disagree" to "strongly agree", as well as the midpoint of neutral responses.

4. Respondents were surveyed about their interest in the NRM exhibition and descriptive statistics were used to explore open-ended responses.

5. Percentage analysis to assess issues related to the incorporation of digital interactive technologies in NRM exhibitions contributes to further research discussions.

• Analyzing Expert Interviews (Phase 2)

The expert interviews provided valuable insights, organized into three themes:

Learn exactly how the filigree inlay factory operates, the real issues of filigree inlay exhibitions and publicity.

Explore the possibilities of tea digital reality technology to upgrade the traditional exhibition of filigree inlay.

The findings are synthesized into a narrative form and the results are thoroughly discussed.

• Analyzing Audience Evaluation (Phase 3 & 4)

The data from the audience evaluation was analyzed through the following steps: 1. Provide audience experience and feedback for evaluation.

2. Collect and verify the completeness of audience questionnaire responses.

3. a 5-point Likert scale was utilized to assess the level of innovation satisfaction and to collect open-ended responses about the filigree inlay exhibit on digital reality technology to enhance the insights of the study.

4. Implement innovative improvements based on audience feedback and suggestions.

• Analyzing Expert Evaluation (Phase 3 & 4)

The order in which the expert assessments were analyzed is as follows:

1. Provide experts with experience and feedback for evaluation.

2. Collection of expert opinions.

3. Summarize key expert insights and recommendations.

4. Implement innovative improvements based on expert feedback.

-Analyzing Pre-Test & Post-Test Questions (Phase 4)

The analysis of pre-test and post-test issues involves the following procedures:

1. Confirm the completeness of each test questionnaire.

2. a 5-point Likert scale was utilized to assess the effectiveness of the innovation and to collect and analyze open-ended responses related to the exhibition of filigree inlays for digital display technology.

3. mean differences were calculated before and after answering the questions to facilitate a comparative discussion of the findings.

3.7.2 Statistics Used in Data Analysis

• Percentage

1. Likert scale analysis: questionnaire responses were categorized using a five-point Likert scale.

2. Open-ended and ranked questions: Responses from the open-ended and ranked questions were compiled and organized according to the frequency with which they occurred. The findings are also synthesized and analyzed in tabular form.

Mean Calculation

To determine the concentration trend of the data collected from the two sets of questionnaires, the researcher calculated the mean values. To provide a fair reference for the authenticity of the test results.

3.8 Chapter Summary

This study utilized a mixed research methodology. A conceptual framework based on literature review and fieldwork was first established through qualitative methods. Based on the conceptual framework, survey feedback from quantitative research was conducted on volunteers, and feedback from qualitative research was conducted on experts through interviews to obtain a prototype design, which was further modified through interviews with experts and feedback from use by the volunteer audience. The final design was finally tested in a quantitative way.

The study was divided into four distinct phases: the first phase was the conceptual framework phase; the second phase was the investigation and prototyping phase; the third phase was the testing phase; and the fourth phase was the evaluation of the results.

Throughout the research process, experts, volunteers and audience members, as the main samples of the study, provided very crucial data references and feedback. The main independent variable of the study was the filigree inlay exhibition upgraded with digital reality technology, which influenced the dependent variable of the audience's knowledge of filigree inlay. The control variables were consistent across the traditional and digital reality upgraded exhibitions. Questionnaire questions and targeted interview transcripts were designed with varying degrees of accuracy in the collection of data at each research stage. The completeness of data collection, including Likert scale assessment and mean calculations, as well as the assessment of expert data provided a more accurate judgment of the design and adjustment of the study. The use of an integrated research methodology was ensured for the effectiveness of the digital reality techniques utilized in the filigree inlay exhibition.

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CHAPTER 4 RESEARCH RESULT

This chapter carries out the research design according to the research objectives mentioned earlier regarding the learning analysis of the content and process of filigree inlay, the learning analysis of digital reality technology and application theory, and elaborating the design process.

The first stage is a comprehensive study in three ways, including a questionnaire survey, expert interview, and field study. The questionnaire survey quantitatively analyzed 455 volunteers about the needs and preferences of the filigree inlay exhibition. In the expert interview stage, the researcher qualitatively analyzed the craftsmanship of filigree inlay and the exhibition needs of filigree inlay exhibition organizers. During this stage, the researchers also gained a more accurate and detailed production process of filigree while performing the field study. Finally, the content of the filigree inlay that needs to be used most for interactive experience through digital reality technology will be summarized.

Later, interviews with experts were conducted as the primary method for analyzing digital reality technology. The interviews focused on using digital reality to create a better interactive experience for the filigree inlay experience. This chapter also included a summary of digital reality technology suitable for the current stage, from feasibility to better experience and what type of technology can deliver what type of filigree inlay content.

Lastly, the complete design process of making filigree inlay content media includes visual style selection, draft design and selection, interactive prototype testing and feedback, program development, final testing, and test results.

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4.1 Questionnaire Data Analysis

The data analysis from 455 respondents reveals that their attitudes toward filigree inlay exhibitions and preferences leaned toward interactive displays and informative content about its techniques and history. Results will be presented as follows:

Question 1: Ranking of preferences for the content of non-heritage exhibitions

Volunteers were asked to rank these six items from highest to lowest according to preference, and the ranking results were rated as the average composite score of the options = (Σ frequency × weight) / number of times the question was filled out. The survey is shown in Figure 36.

Figure 36

Ranking Results of the Survey on the Content Preference Level of Non-heritage Exhibition



Note. Collected and compiled by the researchers.

Figure 34 shows that knowledge of materials is given the highest preference, followed by classical relics and aesthetics, followed by knowledge of author information, craftsmanship techniques, and history. Based on this result, the degree of content in the experience can be designed accordingly.

Question 2: Ranking the importance of the characteristics of the non-heritage exhibits

In this question, respondents were asked to rank these six features in descending order of importance. The rankings were scored as the average composite score of the options = (Σ frequency x weight) / number of times the question was filled out. The result is shown in Figure 37.

Figure 37

Findings on the Order of Importance of the Features of the NRM Exhibitions



The first three key features revealed by the respondents are comfort, ease of understanding, and interesting themes, followed by interactivity, artifact displays, and artist and author information.

Question 3: Importance of Behavioral Outcomes after Participation in Non-Heritage Exhibitions

The question explored what outcomes volunteers found meaningful and interesting after a non-heritage exhibit. Four options were provided: learning about artifacts, creating DIY works, sharing the exhibit on social media, and participating in immersive experiences. The multiple-choice responses were calculated as a percentage of valid responses, with the results summarized and shown in Figure 38. Figure 38

Results of a Survey on the Importance of Behavioral Outcomes Following Participation in an Exhibition



Figure 36 shows that the majority of the respondents (63.08%) preferred to perform DIY of their work at the exhibition, 59.78% were willing to share on social media, 39.12% received a wealth of artifact information, and 27.03% participated in an immersive experience.

Question 4: Choice of topics to be combined with non-heritage

This questionnaire aimed to identify three critical topics of interest in filigree inlay culture: blessing rituals, combining cultural relics with modern functionality, and pattern application. The results are displayed in Figure 39, showing that 63.2% of respondents chose blessings ,28.5% the combination of cultural relics and the functional use of modern items, and 11 %, the application of motifs, respectively. **Figure 39**

Results of a Survey on Topics that can be integrated with Filigree Inlay



Note. Collected and compiled by the researchers.

According to the blessings, the researchers also surveyed the degree of interest in the six aspects. The survey results are shown in Figure 40, which shows the blessings regarding health longevity(73%), career lucky(60%), wealth (59%), study (44%), marriage happiness(33%), and children prosperity(20%)were mentioned according to their preferences.

Figure 40

Blessing Content Interest Level Survey



4.2 Filigree Inlay Expert Interview Analysis

The interview was conducted by focusing on the content of the exhibition as the organizer of the filigree inlay exhibition and the types of exhibitions of filigree inlay to gain a better understanding of the process of filigree inlay. The interview's specific content was conducted by Mr. Ma Weisheng, the inheritor of Liangshengda Filigree Inlaid Specialty Art Co., summarized in Table 16.

Table 16

Interview with Chinese Filigree Inlay Expert: Detailed Q&A

Question	Answer
1. How did you learn and master	As an inheritor of the filigree inlay
the technique of Chinese filigree	technique, I have been exposed to this craft
inlay?	since I was a child. During the learning
	process, I first started with the basic simple
	processes such as pinching and welding, and
	after a lot of practice and repeated
	operations, I went through every aspect of
	the inlay process, from the drawing of metal
	wires and the design of patterns, and through
	the combination of innovation and modern
	design.

