CREATIVE CULTURAL PRODUCT DESIGN FROM ANCIENT CHINESE ARCHITECTURAL ELEMENTS

By
Mr. Guangzhou LI

A Thesis Submitted in Partial Fulfillment of the Requirements
for Doctor of Philosophy DESIGN
Silpakorn University
Academic Year 2023

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โดย

Mr.Guangzhou LI

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปรัชญาดุษฎีบัณฑิต

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Title	Creative cultural product design from ancient Chinese architectural elements
By	Mr. Guangzhou LI
Field of Study	DESIGN
Advisor	Associate Professor Doctor. Ratthai Porncharoen

Faculty of Decorative Arts, Silpakorn University in Partial Fulfillment of the Requirements for the Doctor of Philosophy

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Mr. Guangzhou LI : Creative cultural product design from ancient Chinese architectural elements Thesis advisor : Associate Professor Doctor. Ratthai Porncharoen

"Bucket arch" and "Mortise and tenon" structure is an essential structural technique used in ancient Chinese architecture and furniture. However, it has begun to disappear from the lives of modern Chinese people because the modernization and maturity of craftsmanship and industrialized products are more accessible for Chinese people to accept.The objectives of this study are: 1) Study data to create design requirements.2) Stage of design Product development and prototyping. 3) Study the satisfaction results of the target group through the exhibition. This study adopts the following methods to achieve the research objectives: 1) Adopt the method of an open questionnaire to collect user data who are interested in and demand Chinese traditional cultural and creative products, collect consumer demand data from sample consumers, and collect target through organization Emotional experience activities to enhance user experience. Dougong creative product feedback data. The duration of data collection was 16 days and 16 experiential events. The number of respondents was 269. The sample is based on a simple random selection sample. The research tools are a checklist questionnaire and a rating scale questionnaire. 2) Opinions and suggestions from 1 product design expert, two environmental art design experts, one marketing expert, two 3D printing experts, and one traditional furniture culture expert. Key informants are selected based on purposeful sampling. The research instrument is also a rating scale questionnaire. 3) The design satisfaction of mortise, tenon, and bucket arch structure garden lamps is high. The respondents were 223 visitors to the final exhibition. The data collection period is one week. They were selected based on simple random sampling. The research tool is a scoring questionnaire. Analyze data using statistics, including mean and standard deviation, to measure consumer satisfaction. The analyzed data were then processed using descriptive statistics.The results of this study show that A = emotional experience, B = cultural factor, C = appearance factor, and D = economic value. Under the scoring standard of emotional design of traditional cultural and creative products, the sample consumers were the most satisfied with the design of mortise and dougong garden lamps. The satisfaction levels are sorted as follows: The first place is that the product can enhance society's sense of self-identity ($\bar{x}$ = 4.130), (S.D. = 1.072). Second place is. This product makes you recall and associate with traditional Chinese culture ($\bar{x}$ = 4.009), (S.D. = 1.099). In third place, the product can help you escape a negative state with a certain sense of pleasure ($\bar{x}$ = 3.924), (S.D. = 1.106). In fourth place is yes. The product is practical and can be used in gardens ($\bar{x}$= 3.744), (S.D. =0.945). The fifth place is. Ease of assembly and use ($\bar{x}$ = 3.700), (S.D. = 1.042)

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Guangzhou LI

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CHAPTER 1
INTRODUCTION

1.1 Background and Importance of the Study

User experience feedback may play a crucial role in making traditional Chinese cultural and creative products more appealing and pertinent to consumers. These items are rich in historical and cultural importance. According to study, creative goods may enhance customers' overall experiences and deepen their commitment to the product by evoking favorable emotional reactions in them.

User needs research, and particularly emotional needs research, is crucial in the setting of the strong integration of traditional Chinese culture and innovative goods for a variety of reasons. First of all, the incorporation of these artistic items into real-world settings increases their consumer appeal and acceptance. Second, traditional Chinese artistic and cultural creations frequently have a rich cultural and historical background. The nostalgic and inherited associations with traditional Chinese cultural and creative items provide consumers a sense of connection and belonging. Third, consumers must be heavily involved in the creation of these goods in order to make them more appealing, meaningful, and pertinent to users. Designers may produce items that are attractive, significant, and influential by comprehending consumer demands and making advantage of the emotional connections that these things can elicit.