2. In your understanding, what	First, it is a traditional handcraft skill of
are the main characteristics of	great finesse and artistry. Even the slightest
Chinese filigree inlay?	deviation affects the result.
	Secondly, it is based on metal lines, and
	through multi-layered wire stacking,
	gem-setting, and other techniques, the work
	presents a delicate effect
3. What materials are used in the	The main materials used are precious metals
Chinese filigree inlay process?	such as gold, silver, and copper, which are
How are these materials	flexible and easy to draw and shape.
obtained?	Gemstones, jade, coral, and agate are also
	used for inlays
4. What is the special 1977	Filigree inlay has an extremely special place
significance or status of Chinese	in our hometown and in the whole Chinese
filigree inlay technology in your	culture. It has led our village out of poverty.
hometown or culture?	
Sh	XIP JAT T
5. What do you think is the value	It also represents the highest craftsmanship
of filigree inlay today?	of Chinese gold and silver craftsmanship. It
	is our Chinese luxury.
6. What are the challenges and	There are still a lot of people who like to
difficulties facing the inheritance	approach us for customization. However,
and development of Chinese	this skill requires very high handmade
filigree inlay?	precision which needs years of practice and
ingree may.	accumulation, and the craft is hard to be
Jne	recognized and loved Secondly, the cost of
101	craft works is high
7 How did war and id d	
I = HOW (110 VOI) CODE With the	We actively participate in all kinds of
/. How all you cope with the challenges and difficulties in the	we actively participate in all kinds of non-heritage cultural promotion activities
/. How did you cope with the challenges and difficulties in the inheritance and development of	non-heritage cultural promotion activities,
7. How did you cope with the challenges and difficulties in the inheritance and development of Chinese filigree inlaw?	we actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know shout this craft
challenges and difficulties in the inheritance and development of Chinese filigree inlay?	we actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know about this craft.
challenges and difficulties in the inheritance and development of Chinese filigree inlay?	we actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know about this craft. Including some online communication methods
 7. How did you cope with the challenges and difficulties in the inheritance and development of Chinese filigree inlay? 8. Have you ever tried to 	we actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know about this craft. Including some online communication methods.
 7. How did you cope with the challenges and difficulties in the inheritance and development of Chinese filigree inlay? 8. Have you ever tried to combine Chinese filigree inlay. 	 we actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know about this craft. Including some online communication methods. Yes, for example, for the Winter Olympics we combined filigree inlaw with inde to
 7. How did you cope with the challenges and difficulties in the inheritance and development of Chinese filigree inlay? 8. Have you ever tried to combine Chinese filigree inlay tachniques with other art forms. 	 We actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know about this craft. Including some online communication methods. Yes, for example, for the Winter Olympics we combined filigree inlay with jade to make a curling convenir. We clear true to
 7. How did you cope with the challenges and difficulties in the inheritance and development of Chinese filigree inlay? 8. Have you ever tried to combine Chinese filigree inlay techniques with other art forms or techniques? 	 We actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know about this craft. Including some online communication methods. Yes, for example, for the Winter Olympics we combined filigree inlay with jade to make a curling souvenir. We also try to
 7. How did you cope with the challenges and difficulties in the inheritance and development of Chinese filigree inlay? 8. Have you ever tried to combine Chinese filigree inlay techniques with other art forms or techniques? 	 We actively participate in all kinds of non-heritage cultural promotion activities, through exhibitions, fairs, and other ways to let more people know about this craft. Including some online communication methods. Yes, for example, for the Winter Olympics we combined filigree inlay with jade to make a curling souvenir. We also try to combine it with more innovative and topical

9. What suggestions or guidance	Advice for beginners. First, we must have
do you have for beginners or	enough patience and concentration, filigree
those interested in Chinese	inlay is an extremely delicate skill, that
filigree inlay?	needs a long time to practice mastering.
	Secondly, the basic work is very important,
	learn to pull the wire, pinch the wire, and
	other basic techniques to lay a good
	foundation. Then more understanding and
	study of traditional culture, because filigree
	inlay is not only a craft, but also the
	inheritance and understanding of Chinese
	culture.
10. What are your prospects or	I hope that more young people willing to
expectations for the future	learn about this skill, and only by constantly
development of Chinese filigree	injecting fresh blood can we ensure its
inlay?	continuation. Secondly, I hope that it can be
22	displayed and promoted in a technological
/ July	way. I expect that filigree inlay is not only
	limited to traditional jewelry but can also
	find applications in more fields, such as
ale a	fashion design and home decoration.
11. How do you think can we	First, education is key. We need better ways
better promote and protect the	to attract more young people to the craft.
Chinese filigree inlay?	Modern technology can also play an
	important role. Secondly, we also need to
923	enhance the protection of intellectual
Jnos	property rights and non-heritage culture.
12. Which production process do	There are several key steps in the most
you think define Chinese filigree	specialized production process of filigree
inlay?	inlay. The first is the production of filigree,
	which is mainly a process that uses metal
	filigree as the main application; in fact, it is
	the "pinching" process, which is the core of
	the whole technique. Pinched wire requires
	the craftsman to precisely bend the hair-thin
	gold and silver wire into various complex
	patterns and shapes, which not only tests the
	craftsman's skill but also requires great
	patience and concentration. Then come the
	"filling" and "soldering" steps, which secure

	and join the pinched wire patterns together
	to make them strong and durable. These
	steps are done by hand and there is no room
	for error. Finally, the "setting" of the stones
	is the key to the value of the piece.
13. What content do you want to	Currently, our exhibition is primarily a
showcase in the filigree	display-type exhibition aimed at promoting
exhibition?	this craft and helping visitors understand the
	production process of the technique.
	Currently our exhibition is primarily a
	display-type exhibition aimed at promoting
	this craft and helping visitors understand the
$(0) / \epsilon$	production process of the technique.
	Additionally, our works participate in
	awards from the Craft Art Industry
E C - A	Association. We also hope that more people
	pay attention to filigree inlay and inspire us
	with innovative ideas for our creations.
14.What are your expectations	We hope to attract a wide audience,
for the audience of the filigree	especially young people, to understand and
inlay exhibition?	participate in this traditional craft. We are
	also exploring online communication
	methods to promote the filigree inlay craft
	and products.
15.What are your expectations	I hope that visitors have a deep impression
for the takeaways of young	of the beauty and complexity of filigree
visitors after attending the 7	inlay and that they willing to further learn
filigree inlay exhibition?	about and experience it. I also hope to
	promote the sales and marketing of filigree
	inlay products, attracting more people to
	participate in this field.
16. Do you have any suggestions	First, we can spark the audience's interest by
------------------------------------	--
for the content of the interactive	using innovative methods to present the
experiences in the exhibition?	content. Since filigree inlay is considered a
	luxury craft in China, I hope to bridge the
	gap between the audience and the art of
	filigree inlay through interactive
	experiences, allowing them to participate in
	the creation of the content. Since filigree
	inlay is considered a luxury craft in China, I
	hope to bridge the gap between the audience
	and the art of filigree inlay through
	interactive experiences, allowing them to
	participate in the creation of the artwork. of
Xar / E	the artworks.

Note. Collected and compiled by the researchers.

4.3 Field Study in Filigree Inlay Studio

The field study mainly involved in-depth experience and practice of making filigree inlay. During this process, the researcher also experienced making filigree inlay in the studio. The field study allowed the researchers to observe the actual drawing, pinching, filling, soldering, and inlaying processes. Especially in filigree, the fineness of craftsmanship and artisanal spirit were also patiently explained. The knowledge of enameling and filigree was also discussed. Figure 41-43 shows the field study process results.

Figure 41

The Researcher Learning the Production Techniques in LiangShengDa Filigree Inlay Studio



Note. Photographed by the researchers. (2024)

Learning the Processes of Make Filigree Frame and Filling



Note. Photographed by the researchers. (2024)

Notes on the Filigree Inlay Craft Process from Learning at the Studio



Note. Photographed by the researchers. (2024)

4.4 Digital Reality Technology Application Analysis

4.4.1 Expert Interview Analysis

The researcher first conducted an interview with Mr. Kevin Ong, who is engaged in developing digital reality technology, to initiate an interactive experience focused on intangible cultural heritage crafts. Table 17 shows the details of the interview.

Table 17

Interview with MR Develop Expert: Detailed Q&A

Question	Answer
1. How suitable if use MR to	MR can exist virtual and real in a space so
develop a digital Chinese filigree	that the audience can not only see the
inlay exhibition?	physical exhibits but also through the virtual
	scene to understand the production process
	of filigree inlay. For example, we can use
	MR technology to show the whole process
	of stretching, pinching, and inlaying of gold
	wire next to the real exhibits to enhance the
	audience's sense of interaction and
	immersion.
2. What are the key factors to	At the heart of the MR experience is user
consider when developing mixed	interaction, so you need to ensure that the
reality experiences?	interface is user-friendly and easy to use.
	Interface elements should be intuitive, and
1 July	interaction should make sense so that users
	can easily immerse themselves in the
Con the Co	combination of virtual and reality without
alas	feeling complicated or confused.
3. What impact mixed reality	Traditional craftsmanship is often delicate
technology have on Chinese	and complex, making it difficult to fully
filigree inlay?	present through simple displays. With MR
	technology, viewers can see virtual details of
973	craftsmanship, such as the steps of filigree
17517	pinching, soldering, and inlaying.
	don
	MR can also combine modern technology
	with tradition for innovative displays.
	Through the virtual environment, designers
	can showcase novel filigree inlay works,
	modern design concepts, and creative
	applications.
4. How to ensure user comfort	It starts with a good UI design that makes it
when developing mixed reality	easy to guide the user through the process.
applications?	Secondly, it is important to consider that the
	number of facets of the model used is not
	easily too high, which can cause the program
	the safety of the site where it is used.

For to run out of flow.
To ensure stable use of the program, it is
tested and debugged.
It is also important to ensure example, the
display of cultural heritage, teaching and
training, recreation, and tourism.
It is still necessary to have interaction
methods and smooth UI interfaces that are in
line with the real experience; at the same
time, it can be used in conjunction with the
use of some sound effects to open the user's
multi-sensory experience and enhance the
sense of ambiance in the experience space.
This can be used according to the real needs;
for example, it can show the process; virtual
try on jewelry; cultural background
explanation or the display of cultural relics;
the design of crafts, and so on can be used.

Note. Collected and compiled by the researchers.

Based on Mr.Kevin Ong's interview, software such as Digital Reality Museum, Chinese Character Art Museum, Pottery Experience, and Digital Reality UI Design were mentioned to the researcher. The interview process is shown in Figure 44-45.



The Researcher Discussing Digital Reality Interactive Experiences with Ang, a Digital Application Developer Kevin



Note. Photographed by the researcher. (2023)

Figure 45

The Reseacher Trying Out a Vritual Experience



Note. Photographed by the researcher. (2023)

4.5 Design Process

4.5.1 Selection of Visual Style

In the visual style selection phase, the researcher explored the cultural visual style for filigree inlay. The design options included different visual styles and character modeling. Through expert evaluation and volunteer questionnaires, a style and image that more accurately conveyed and represented the craft of filigree inlay was firstly selected as per following criterions:

4.5.1.1 Virtual Content Style Design and Selection

Visual styles were further selected based on questionnaires and feedback from visual arts experts. Regarding the questionnaire survey, the researcher analyzed the visual presentation style preferences of the volunteers' filigree inlay content. The results of the analysis are shown in Figure 46.

Figure 46

Results of the Survey on Visual Style Preferences for Filigree Inlay Content



Note. Collected and compiled by the researchers.

Figure 47 shows that majority of respondents (33.63%) preferred the traditional Chinese style followed by modern Chinese style (27.25%), 24.18% preferred cartoon style and 14.95% chose real style.

Results of the survey of the Filigree Inlay Virtual Experience Scenario



Note. Collected and compiled by the researchers.

When asked about their preference for the virtual exhibition scenario (Figure 47), 38.9% of respondents preferred the handicraft workshop, while 30.99% preferred the exhibition, and 30.11% preferred the artifact's original site.

The literature review stated in the previous chapter reveals that color plays a crucial role in audience appeal, influencing both appreciation and engagement. Recognizing this, researchers conducted an additional survey to determine the most popular color preferences among attendants through the survey. The results from the survey reveal that the most preferred color, followed by and respectively (Figure 48) ยาลัย

Figure 48





Note. compiled by the researchers.

Based on the above survey results, the researcher conducted three preliminary designs and asked the experts for primary evaluation. The highest-scored design was adopted as the main visual style for this study. The expert comments and scoring of the three visual styles are presented in Table 18.

Table 18

<i>Comments and Ratings from Experts</i>	on the Three Visua	l Styles
--	--------------------	----------

Design Style	Comment	Score (0-10)
	1. The characteristics of filigree inlay	5.3
- ACL	are not well represented.	
	2. The lines appear unclear in the MR	
	visual effect.	
STARL	3. The transparency design has depth,	
	but it affects the prominence or	
	clarity of the virtual content.	
START	4. The visual style is like the real	
	world, which weakens the sense	
	of immersion.	
Contraction of the second seco		
	1. It showcases the characteristics of	8.3
礼丝镶嵌	imperial craftsmanship.	
	2. It offers a unique visual effect	
开始START	different from the real world,	
	making the experience more	
	engaging.	
	3. Needs additional atmospheric	
A A	layers to make the visual effects	
中 · 并 · 绘 START	more dynamic.	
	4. The edges of interactive buttons	
	should be clear and smooth.	
	5. What elements are used in the	
	dialog box?	



- 2. The ple 3. The we
- 1. The visual style resembles the Song or Tang dynasties, which does not match the flourishing Qing dynasty aesthetic.
 - 2. The color saturation is very pleasing.
 - The elegant style does not align well with the lavish nature of filigree inlay.

Note. Compiled by the researchers.

7.5

4.5.1.2. Character Design and Selection

Before the character design, the researcher surveyed the preferences of the character's image. According to the survey results in Figure 49, the researcher designed two characters with different images and the inspiration and process of character design. The most popular character design was selected through a secondary survey by volunteers.

Figure 49

Preferred NPC Character for the Interactive Experience



According to the volunteers' survey data, the characters in the experience preferred to be associated with artisans and images of the same age as themselves. For this reason, two image designs based on this result are presented in Figures 50-53.

Figure 50

Character Design Sketch



Note. Illustrated by the researchers.

Final Character Design



Note. Illustrated by the researchers.

The two images of bat were evaluated by the volunteers by their preference and the results are shown in Figure 54.



Based on the results, the majority chose role two. The reasons for this are mainly more recognizable and memorable; it also has a good symbolism; and the image is more vivid. Therefore, the researcher used image two as an interactive character to guide the audience.

4.5.2 Design and Selection of Digital Experience

In the draft design stage, the researcher designed the sketch program including AR virtual content, and MR interactive experience script process. Through expert review and multiple rounds of adjustment, the final choice was made to show the filigree inlay process while ensuring audience participation and learning in the exhibition.

4.5.2.1 AR Design and Selection

The sketching design process of the AR part is mainly divided into the design of the identification diagram and the design of the virtual content display. Regarding the content of the identification diagram, the researcher selected two design options, namely the process and illustrations with beautiful symbols combined with the filigree mosaic culture, such as traditional patterns and motifs, as identification markers to ensure their uniqueness and recognition rate. These two options were selected through expert feedback respectively. The experts' feedback and scores are shown in the Table 19.

Table 19

Expert Feedback and Ratings on AR Experience

Design Style	Feedback Content	Score (0-10)
	 There is an introduction to the craft, but there is no dissemination of the cultural aspects of filigree inlay patterns. If the craft is illustrated, it would be more suitable for the content created by the artisans and more engaging. The flowchart resembles an instruction manual and lacks communicative value. 	6.5
	 The design is very decorative; I recommended add the text for introduction and explanation of the meaning. The pattern content Extraction needs to be accurately and briefly shown. 	8.7



Note. Compiled by the researchers.

According to the experts' suggestions and survey results, the researchers decided to refine the second option, extract the symbolism of the filigree mosaic relics, combine it with the audience's favorite symbolism of praying for blessings, and make three kinds of AR identification charts. The design process is shown in Figure 55. **Figure 55**





Note. Illustrated by the researcher.

The second identification chart combines the filigree process of filigree inlay and filigree filling with wealth and blessings, and the design process is shown in Figure 56.

Figure 56

The Design Process Using Filigree Elements of the Prayers of Wealth and Blessings Image



Note. Illustrated by the researcher.

The third identification chart combines the soldering and inlaying process of filigree inlay with the blessing of a long and healthy life, and the process of combination is shown in Figure 57.

Figure 57

The Design Process Using Welding and Inlay Elements of A Long and Healthy Life Image



Note. Illustrated by the researcher.

A sketch flow was designed for the virtual animation display of the AR stage based on the process flow. The overall process was divided into the most basic six links for display. The six links are placed in three identification diagram scenes to reduce the single playback time and increase the audience's participation. The process sketch design is shown in Figure 58 and Figure 59.

Sketch Design of the AR Virtual Information Content



Note. Illustrated by the researchers.

Figure 59

The Design Process of the AR Virtual Content Process



Note. Illustrated by the researchers.

4.5.2.2 MR Script Design and Selection

A total of two scripts were designed for the MR. The first script failed to meet the actual research objectives after testing due to an incomplete research process that did not incorporate the opinions of experts and professors in a timely manner. The design process of the second script was then launched. The two script design processes have been shown below.

1. The first script program

This script program wants to let the audience realize the DIY of filigree inlay jewelry through MR, and complete the learning of the culture of filigree inlay pattern in use. The design is shown in Figures 60-69.

Figure 60



Note. Illustrated by the researchers.

The Design of the Task 1 Introduction Screen (1)





The Design of the Task 1 Introduction Screen (3)



Note. Illustrated by the researchers.