Connotation type and value of Chinese traditional culture is a national culture that embodies national characteristics and humanistic characteristics. Developed from Chinese civilization. (Dongling, 2011). Traditional Chinese culture was formed by farming culture centered on the Han people. With the development of history, Han culture has also penetrated into various ethnic groups. The cultures of different regions are endless in their territory, with different connotations and forms. The integration and harmony of Chinese traditional culture is the foundation of its strong vitality. (Axiang, 2021).

Traditional Chinese culture is a patrilineal culture based on the family. Focus on the family rather than the individual. There are few groups and individuals. Ancient Chinese society established a family system based on patrilineal relations, which is the foundation of the country. Laying the social foundation for the formation of patriarchal culture. (Daji, 2002). Traditional Chinese culture is an ethical culture that emphasizes respect for heaven. The meaning of man and the unity of man and nature Support the thought of joining the world and oppose the thought of leaving the world. To respect God's will is to respect. But morality is more important. And consider the unity of the divine path and the human path. (Wangheng, 1989). "Chinese cultural identity" through Chinese cultural and creative products As China is experiencing rapid consumption of upgraded products and media communication. Traditional Chinese cultural products are integrated into contemporary fashion. Oriental aesthetics and artistic quality are therefore sought after by more and more young people. " Chinese traditional cultural and creative goods are now commonplace in consumer society and have an impact on how people dress, eat, live, travel, and utilize things. (Mingbing, 2021).

Once upon a time, throughout the vast and varied history of ancient China, architecture evolved

over centuries, reflecting each era's cultural, technological and artistic advancements. From the Stone Age to the glorious Qing Dynasty, Chinese architecture's design features and aesthetics changed dramatically, leaving behind a rich legacy.

During the Stone Age, when ancient Chinese civilization was in its infancy, architecture was crude and functional. Nomadic tribes built simple dwellings using readily available wood, hides, and woven reeds. These buildings are primarily intended for habitation, and the load-bearing capacity is met by the material's inherent strength. For instance, the first example of a wooden building found in China is the Hemudu Ganlan architectural site in Yuyao, Jiangsu and Zhejiang, which dates back more than 6,900 years. Many mortise and tenon structures have also been discovered, such as mortise and tenon intersecting with standard beams and columns in later generations; cross-mortise and tenon approaches are very similar.

As civilization entered the Bronze Age, architecture became more complex. The advent of the city walls marked a significant development. These cities were surrounded by solid walls, which provided protection and safety to the inhabitants. Load-bearing walls are built of stone or brick, demonstrating a growing understanding of structural integrity and defensive strategies. For example, in the archaeological excavations in Anyang, Henan Province, among the noble tombs of the Shang Dynasty, there are architectural wooden structures and signs of black and red paintings and carvings.

Due to the extensive use of iron tools during the Spring and Autumn Period and the Warring States Period, production increased, cities proliferated, and city walls, palaces, and tall buildings were further constructed. Construction using wood beam frames is joint. We may comprehend its general position from the mortise and tenon structure of the wooden coffin in the graves of the same date. For instance, the Chu Tomb No. 5 in Dangyang, Hubei, features a mortise and tenon construction. Bucket arch has also appeared, and its structure is relatively simple. For example, the utensils shown in Linzi, Shandong Province, depict palace buildings, and the image of Bucket arch already exists.

Architectural design flourished during the imperial dynasties in ancient China, especially the Qin and Han dynasties. The implementation of timber-framed buildings characterizes the architecture of this period. Interlocking wooden beams and columns have been carefully assembled to create a structure of extraordinary strength and flexibility. This load-bearing technique allows the construction of spacious buildings and halls. China started to develop Buddhist structures once the Han Dynasty brought Buddhism there. The earliest Buddhist temple was erected in Luoyang.

The Wei, Jin, Southern, and Northern Dynasties were characterized by numerous conflicts, turmoil, and a situation in which different ethnic groups were merging. The most preserved are Buddhist temples, pagodas and giant caves. Based on the Han Dynasty, these buildings absorbed elements of Buddhist architecture in India and Gandhara. For example, the wooden pagoda of Yongning Temple was built during the Northern Wei Dynasty. Regarding building materials, the Northern Wei Dynasty began to use glazed and black tiles in the palace.

The artistic aspects of ancient Chinese architecture are also prominent. An elaborate roof system was designed with eaves projecting outwards to provide shade and protection. These overhanging eaves

became a distinctive feature of Chinese architecture and were often decorated with intricate carvings depicting mythological creatures, dragons and gods.