The Design of the Task 1 Introduction Screen (5)



Note. Illustrated by the researchers.

The Design of the Bless Meaning Explaination Screen (1)



Note. Illustrated by the researchers.

This design was scripted followed by a simple functional build in Unity. The building effect is shown in Figure 70. And 12 volunteers were tested to use the program, and the user feedback in the test is shown in the Table 20. Through the collection of feedback, it is obtained that this program could not complete the user experience very smoothly, and the learning content of filigree inlay knowledge is too little. Therefore, this program is not available for use. However, the problems generated by this design have drawn lessons for the second program.

Figure 70





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Note. Illustrated by the researchers.

Table 20

Summary of Feedback From 12 Users Testing the First Program

Number	Adjustments Content
1	Lack of pedagogical content to use
2	The viewpoint is constantly moving, and the position of the model
	cannot be fixed.
3	Model effects can't be harmonized with materials and glosses in MR
4	Models cause the system to lag and not flow smoothly
	An An
5	Not satisfied with learning the content of filigree inlay workmanship
	A A == A B
6	DIY sessions have too much freedom for users to complete the
	experience in its entirety
N (C	

Note. Compiled by the researchers. Therefore, since the test could not achieve the research objectives and the interaction design could not be used smoothly, it was decided not to apply this solution.

2. Second Experience Design

After summarizing the experience of the first failure, the second script design was carried out by re-establishing the opinions of experts and testers under the guidance of the professor. This script design started with the process design of sketching and the design is shown in Figure 71. Modifications were made through as shown in Figure 72 to prototype the interaction through Figma.

The Filigree Design Sketches of the MR Experience Using Post-it Notes



Note. Photographed by the researchers.

Figure 72

Flow Interaction Testing Using Paper Prototyping Technological



Note. Photographed by the researcher.

In the test, the following issues were modified according to user satisfaction, for example, a user operation teaching board was added to teach players before the program started; gesture interaction was modified to be more accurate, and more steps were added to ensure that each step linked smoothly with the next one without delay of information.

Based on the test results of from previous preliminary draft, the researcher created interaction prototypes using Figma to restore the interaction except for the gesture controls. The content of the design in Figma is shown in Figure 73-107. The interaction prototypes generated through Figma are further given to experts and volunteers for testing and feedback.



Note. Illustrated by the researcher.

The Design of the Hand Gesture Instruction Screen



Note. Illustrated by the researcher.

The Design of the Experience Objective Screen



Note. Illustrated by the researcher.





Note. Illustrated by the researcher.

The Design of the Torch Usage Instruction Screen (2)



Note. Illustrated by the researchers.

The Design of the Making of Filigree Rod Screen



Note. Illustrated by the researchers.

The Design of the Carbide Drawplate Information Screen



Note. Illustrated by the researcher.

The Design of the Ineraction Instruction to Operate the Drawplate Screen



Note. Illustrated by the researchers.

The Design of the Filigree Type Explanation Screen (Simple Circular Filigree)



Note. Illustrated by the researchers.

The Design of the Circular Braided Filigree Type Making Instruction Screen (2)



Note. Illustrated by the researchers.
The Design of the Filigree Wire Cutting After the Creation of the Filigree Frame Screen

Set 第七步 掐丝 Step 7 Filigree Frame 掐丝图纸 Filigree Frame 切影 CUT Note. Illustrated by the researchers. Figure 92 The Design of the Filigree Frame Completion Screen 第七步 掐丝 Step 7 Filigree Frame 掐丝图纸 Filigree Frame

Note. Illustrated by the researchers.

The Design of the Filigree Circular Frame Instruction Screen



Note. Illustrated by the researchers.

The Design of the Flat Filigree Creation Instruction Screen



Note. Illustrated by the researchers.

The Design of the Filigree Filling Instruction Screen



Note. Illustrated by the researchers.

The Design of the Welding Flux Creation Instruction Screen



Note. Illustrated by the researchers.

The Design of the Filigree Flux Mixing Information Screen (2)



Note. Illustrated by the researchers.

The Design of the Flux Making Completion Screen



Note. Illustrated by the researchers.

The Design of the Welding Screen



Note. Illustrated by the researchers.





Note. Illustrated by the researchers.

4.5.2.3 Extraction of Pattern Culture

According to the survey results, which portrayed the high demand for blessings, the researcher created the filigree inlay pattern related to this symbolism and meaning. This process mainly included the study of traditional patterns, screening, and redesigning the selected elements. Figure 108 shows the process of pattern sourcing, screening, and drawing.

The Process of Extracting Patterns



Note. Illustrated by the researchers.

4.6 Prototype Testing

AR and MR interaction prototypes were introduced to 20 volunteers and three experts for testing. The volunteers and experts were requested to make suggestions for optimizing the details of the design prototypes. The suggestions were categorized into content, visual, and interaction as shown in this following step.

4.6.1. Audience Testing

The researcher summarized the opinions of the 20 volunteers into three categories, which are presented in Table 21.

Table 21

Suggestions from Volunteers After Testing the Interaction Prototype

Suggestion Type	Suggestion Content
Element	1. Some operation pages have a lot of information, it is
	recommended to add buttons to autonomously control the
	jump time
	2. The language used to introduce the content could be
	more concise
	3. The arrows in the drawing session are not clearly
	labeled, and it is impossible to tell what the change is at
	first glance
Experience	1. Headgear needs to be wiped down and sanitized after
	each person uses it
	2. Standing experiences are better than sitting experiences
Other comments	1. The gesture interaction section can be clearer with
	patterns instead of text.
	2. Is it possible to add some material sound effects to the
	interaction, such as fire sound effects
as	
ote. Compiled by the	researchers.
1	

4.6.2 Phototype Testing Result by Experts

• Filigree Inlay Expert Test

The filigree inlay expert conducted testing based on the interactive prototype script. The researcher interviewed the expert using questions in a Table 22 and received the expert's feedback for revisions.

Table 22

Suggestions from Filigree Inlay Expert After Testing the Interaction Prototype

Test Content	Result	Suggestion
1. The knowledge	Valid	1. When melting you can add a bowl
about Chinese		tong to hold the bowl;
filigree inlay		2.It is proposed to eliminate flat
presented in the		filigree, which is commonly used in
experience is	AA	enameling;
valid.	C3 LIX F	3.A slate could be added below the
f in the second s		welding link;
	Th 1:0	4.A drawing board can usually only
	L' BAR	do 0.5mm in diameter can be used.
		MAD
2. The experience	Good	It's cute, impressive, and the moral
shows the		is good too.
characteristics of		
Chinese filigree		SEN M
inlay	K DY	27/5)
3. The	Good	The interactive sessions were all
interactivity in the	Incis	very experiential and the
experience is	212138	movements were very much in line
suitable.		with the actual hands-on actions.
1 The comfout of	Good	The information is uncluttored
4. The comfort of	GOOU and Comfortable	and the flow is smooth, however
the experience?	and Connortable	the length of the experience is
		kept to about 5 minutes as much
		as possible
		as possible.

Note. Compiled by the researchers.

4.6.3 MR Development Expert Testing

After experiencing the interactive prototype, the MR development expert provided feedback on the feasibility of the program's MR implementation, offering suggestions for overcoming certain technical development challenges and recommendations on how to improve the overall experience. The expert's specific feedback is presented in Table 23.

Table 23

Test Content	Feedback
1. What technical	1. It's better to use tandem mode to finish smoother
issues have you	2. Models should be kept at 10,000-30,000 polygons
experienced?	for low to mid-range devices to ensure smooth
	rendering
	3. Ensure that the text appears clearly in MR by adding
	a background color or stroke.
	4. Interaction involves liquid modeling and liquid
, E	dynamics, which is costly to develop, and can be
5	converted to 2D animation if the teaching
	dissemination effect is not affected.
B	5. MR's equipment requires frequent headgear for
	debugging during production.
2. How would the	1. Add some sound effects to make the experience
experience be	more realistic
improved?	2. UI material and model animation material must be
	clear, using at least 1080p (1920x1080) resolution
	image material

The MR Development Expert Provided Development Feedback After Testing the Interactive Prototype

Note. Compiled by the researchers.

4.7 Prototype Adjustments

Based on the volunteers' tests and expert feedback, adjustment made to the interactive prototype in Figma as shown in the Table 24. The revised plan is more feasible, the instructional content is more accurate, and the UI design is better suited.

Table 24

<i>Modifications</i>	Were	Made t	o the	Interactive	Prototype	Based	on	Feedb	ack

Number	Adjustments Content
1	Added tools used during the process: pliers, slate,
	refractory plates
2	Optimized text messages
3	The description of the interaction method has been
	changed from text to a graphical representation.
4	The design of the arrows in the drawing section was modified
5	Added manual jump button
6	Modified the interaction of round filigree
7	Stroke the text
8	Modified 2D animation effects for liquid dynamics

4.8 Model Production and Program Development

4.8.1 AR Production and Development

The production of AR is divided into the production of transparent animation video and the production of AR scenes. Transparent animation video applies Adobe After Effects; the construction of AR effect scene applies Kivicube platform to realize, the platform can realize the user through the WeChat small program to scan the picture recognition.

Transparent animated video production

Kivicube transparent video does not mean that the video contains Alpha channel (we know that mov and avi format can be with Alpha channel), but a "special" form. We need to create a whole video is a solid black background color, the left half: the source video (transparent video with Alpha channel) in the transparent part of the conversion to solid black, the right half: the source video of the transparent part of the conversion of solid black, non-transparent part of the conversion of solid black, the first step is to create the animation through Adobe After Effects first, the specific production process is shown in Figure 109.

Figure 109

Adobe After Effects Animation Creation Process



Note. Illustrated by the researchers.

The finished video needs to be exported using the video and audio encoding software Adobe Media Encoder. When exporting chooses Quicktime format, preset GoPro SineForm RGB 12-bit alpha at Maximum Bit Depth as shown in Figure 110.

Figure 110





The second step is to put the exported animation into the After Effects software again to make the transparency. Special transparent video needs to be as shown in Figure 111 effect, the left side of the normal animation, the right side of the white mask for the animation effect; production is complete and then exported through the Media Encoder to the preset H.264 MP4 video format can be. Export video format shown in Figure 112.

Creating Transparent Video Format in AE



Figure 112

Transparent Video Export Format Settings



Note. Illustrated by the researcher.

AR scene creation

Go to the Kivicube platform and create an image AR scene. Upload the recognition image and the created transparent video after creation. Create a desktop for Kivicube's AR scene as shown in Figure 113. In the scene, the size and position of the AR virtual content can be adjusted. The recognition map of this design is shown at 90 degrees to the virtual content. It is more convenient for the audience to see the finished animation effect by scanning the postcard. The session created three scenes covering the basic craft process demonstration of filigree inlay.

Figure 113

The Process of Making Three AR Scenes in Kivicube



Note. Illustrated by the researcher.

AR effect display

The three identification diagrams demonstrate the six conventional steps of filigree inlay: drawing, pinching, filling, stacking, soldering, and inlaying. The effect of the six steps is shown in Figure 114.

Figure 114

Six Filigree Processes in AR



Note. Photographed by the researchers.

4.8.2 MR Production and Development

The second layer of immersive interactive experience in this research, MR gesture control is chosen to realize the interaction of virtual reality overlay. The production of MR is mainly divided into three phases: model creation, platform development, and debugging and testing. The content presented in MR is mainly divided into flat UI and 3D models. The model is created by Blender to ensure that the polygon count of the model is suitable for real-time rendering. Materials, textures and lighting effects are added according to demand to enhance the realism of virtual objects. Program development is carried out through Unity to realize the superposition and interaction of real and virtual scenes.

Modeling

The modeling is done using Blender and finally exported to. fix format for use. The elements to be modeled in MR are filigree inlay components, hairpin base, earring base, necklace base, gemstone, operating table, tray, and display stand. The process of modeling is demonstrated in Figure 115. The rendering is shown in Figure 116.





Note. Illustrated by the researchers.

Figure 116 *The Rendering Effect of the Model*



UI design

The UI design of this study is mainly applied to the experience of MR. The design is inspired by the ancient Chinese flower and window pattern of the disk long pattern, as shown in Figure 117; the interaction design effect of the buttons is shown through 118; the UI design of the home page is shown in Figure 119; the design of the information box of the UI, the design style is shown through Figure 120; and the title UI design is shown through Figure 121.

Figure 117

Ancient Chinese Flower and Window Patterns with Disk Long Patterns Redesigned



Note. Illustrated by the researcher.

Figure 118

Button Interaction Design



Note. Illustrated by the researcher.

The UI Design of the Information Box



Note. Illustrated by the researcher.

UI Information Hierarchy Design



4.8.3 Animation Process

Considering the development feasibility, this study decided to use it for MR experience through 2D animation. Firstly, the interaction content that requires the use of animation was identified. Next, the movement patterns and state changes of the objects were determined. Then, the drawing software drew frame by frame to ensure that each frame was coherent with the other frames. The drawing process of each animation frame is shown in Fig. All the animations when it comes to the material part, are all categorized into gold and silver materials, and the figure shows the animation for the gold material. Next, the three animation frames were exported to PNG format suitable for the MR platform. Finally, the 2D animation is integrated into the virtual environment through MR development tools to ensure that it runs smoothly in the interactive experience and is linked to user actions. In this way, the user can visualize the animation effect in MR to enhance the sense of immersion (Figure 123-129).

Frame by Frame Character Animation





Frame by Frame Torch Animation



Note. Illustrated by the researchers.

Frame by Frame Filigree Frame Creation Animation



Note. Illustrated by the researchers.

4.8.4. Platform Development

MR's platform development of choice uses Unity. unity supports multi-platform development, enabling rapid deployment of projects to different devices and operating systems, such as PCs, cell phones, MR, and AR devices. With powerful 3D and 2D engines, it is suitable for developing complex interactive scenes and high-quality graphical content.

Unity platform development can be divided into the following stages. Create an MR environment: Enable mixed reality plug-ins such as Windows Mixed Reality or Oculus in the XR Plug-in Management tab; Gesture interaction design: Import the Mixed Reality Toolkit (MRT) in the Unity Package Manager. Toolkit (MRTK) in the Unity Package Manager, which is a toolkit designed for developing mixed reality applications. It provides basic interaction functions such as gesture, voice, and spatial mapping. Allow users to interact by grasping, rotating, and scaling the model. The Unity development process is shown in Figure 130.





Note. Photographed by the researcher.

Check whether the gesture interaction meets the expected results. Adjust the scenario, interaction rules, and user interface based on the test results to optimize the user experience as shown in the Figure 131-132.

Figure 131

Using Gesture to Control Torch



Note. Photographed by the researchers.

4.9 Final Testing

The final testing phase is divided into audience questionnaire testing and expert interview testing to ensure that the design ultimately makes the most realistic judgment of the effects produced by the filigree exhibition.

The questionnaire test will be conducted separately for two groups: 40 visitors who attended the traditional exhibition and 40 visitors who attended the exhibition upgraded with digital reality technology, respectively. The questionnaire consists of 10 questions and is divided into three levels: easy, medium, and difficult. It was administered after the audience visited the exhibition.

The study invited MR development experts and filigree inlay craft experts to evaluate the prototypes. The MR experts mainly focused on the details of the technical implementation and provided suggestions on how to optimize the program performance and enhance the user experience, while the craft experts evaluated the accuracy of the content and the reproduction of the artistic expression and suggested further improvements.

4.9.1 Traditional Exhibition Test Results

The study was tested on a group of 40 people who visited a filigree inlay exhibition as shown in the Figure 133.

Figure 133

Audience Testing at the Filigree Inlay Exhibition (Traditional Exhibition)



Note. Photographed by the researcher. (2024)

40 volunteers were requested to answered 10 questions after conducting a tour at the exhibition. The final average accuracy rate was 32.74% as shown in the Table 26.

Table 25

Test Results for Traditional Exhibition Regarding the Knowledge of Filigree Inlay Process

Title No.	Frequency	Accuracy Rate
1	35	87.5%
2	18	45%
3	21	52.5%
4		20%
5	A 12	30%
6	10 2 4 4	25%
7	4	10%
8	3	7.5%
9	Sun 137 home	42.5%
10	3	7.5%
Average Value		32.75%
<i>Note</i> . Compiled by th	ne researchers.	2113

4.9.2 Digital Reality Exhibition Test Results

The Digital Reality exhibition was tested for use through 40 visitors by incorporating AR and MR experiences. The exhibition test poster is shown in the picture and the test site is shown in Figure 134. Volunteer audience test scenarios are shown in Figure 135.

Figure 134

AR and MR Filigree Inlay Experience Exhibition Poster



Note. Illustrated by the researchers.

Photos of the AR and VR Filigree Exhibition



Note. Photographed by the researchers. (2024)

After the experience, the volunteers were requested to answer 10 questions, the percentage of the correctness of the questions was 78.75% as shown in the Table 26. Table 26

AR and MR Interactive Ex	xperience Exhibition	Test Results of the	he Knowledge of
Filigree Inlay Process			

Title No.	Frequency	Accuracy Rate
1	40	100%
2	34	85%
3	32	80%
4	36	90%
6	35	87.5%
6	29	72.5%
7	28	70%
8	22	55%
9	30	75%
10	29	72.5%
Average Value	ALESS P	78.75%

4.9.3 Expert Test Results

The final design was presented and experienced to the three experts, who gave evaluations and suggestions from three aspects, namely, the communication of the content of the filigree mosaic and the objectives of the exhibition, the experience of the application of digital technology, and the visual design. Table 27 provides specific feedback from the filigree experts.