The brackets of the bucket arches are carefully crafted and interlocking, providing structural support and becoming a source of aesthetic pleasure. Intricately carved wooden brackets are stacked on each other to form an interlocking network that provides stability and flexibility. Besides their functional importance, bucket arches were also considered prominent decorative elements. Intricate carvings adorn the stand, featuring mythical creatures, dragons and delicate floral motifs. These designs enhance the overall aesthetic appeal and reflect the spiritual beliefs and cultural symbolism prevailing in that era. For instance, the main hall of the Nanchan Temple in Mount Wutai, Shanxi, represents this period, and the structure's columns are carefully aligned and match one another. There are several bucket arches, and the roof is enormous.

During the Song Dynasty, there was a shift towards a more refined and understated architectural style. The wooden frame structure becomes prominent, emphasizing harmony with nature. The buildings are designed to blend seamlessly into the surrounding landscape, incorporating elements of water, rocks and gardens into the architectural layout. The load-bearing structure is exquisitely crafted, presenting balance, elegance and restraint. Song Dynasty buildings also adopted prominent roof systems. The pitched roof with overhanging eaves is designed to protect the building from rain and direct sunlight. The corners of the roof curve upwards to create a graceful silhouette reminiscent of a bird in flight. This unique architectural feature adds a touch of elegance to the structure while also serving a functional purpose. During this period, Chinese architecture appeared in a new stage of development, and various forms of palaces, platforms, buildings, and pavilions appeared. In particular, it is stipulated that the proportion of wood used in houses and the flexural strength should be lower than 0.23%. From the perspective of wood beam mechanics, it was ahead of the world level at that time.

After many centuries, a beautiful era was inaugurated by the Ming and Qing empires. Large royal residences and expansive gardens were constructed to display the dynasty's riches and dominance. Masonry is used to support the load-bearing walls, and decoration, symmetry, and proportion are all carefully considered. The structures are decorated with intricate woodwork, painted details, and glazed tiles, which elevates the architectural setting. Symmetry and grandeur were highly valued in Qing Dynasty architecture. The buildings are characterized by vast courtyards, imposing gates and intricate decoration. Intricately carved stone and woodwork adorn the facades, depicting myths, historical events and scenes from everyday life. The colour palette expanded to include vibrant hues, and buildings were decorated in reds, greens, and gold, reflecting the splendour and wealth of the empire.

In conclusion, there have been significant changes in ancient Chinese architecture from the Stone Age to the Qing Dynasty. From the humble dwellings of early civilizations to the grand palaces of emperors, load-bearing techniques and aesthetics changed, reflecting each period's cultural, social, and technological developments. The legacy of ancient Chinese architecture still testifies to the civilization's ingenuity, craftsmanship and artistic sensibility, making us marvel at their timeless beauty.

The bucket arch was created because of ancient Chinese building materials' defects and structural characteristics. From archaeological findings, as early as the Qin and Han periods, the Bucket arch style appeared on bronzes, which was in the initial embryonic stage of the Bucket arch system. (Xiong & Fu, 2022) The architectural forms tended to take shape during the Three Kingdoms, Two Jin Dynasties, Southern, and Northern Dynasties, establishing a very simple Bucket arch treatment. (Xingbo & Peijun, 2023) The Palace Museum's collection of palace room maps can demonstrate the Bucket Arch's use in home building during the Spring, Autumn, and Warring States periods, and the construction of Tianlongshan caves demonstrates the Bucket Arch's level of development during this time.(Gordon et al., 2014) This period of the bucket arch is significant; the number is small, the column is typically arranged in one or two, the height can reach half of the height of the column, and the style is solemn and straightforward, such as the main hall of Fo Guang Temple on Wutaishan in Shanxi, and it was developed during the Sui Dynasty and Tang Dynasty, with a very mature wooden structure system and bucket arch system. In the Song Dynasty, the Bucket arch system began to become mature and refined and even moved towards femininity and magnificence, which was a turning point. The height of the Bucket arch gradually became two-sevenths of the height of the column, and the size gradually became smaller. From the Yuan Dynasty, after a transitional period, the Bucket arch system began to undergo a functional transformation from structural forms to decorative components. (Sainan & Dolah, 2022)In the Qing Dynasty, the decorative function gradually increased, the number of fighting arches increased, and the image shape became more and more complex. According to the above information, it is concluded that the Bucket arch system has different characteristics in different periods, and the evolution process is a process from scratch, from large to small, from simple to complex, from majestic to delicate, from stressed components to gradually and even into decorative components. (Ting et al., 2022)