Table 27Feedback from Filigree Experts on the Final Work

Details			
1. Detailed steps convey knowledge of the filigree inlay			
process, reducing the difficulty of the experience while at			
the same time providing a sense of participation in the			
experience.			
2. It's nice to be able to iterate and pick and choose learning			
steps for easy review			
3. MR's see-through effect allows you to see the outside			
environment, suitable for frequently moving exhibition			
environments.			
4. Helpful for learning the filigree process in a new and			
more interesting way!			
The possibility of including a display of filigrap inlay work			
The possibility of menualing a display of finglee may work			
in the future			
in the future e researchers.			
in the future e researchers.			
e researchers.			
e researchers.			
e researchers.			
e researchers.			
e researchers.			
in the future e researchers.			

Table 28 shows the digital reality technologists' feedback on the final work. Table 28

F	eedback from Digita	al Reality Experts on the Final Work
	Type of Feedback	Details
	General Comment	1. Interaction effects are currently smooth and stable
		2. Overall smoothness and fluidity, no lag in operation that
		is unknown

	is unknown
	3. Great for science and demonstration learning as a process flow
Suggestion	1. Recognition of gesture interactions requires more standardized gestures, which can be guided in teaching more standardized gestures
	2. In the future, it is possible to include a user feedback collection function to be able to analyze the user experience with the help of data. Enhanced Learning Effectiveness
	3. MR can turn off the protection mode when using it, the viewing angle will be more stable
<i>Note</i> . Compiled by t	he researchers.
Table 29 below shows the feedback from the visual arts experts on the evaluation and recommendations of the final work.

Table 29

Feedback from Visual Art Experts on the Final Work

Type of Feedback	Details			
General Comment	1. The visual style is consistent with filigree inlays.			
	2. The overall UI is smooth, and the instructions are simple			
	and clear.			
	\wedge			
	3. Can be very effective in conveying information,			
	4. Each interface and scene are well-composed and helps			
	guide the user's visual focus.			
Suggestion	1. It is recommended to test the contrast of the visual and			
	the brightness of the scene where the information you are			
	looking for stands out clearly.			
L	2. In the future, you can add some technology to the			
a	traditional style. More Innovative.			

Note. Compiled by the researchers.

4.10 Testing Result Analysis

In the final test of the filigree inlay AR and MR display process, we collected data from two perspectives: the learning level of user knowledge and expert evaluation suggestions. Through the final test, we obtained a large amount of feedback, which provided a valuable reference for improving the display design.

First, from the comparative data of users' acquisition of knowledge about the process of filigree inlay, the interactive experience exhibition using AR and MR methods increased the correct rate of knowledge learning by 46% compared with visiting the traditional exhibition. Most volunteers indicated that learning about the filigree inlay process through AR and MR displays was a novel and attractive way. Experienced viewers believe that the AR recognition map is very suitable for the aesthetics of people nowadays and is decorative, and the virtual content of AR helps users understand the complex steps in the filigree inlay process more intuitively and quickly. For the MR experience, the experiential audience generally thought that the combination of interactivity and virtual reality was novel and interesting, and the gesture interaction made the process more vivid, enhancing the understanding of the details of the filigree inlay process and the learning of the overall process.

Secondly, in terms of expert feedback, filigree inlay craft experts believe that AR and MR technology has realized the communication of knowledge in displaying the crafting process, especially the details and gesture interaction, which is very memorable. Digital technology experts pointed out that the technical application of AR and MR meets the requirements of the exhibition, and the completion of the sense of experience will get better and better with the development of technology. The visual art expert highly praised the overall visual design and interaction fluency but suggested that more attention could be paid to the combination of science technology and culture as well as the brightness contrast with the real scene in the UI design.

Summarizing the above feedback, the final test results show that AR and MR technologies are effective in demonstrating the filigree inlay process. This feedback will help us to improve the user experience effect in the subsequent optimization.



CHAPTER 5 RESEARCH CONCLUSION

This research aimed to develop an interactive augmented reality (AR) and mixed reality (MR) media experience for filigree inlay exhibitions, enhancing engagement and understanding of the art form. Through innovative applications of AR/MR technology, the project successfully created a digital platform that enables users to visualize intricate filigree designs, interact with 3D models, and explore detailed craftsmanship in a virtual environment. The interactive media achieved the objective of providing a unique educational experience, allowing visitors to examine filigree art's historical and cultural aspects closely. User feedback demonstrated increased engagement, with participants expressing enhanced appreciation for the artistry due to the immersive, hands-on interface. This AR/MR approach represents a promising direction for cultural exhibitions, blending technology with traditional craftsmanship to preserve and promote cultural heritage. Future developments could expand to include additional artefacts, further enriching the museum experience and fostering broader cultural awareness. The consistency of the findings with the study objectives is verified. The discussion section verifies the consistency of the study expectations with the study results, compares such studies that are comparable to the field of this study, and discusses the differences with the study. The study's Recommendations and limitations were obtained based on the analysis. Finally, based on the analysis, the future research of this study is expected to explore the impact of digital reality technology on cultural experience and advocate using digital reality technology for a more diversified interactive experience to achieve better teaching of cultural experience. กยาลัยดิจ

5.1 RESEARCH RESULT DISCUSSION

According to the test results of this study, it can be said that the interactive experience exhibition of filigree inlay using AR and MR digital reality technology can improve the audience's learning ability regarding the knowledge of the filigree inlay process as well as increase the audience's interest in the experience of filigree culture. The test result shows that the ability to learn through the interactive experience exhibition of digital reality technology is 46% higher than the traditional exhibition. During the test, the audience showed higher interest in the immersive interactive experience, which proves that digital reality technology can also effectively serve as a tool to improve the dissemination and learning of cultural content.

From this finding, the researchers believed that digital reality technology could significantly enhance the craft cognitive effect of the filigree inlay exhibition

due to its immersive interactive experience . According to several research studies, the immersive experience allows learners to explore and memorize the content through interactive participation rather than passively receiving information.(Allcoat & von Mühlenen, 2018; Radianti et al., 2020)

In addition, learning strategies that simplify complex content into intuitive images, gestural interactions, and virtual presentations allow viewers to engage with the details of each step and increase their depth of understanding. Research has shown that this interactive experience is more engaging than traditional presentations, helping to drive interest and reinforce the content.

5.2 RELATED STUDY COMPARISON

Many scholars have recently tried to enhance the display of traditional skills by emerging technologies to increase the sense of immersion and participation of the audience. For example, Syed Shaharuddin et al. developed augmented reality architecture for Malaysia and Indonesia on batik craft to help students understand batik(Syed Shaharuddin et al., 2021). Zhang Lufang enhanced the understanding of bamboo weaving craft through VR(Zhang et al., 2023). These studies show that digital technology can achieve a high degree of user engagement effect in traditional cultural presentations. In addition, Antonya designs and develops a mixed reality installation for the Onyx Craft Museum on Tinos Island, Greece (Antonya & Butnariu, 2022). Hauser applies digital reality technology to the silk museum in Krefeld, Germany, to demonstrate the process of garment production (Hauser et al., 2022). The application of digital reality technology in the museum gives the audience a "hands-on" effect, thus promoting the inheritance of traditional crafts.

Moreover, Guan Jueqin uses VR to apply ceramic production methods to technology education in secondary schools (Guan et al., 2023). Although these studies provide a wealth of theoretical basis and application examples, some things could be improved. First, many of these studies focus on displays in fixed locations such as museums, emphasizing spatial arrangement and equipment use while neglecting how digital displays can be adapted for different display environments. In addition, with the potential of AR and MR technologies to be used for user engagement, there are few explanations of how this potential can be applied explicitly to other challenged production processes, such as filigree inlay. Therefore, it is helpful for further discussion in the current literature on how to address the use of these technologies and the new experience of in this entirely exposed and high-risk environment.

Based on the existing research mentioned above, this research focused on exploring the application of AR and MR technologies in the display of the filigree inlay process and aimed to propose a digital display method that is more suitable for general viewers. In the end, the researchers designed an interactive experience system based on MR technology, which enables the audience to experience the production process of filigree inlay in a virtual space and yet observe its real working environment. As a result of field observation and testing, the researcher found that these technologies are not limited to fixed museum spaces but can be applied in a variety of environments, such as exhibitions and educational institutions. As aimed, this research achieved a new attempt at the application of technology to provide a model that can be used for the digital preservation and promotion of more intangible cultural heritage in the future in terms of displaying intangible crafts.

5.3 CONCLUSION

Applying digital reality technology's immersive and interactive features to the filigree inlay experience exhibition effectively solves the problem of difficult experiences. Thus, it improves the audience's knowledge in many ways.

5.3.1 Content Extraction of Filigree Inlay Culture and Process in Line with

Learning Strategies

In this study, a learning strategy-compliant approach was used in the content extraction of filigree inlay culture and process. The extraction of the process and cultural content is characterized by three learning strategies: summarizing, drawing, and gesturing. This extraction method provides critical content for the application of interactive experience. By simplifying the difficulty of understanding when the audience participates and deepening the understanding of the difficulty and precision of the process, this extraction method not only makes the experience content more participatory but also enhances the memory of knowledge.

5.3.2 Effective Realization of the Immersive and Interactive Features of

Digital Reality Technology

immersive characteristics of digital reality technology is to immerse the experience through AR and MR progressively. Virtual elements were presented as close to the scene, creating realism and enhancing the user's immersion. The researcher believes that using background music and physical sound effects in the interaction to simulate the atmosphere of the actual scene makes the user more immersive. In addition, through the gesture interaction design, the application of interactive gestures close to the actual operation makes the user feel similar to the natural physical response(Li et al., 2019). A virtual image assistant is added to the virtual environment to help viewers enter the experience scene and guide the interaction process, which can enable users to interact clearly without cumbersome operations and enhance the natural smoothness of the experience.

5.3.3 Innovative Design for Filigree Inlay Immersive Interactive Experience

Exhibition

The innovative design of this research was created according to multiple aspects of content, for example, interaction scripting, visual design, and program development. In this study, MEUX's exhibition needs of the audience and the filigree inlay exhibitor review before the final design to be more accurate and meet the needs of culture and audience. The application of digital reality technology is a display and an essential interactive mode to disseminate the content effectively. This innovation in digital reality technology to help traditional culture has a more ecological way of dissemination.

5.4 LIMITATIONS OF THE STUDY

Even though this research has achieved some positive results in the filigree inlay exhibition, some limiting factors affect the effectiveness of the research at different levels. For example, there are many limitations, such as technical conditions, user experience feedback methods, development costs, and cultural content protection.

In terms of technical conditions, for example, the compatibility of the development platform of AR for the use of software. The standard accuracy of gesture recognition of MR requires a high degree of accuracy. Programs developed for different devices are incompatible and not suitable for multiple types of devices. Differences in the performance of different devices can affect the (Xiong et al., 2021). In addition, the content production process requires high precision and resolution of the model. If the technical means cannot reach these standards, it will directly affect the realism and immersion of the exhibition.

There are still limitations in user experience feedback; at present, we can only summarize direct feedback from users, and we are unable to monitor or establish some kind of virtual feedback mechanism to collect users' actual operations and conduct feedback analysis.

Regarding the development cost, implementing digital reality technology to upgrade the filigree mosaic exhibition requires a high economic cost, including server purchase, software development, technical maintenance, and special effects and modelling production. The high cost to the front end limits the technology's in-depth development. It may also make it impossible to realize the digital transformation of some traditional cultural exhibitions.

In terms of cultural preservation. An exhibition that relies too much on digital technology may weaken the direct feeling of traditional cultural elements, leading to a decrease in the audience's sense of identity and belonging to the culture. Therefore, attention should be paid to grasping the appropriate use of digitalization. At the same time, the protection of intellectual property rights involving culture, the attribution of

content copyrights, and data security issues during the use of technology need to be emphasized.

5.5 RECOMMENDATION

Many aspects of the application of digital reality technology for art exhibitions deserve further optimization to achieve an ideal audience experience and cultural transmission effect. This subsection summarizes the recommendations for the three aspects of technology application, user experience, and cultural knowledge conveyance to promote the further development of the filigree mosaic exhibition under the upgrading of digital reality technology.

Firstly, the researchers suggested developing equipment and technology. As the compatibility and performance of different devices may lead to inconsistent experiences, adaptability can be considered through the technical team's support. In addition, optimize the quality and speed of the displayed content to reduce the waiting time and make it easier for the audience to integrate into the immersive experience. Interactive sessions should streamline operational design and image loading speed to ensure ease of use and smoothness.

From the viewpoint of audience experience, the interactive link is crucial for enhancing the effect of the experience. Therefore, in the future exhibition design, the audience's sense of participation and interest in exploration can be further enhanced through diversified interactive methods(Flavián et al., 2019). For example, DIY interactive links can be added to the MR display, allowing the audience to try to design their own simple filigree inlay patterns, which not only helps to enhance the audience's interest but also deepens their understanding of the culture of filigree inlay patterns. In the AR experience, interactive interaction with cultural relics can improve reality and virtual interaction.

In the communication of cultural knowledge, the diversified types of filigree inlay culture can be slowly enriched, such as showing the development history of filigree inlay in Chinese history, representative works, and their traditional meanings. Exciting stories and background knowledge can be added and integrated into the digital exhibition so that the audience can see the craftsmanship of filigree inlay and understand its cultural value and historical significance. At the same time, adding expert commentary or an audio guide to the exhibition is suggested to help the audience understand the artistic value of filigree inlay more deeply.

5.6 FUTURE OUTLOOK

In the future, as digital reality technology continues to advance, filigree inlay exhibitions can realize a higher level of immersive experience and interactive interaction. They will gradually expand their influence in their cultural dissemination and education.

Future virtual exhibition scenarios may include real-time interactive virtual artisan instruction, allowing viewers to interact with the inheritors as if they were in a traditional workshop through virtual and genuine interactions. Enhanced sensory engagement can be achieved by adding olfactory and tactile stimuli to the interactive experience, adding a sense of scene piping experience that more closely resembles the actual work(Ranasinghe et al., 2018). With advances in Artificial Intelligence (AI) and machine learning technologies, exhibition content can be personalized to audience preferences through real-time data analysis, thus enhancing the depth and breadth of the experience.

Future digital filigree inlay exhibitions can be interactive online through social platforms. Viewers can share their work and express their insights with other viewers through the virtual platform. For example, a virtual filigree inlay exhibition hall can be designed for users to upload their own production of virtual filigree inlay works, and it can be open to comments and interactions between the audience. The hall can also dock filigree inlay factories for product customization in the production process.

In the future, digital reality technology will be a tool for displaying craftsmanship and establishing a deep emotional connection with the audience, realizing the cognitive processing from simple to complicated(Allcoat et al., 2021). It can bring the audience into the learning journey of ancient artisans, providing multi-level learning content from primary to advanced. Through the development of multi-level learning content, viewers can independently choose their learning content according to their interests and levels and satisfy the educational significance of craftsmanship in cultural heritage.

Through continuous optimization of technology applications, upgrading of user experience, and research of cultural content, traditional crafts such as filigree inlay will be renewed in the digital era with new ways of inheritance. Not only will this help the dissemination and inheritance of traditional crafts, but digital technology will also play an essential role in helping the inheritance and education of traditional culture.

APPENDIX



APPENDIX A. IOC INVITATION LETTER

No.8610/ 0170

Faculty of Decorative Arts, Silpakorn University Na Phra Larn Rd., Phra Borom Maha Ratchawang Phra Nakhon, Bangkok 10200 Thailand

9th January, 2024

Subject: Invitation to be an inspector of research tool quality

Dear Asst. Prof. Thammasak Aueragsakul

Miss Ruiying LI is a graduate student ID 650420037 in Design Program at Graduate School, Silpakom University. Currently, he is conducting his thesis study entitled : Research on Realizing Emotional Healing through VR Art Creation. In this regard, Graduate School, Silpakom University would like to invite you to inspect the quality of research tools for the student.

Your kind assistance and academic contribution is much appreciated.

T. Jiavakun

(Dr. Thanatorn Jiarakun) Dean of Faculty of Decorative Arts, Silpakorn University





No.8610/ 0171

Faculty of Decorative Arts, Silpakorn University Na Phra Lam Rd., Phra Borom Maha Ratchawang Phra Nakhon, Bangkok 10200 Thailand

9th January, 2024

Subject: Invitation to be an inspector of research tool quality

Dear Asst. Prof. Wannaporn Chujitarom

Miss Ruiying LI is a graduate student ID 650420037 in Design Program at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled : Research on Realizing Emotional Healing through VR Art Creation. In this regard, Graduate School, Silpakorn University would like to invite you to inspect the quality of research tools for the student.

Your kind assistance and academic contribution is much appreclated.

T. Siavakon

(Dr. Thanatorn Jiarakun) Dean of Faculty of Decorative Arts, Silpakorn University



Faculty of Decorative Arts, Silpakorn University Na Phra Larn Rd., Phra Borom Maha Ratchawang Phra Nakhon, Bangkok 10200 Thailand

9th January, 2024

Subject: Invitation to be an inspector of research tool quality

Dear Asst. Prof. Paniti Keowsawat

Miss Ruiying LI is a graduate student ID 650420037 in Design Program at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled : Research on Realizing Emotional Healing through VR Art Creation. In this regard, Graduate School, Silpakorn University would like to invite you to inspect the quality of research tools for the student.

Your kind assistance and academic contribution is much appreciated.

T. Jiavakun

(Dr. Thanatorn Jiarakun) Dean of Faculty of Decorative Arts, Silpakorn University

APPENDIX B.