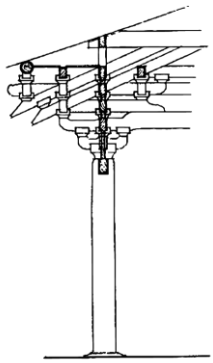
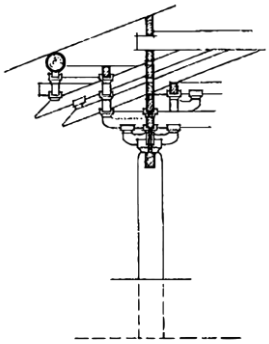
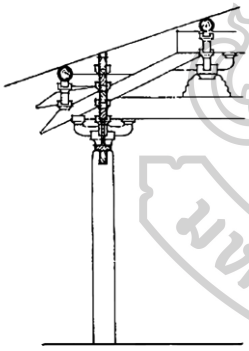
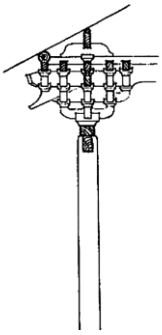
In the article research, through 3D printing of ancient building Bucket arch models of these three periods (Tang Dynasty, Song Dynasty, Qing Dynasty), in-depth research, the Tang Dynasty Bucket arch is massive and less layered, and the Song Dynasty Bucket arch size gradually became smaller. It formed a national norm, Qing Dynasty Bucket arch had more emphasis on decoration, and the shape was more and more complex. The typical analysis and summary of these three periods play a vital role in grasping the historical information, structural characteristics and product design of Bucket Arch.(LI et al.)

The bucket arch structure is unique to ancient Chinese architecture, at the junction of building columns and beams. In ancient China, the bucket arch structure was a sign of distinguishing architectural grades, and the nobler the building, the more complex and prosperous. Along with the distinctive visual beauty of ancient Chinese architecture, the technical qualities of artistry, supporting building weight, and seismic and compressive capabilities, the bucket arch structure also represents the spiritual meaning of traditional Chinese culture. Therefore, it has very high research value. Traditional Chinese architectural design combines traditional Chinese cultural concepts. The ancients upheld the idea of the unity of man and nature. Ancient Chinese architecture is a building system characterized by wooden structures, which is known as representing the Oriental building system because of its long history.(Bo,2010) The ancient Chinese building system has a resilient frame structure for earthquake resistance, a rational arrangement

of interior spaces according to needs, flexibility in the setting of doors and windows, ease of construction and maintenance and dismantling, and a variety of roof variations, among others. The bucket arch structure is a fine art that combines material and spiritual functions. It possesses a unique style in terms of aesthetics and structure, with ingenious conception and meticulous form-making, decorative beauty and formal beauty. (Jinjing, 2011). The arch symbolises and represents the spirit and temperament of classical Chinese architecture. The primary function of the arch is load-bearing and seismic resistance. The arch greatly influences traditional wooden structures' capacity to stand. The arch, a standard component of the mortise and tenon joint, serves as a conduit for the distribution of forces. The arch is essential to earthquake resistance because it distributes the weight of the eaves, creating balance and stability. (Wenqi, 1999).

Generally speaking, there will be no significant changes in a building within 100 years because the occupants also have a safety need for "stability". Therefore, it can be seen that the building must have "stability". In China, the study of ancient buildings generally focuses on the strength and toughness of wood structures, mechanical structures, and space design logic. The numerous little timber mortise joints that make up the wood framework are crucial in changing the inclination angle and balancing the bending moment. As a result, during an earthquake, they function as a damping mechanism thanks to friction and dislocation between the mortise and tenon, which may absorb a significant amount of external energy and improve the seismic and impact resistance of the entire structure. Compared with the practical significance, studying ancient architecture is more important to continue the tradition, explore the ancients' definition of "stability", and continue an aesthetic inheritance from ancient times.(Que et al., 2017)

From the elevation drawings of the following historical periods, different information about the arch, the history of the arch and the characteristics of the building to which it belongs can be derived.

	Bucket arch information: 1.Tang Dynasty,A.D 857 2. Foguang Temple's Main Hall, Mount Wutai, Shanxi Province
	Description: The hall was constructed in 857; the previous hall was demolished and rebuilt. The enormous Bucket arch is proportionately massive, with four layers protruding—two layers of Gong and two layers of Ang—and rising to around one-half. The bucket arch design gives the entire structure a melancholy appearance absent from succeeding structures.
	Bucket arch information: 1. Liao Dynasty, A.D 984 2. Guanyin Pavilion of Dule Temple, Ji County, Hebei Province
	Description: The building where the bucket arch is located has a three-story "stacked column" structure (the bucket arch and the beam and column structure are superimposed), and each floor has a complete set of columns and bucket arches. The proportion of the bucket arch is also close to half of the column. The top floor adopts double-layer Gong and double-layer Ang.
	Bucket arch information: 1. Song Dynasty, A.D 1008 2. Yongshou Temple Yuhua Palace, Yuci County, Shanxi Province (Destroyed)
	Description: According to research, the architecture of this period is a transitional case in the Song and Yuan periods in terms of architectural style, and the building is not magnificent and not eye-catching. The bucket arch is very simple, single Ang, appears oblique Ang shape, looks like double Ang. The bucket arch is proportionally larger, slightly less than one-third the height of the column.
	Bucket arch information: 1. Chin Dynasty, A.D 1130-1143 2. Three Holy Halls of Shanhua Temple, Datong, Shanxi Province
	Description: In the area ruled by the Jin people at the time, the Bucket arch used oblique gong, and each Bucket arch evolved into more than three floors, and the intricacy became a burden on the trunk. The Jin Dynasty and the Southern Song Dynasty coexisted during this time, and the only wooden building from this era that still stands today is the Taoist building Xuanmiaoguan Sanqing Hall in Suzhou, Jiangsu Province. It was constructed in 1179, but its design differs from that of the northern building, and the proportion of the Bucket arch to the entire structure has shrunk significantly.

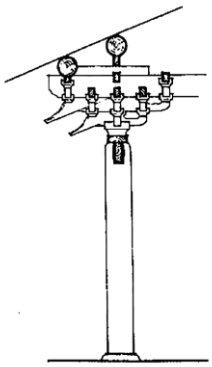
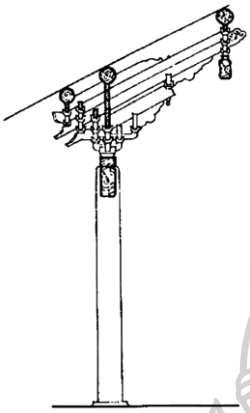
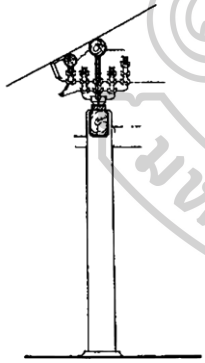
	Bucket arch information: 1. Yuan Dynasty, A.D 1250 2. Yanghe Tower, Zhengding County, Hebei Province (Destroyed)
	Description: During this period, there were many important changes in the bucket arch, false Ang was commonly used, the column bucket arch was enlarged on the side of the outer eaves, because the bucket arch shrank with the times, the bucket arch structure appeared very fragile, and the proportion of wood used in the structure would increase. This building has a double Ang, in fact the two Angs on the pillars are fake.
	Bucket arch information: 1.Ming Dynasty, A.D 1421 2. Sheji Temple,Beijing (now Zhongshan Park) Hall of Enjoyment (now Zhongshan Hall)
	Description: Since the early 15th century when the capital of the Ming Dynasty was Beijing, court architecture has developed a different concept of proportionality than before, and the Bucket arch has suddenly changed in proportion, shrinking to one-fifth of the column. Before the 12th century, there were no more than two arches between the pillars, but now it has increased to four or six. These bucket arches are more of a decorative rather than structural component, and many decorative carvings are added to the tail of the Ang, but a lot of trunks need to be added to support the bucket arch.
	Bucket arch information: 1.Qing Dynasty, A.D 1776 2. Wenyuan Pavilion, once the Royal Library of the Forbidden City in Beijing Forbidden City during the Qing Dynasty
	Description: After the publication of the Code of Engineering Practice in 1734, all royal buildings belonged to the same style. The building as a whole is very large, but the proportion of the bucket arch is very small, accounting for one-sixth of the height of the column, and the bucket arch is barely visible from a distance, and the bucket arch is painted with cyan, green and gold moldings.