VIVA VOCE PRESENTATION

Slide	Presentation Script
The Interactive Experience of Filigree Interactive Experience of Filigree Interactive Experience of Filigree Reality Technology	1. Good afternoon teachers, thank you coming today. My name is Ruiying Li, I will persent my research about 'The interactive experience of filigree inlay exhibition through digital reality technology'
Chinese Filigree Inlay	2. My research about an Chinese filigree inlay, which represents the highest skill in Chinese gold and silver
Filigree Inlay Exhibition	3. Please look at these filigree inlay exhibition photos.
Filigree Inlay Exhibition (2023)	4. These exhibitions only show the filigree inlay work, without any craft process content
Filigree Inlay 1 (2024) Definition in Xlamen, Chine Filigree Inlay 1 Filigree Inlay 1 Filig	5. So, I went to the filigree inlay studio to see the process
	6. I found that more dangerous of the filigree inlay process, so is can't show it at the exhibition.





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	Materials	20. Inlay material use turquoise gemstones pearls
	Turquoise Cemstones Pearl	
-	Relic (In the Palace Museum)	21. I summarized the aesthetic content of 30
		filigree inlay relics from the palace museum
-	Color	22 Summarized the main colors of filigree
		inlay
-	Filigree	23. These are the two styles of filigree
	Simple Circular Filigree Circular Braided Filigree	
	Pattern	24. These are types of fill patterns
	Flower	ลัยสิลปาโ
-	Pattern	25. Wavy
	Way	





	36. Digital reality experts said that a 5-10 minute experience is suitable for more people and won't cause 3D dizziness
Safe" Safe Kevin Digital Technology Developer Expert	37. At the same time, a safe environment is also very important for comfort.
Easy to Learn Summarizing Using Guide Complex Information Explanation	38. I analyzed learning strategies through a literature review.Summarizing strategies need to put complex information into simple explanations.
Easy to Learn Drawing Using Guide	39. For learning graphics, Pre-drawing can help achieve a simpler learning
Easy to Learn Enacting Using Guide	40.The third is enacting strategies, which achieve learning by simulating actions

CharacterImage: Strate of the strate of	 41. According to the literature review, character design can help the audience have a better experience. I chose 4-character styles and used a survey to select the best ones. In the end, I used the top two choices for the design. 42. This is the first character design.
Character Design	43. This is the second character design.
Volunteer selection 55.2%	44. Finally people chose this plan
Application	45. Then, I analyzed the applications of
Which Digital Reality Technology is Suitable for Filigree Inlay Exhibitions? AR? VR? MR?	digital reality to find a suitable technology for filigree inlay









59. Next was the MR process design. The first design couldn't be used because I didn't get feedback from the professor and the test

Here is a brief video of the first design











R/MR Exhibition	85. Next, I tested the AR& MR exhibition audience, and their accuracy rate was 78.75%
Discussion 46%	86. The test results show that the digital reality exhibition improved learning of the filigree inlay process by 46%
Discussion Digital Reality Experience Deepens Interested of Craft Knowledge	87. The audience thinks the experience is more interesting
Discussion More fun than the traditional way	88. The audience thinks the experience is more fun
Provention of the second	89. This is my design video. Please watch it



APPENDIX C. EXPERT INTERVIEW LETTER



No.8610/ 5750

Faculty of Decorative Arts, Silpakorn University Na Phra Larn Rd., Phra Borom Maha Ratchawang Phra Nakhon, Bangkok 10200 Thailand

15 November 2024

Subject: Request for Information and an Interview

Dear Mr. Kevin Ang

Miss Ruiying LI, Student ID 650420037, a doctoral student student in Design at the Faculty of Decorative Arts, Silpakom University. who is currently working on the dissertation titled "The interactive experience of Chinese filigree inlay exhibition through digital reality technology.", would like to request some information and request an interview with in order to collect data as a part of her dissertation research.

On behalf of the Faculty of Decorative Arts, Silpakorn University, we kindly request your cooperation and assistance in providing information and participating in an Interview. For additional details, please contact Miss Ruiying LI at telephone number 0803460334, who will serve as a direct coordinator.

Yours faithfully

JL

(Assoc.Prof. Arwin Intrungsi) Dean of Faculty of Decorative Arts, Silpakorn University



No.8610/ 5743

Faculty of Decorative Arts, Silpakorn University Na Phra Larn Rd., Phra Borom Maha Ratchawang Phra Nakhon, Bangkok 10200 Thailand

15 November 2024

Subject: Request for Information and an Interview

Dear Wu wenyong

Miss Ruiying LI, Student ID 650420037, a doctoral student student in Design at the Faculty of Decorative Arts, Silpakorn University. who is currently working on the dissertation titled "The interactive experience of Chinese filigree inlay exhibition through digital reality technology.", would like to request some information and request an interview with in order to collect data as a part of her dissertation research.

On behalf of the Faculty of Decorative Arts, Silpakorn University, we kindly request your cooperation and assistance in providing Information and participating in an interview. For additional details, please contact Miss Ruiying LI at telephone number 0803460334, who will serve as a direct coordinator.

Yours faithfully

2

(Assoc.Prof. Arwin Intrungsi) Dean of Faculty of Decorative Arts, Silpakorn University



No.8610/

Faculty of Decorative Arts, Silpakorn University Na Phra Larn Rd., Phra Bororn Maha Ratchawang Phra Nakhon, Bangkok 10200 Thailand

15 November 2024

Subject: Request for Information and an Interview

5749

Dear Ma Weisheng

Miss Rulying LI, Student ID 650420037, a doctoral student student in Design at the Faculty of Decorative Arts, Silpakorn University. who is currently working on the dissertation titled "The interactive experience of Chinese filigree inlay exhibition through digital reality technology.", would like to request some information and request an interview with in order to collect data as a part of her dissertation research.

On behalf of the Faculty of Decorative Arts, Silpakorn University, we kindly request your cooperation and assistance in providing information and participating in an interview. For additional details, please contact Miss Ruiying LI at telephone number 0803460334, who will serve as a direct coordinator.

Yours faithfully

) (

(Assoc.Prof. Anvin Intrungsi) Dean of Faculty of Decorative Arts, Silpakorn University

APPENDIX D. ATTENDING INTERNATIONAL ART EXHIBITION





The Legacy of Chinese Filigree Inlay

Mr. Ruiying Li

Chinese filgree inlay epitomizes the pinnacle of Chinese gold and silver artistry, in this illustration, the artist symbolically reimagined the characters representing "luck" and "longevity" from Chinese filigree inlay works. The artist emulated the method of using gold wire in filigree inlay to create a textured filing in the painting. The artist chose gold, blue-green, and turquoise, as the main colors of the painting, based on the conventional proportion of cultural relic materials. This results in the abstract yet readly identifiable features of Chinese filignee inlay.

018

Note

Rulying Li as CEO. QuChu Culture Communication Co.Ltd.

Address No.33 Shuguang Road, Guangyang District, Langfang City, Heibei Province, China.

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APPENDIX E.ACCEPTANCE LETTER FOR INTERNATIONAL ACADEMIC CONFERENCE



Mahidol University

No. 78.35/1695

April 2024

Subject: Results of Review of Your Full Paper Dear Rulying Li,

In reference to submission of your full paper titled "Crafting Cultural Engagement: A Framework for Captivating Chinese Filigree Exhibitions Using Digital Reality" to the first international as well as eighth national conference on humanities and social sciences under the theme "Liberal Arts In the Role of Cultural Capital" organized by Faculty of Liberal Arts, Mahidol University (Thailand) to be held from 6th to 7th June 2024, we are very pleased to announce that your full paper has been accepted for oral presentation in the conference. Please also note that your full paper will be published in the proceedings in the website in due course.

We will contact you shortly to inform you about the details of your presentation, including the venue, time and any other preparations which you might have to make in advance.

Yours respectfully,

Azieti

(Assistant Professor Aphiwit Liang-Itsara, Ph.D.) Dean of Faculty of Liberal Arts, Mahidol University

Faculty of Liberal Arts, Mahidol University 999 Phuttamonthon Sai 4, Salaya Nakhon Pathom, 73170 Thailand

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VITA

NAME

LiRuiying

*นั้นวริท*ยาลัยสิลปาโว

INSTITUTIONS ATTENDED

PUBLICATION

Graduated from Yancheng Teachers University, University of Fine Arts and Design, majoring in Visual Communication, China, 2019; Enrolled in Decorative Arts and Design, Slipakorn University, June 2022 Ruiying, L and Karnchanapayap, G., (2024). Crafting Cultural Engagement: A Framework for Captivating Chinese, Filigree Exhibition Using Digital Reality. Liberal Arts In the Role of Cultural Capital 1st International and 8th National Conference on Humanities and Social Sciences 2024. Bangkok, Thailand. July 6th, 2024.