Figure 1：The evolution of Bucket arch in the past dynasties, Quoted from "A pictorial history of Chinese architecture" (Soper, 1984)

Source: written by Liang Sicheng, 2011

Judging from the above information, researchers are very interested in ancient Chinese architectural structures. Furniture refers to the wood joints, such as bucket arches and mortise and tenon constructions, which have a history dating back thousands of years. Create tests employing emotional knowledge where the researcher is a speaker and an expert on the topic to see more precise results for that design.

Incorporating the "Bucket arch" structure into contemporary product design can revolutionise how we construct and manufacture objects. The unique structural design of the "Bucket arch" allows for greater load-bearing capacity and stability, making it an ideal choice for products that require durability and strength. Moreover, the "Bucket arch" structure has significant cultural and historical value, which can add a unique identity and aesthetic value to the products that use it. By incorporating this traditional Chinese architectural element into modern product design, we can celebrate and preserve our cultural heritage while creating innovative, functional, and visually appealing products. Incorporating the "Bucket arch" structure into contemporary product design can bring numerous benefits, ranging from increased structural integrity, cultural preservation, and aesthetic appeal to sustainability and innovation. By leveraging the advantages of this traditional Chinese architectural element, designers can create products that are both functional and beautiful and that reflect our cultural heritage while meeting the needs of modern consumers.

In conclusion, incorporating the "Bucket arch" structure into contemporary product design is not only a practical solution for creating solid and stable products but also a way to pay homage to our cultural heritage. It opens up new possibilities for innovative and sustainable design, and encourages us to embrace the beauty and significance of traditional architecture in our modern world. By adopting this approach, we can create products that are functional, aesthetically pleasing, meaningful, and relevant to our cultural identity.

1.2 Research objectives

1.2.1 Study data to create design requirements.

1.2.2 Stage of design Product development and prototyping.

1.2.3 Study the satisfaction results of the target group through the exhibition.

1.3 Research hypothesis

With a focus on user experience and emotional experience, cultural and creative product design of Chinese traditional architectural components may achieve maximum customer happiness.

1.4 Research framework

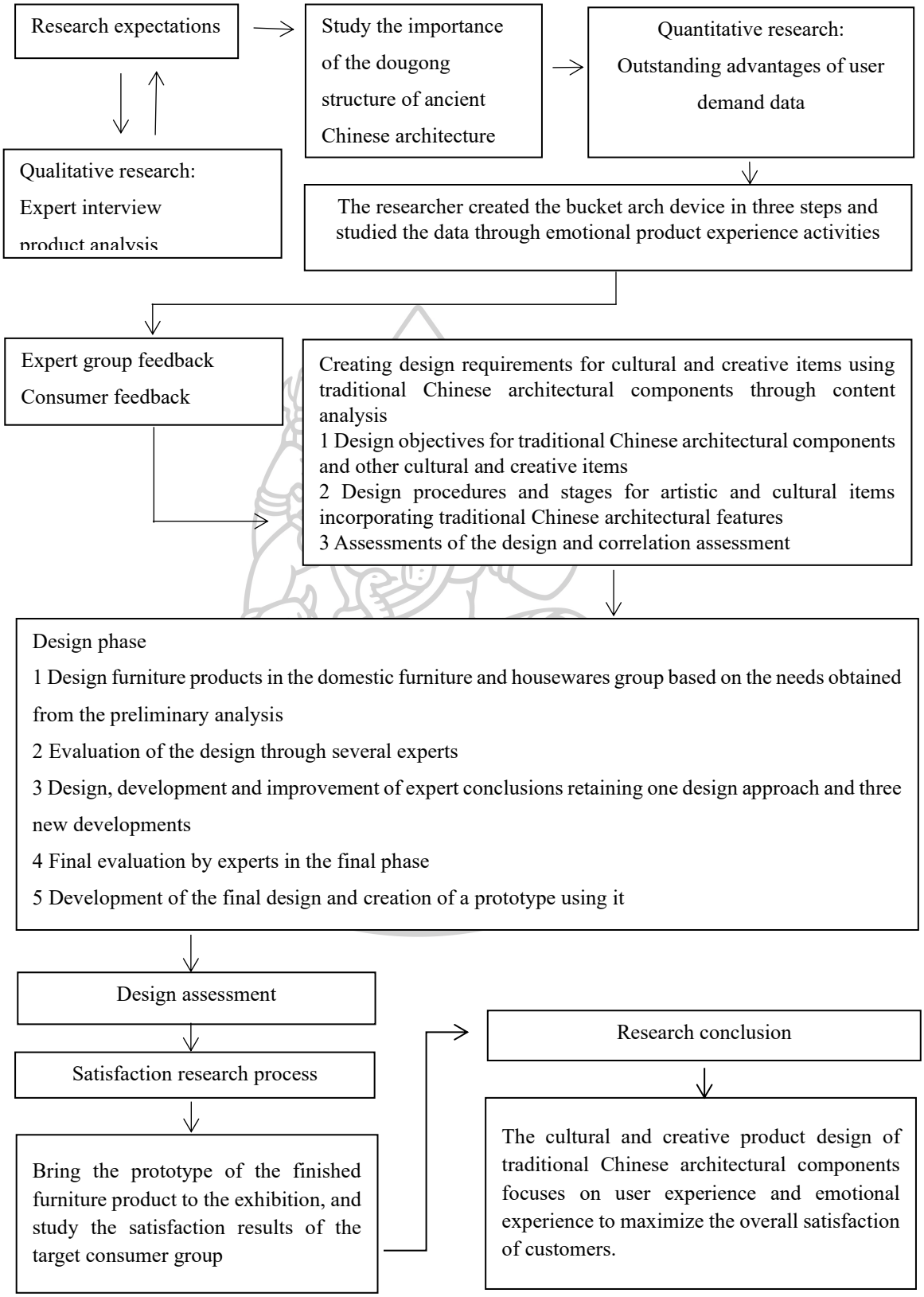


Figure 2 Shows the conceptual framework used for the study
Source: Designed by Li Guangzhou, 2020

1.5 Research Scope

The researchers outlined the three historical periods of the bucket arch structure, the typical tenon and tenon structure for analysis, expert interviews through CAD drawings, and 3D printing to study and analyze the data of the tenon and tenon structure, bucket arch structure in three stages of learning information. Through emotional experience activities, data research is carried out, the needs of target users for creative products of mortise and tenon and bucket arch structure are studied, the content is analyzed, and design guidelines are established. Design phase According to the requirements derived from the previous analysis, the design of home furniture products and small furniture products, design, development and improvement of design methods. In the expert review, final qualification, final design development and prototyping process. Satisfaction study process The process of obtaining and analyzing the evaluation data of target users mainly through the final product prototype exhibition.

1.5.1 Stages of learning information

1.5.1.1 Study of Chinese architectural (arch) timber structures in three historical periods.

1.5.1.2 Research information by interviewing experts with knowledge of ancient Chinese architecture.

1.5.1.3 Research and analyse information about structural materials and timber connections.

1.5.1.4 Research data through the creation of a bucket arch installation in three steps by the researcher and through emotional product experience activities.

1.5.1.5 Research to explore the needs of the target group in a creative product of mortise and tenon and bucket arches and create a new product

1.5.1.6 Analyse the content to create a design specification.

1.5.2 Design phase

1.5.2.1 Design furniture products in the domestic furniture and housewares group based on the needs obtained from the preliminary analysis.

1.5.2.2 Evaluation of the design through several experts.

1.5.2.3 Design, development and improvement of expert conclusions retaining one design approach and three new developments.

1.5.2.4 Final evaluation by experts in the final phase.

1.5.2.5 Development of the final design and creation of a prototype using it.

1.5.3 Satisfaction study process

Prototypes of the created furniture products are brought to the exhibition to study the satisfaction results of the target group of consumers.

1.6 Definition of terminology

To better comprehend the substance and scope of the research, clarify the four groups of proper nouns, such as bucket arch structure, house furniture group, commemorative furniture group, and mortise and tenon structure, as well as the content of the keywords.

1.6.1 Bucket Arch means

Bucket Arch refers to a unique structural element of interlocking wooden brackets. As the basic structural form of Chinese classical architecture, arches are widely used in the roof corners of palaces, temples, courtyards, towers, and pavilions in Chinese classical forms. It was a load-bearing, decorative architectural feature in ancient societies and a symbol of rank and status. The primary function of the cornice is to transmit the force of the cornice to the column, so it is located between the beam and the column. The bucket is a square wooden cushion between the upper and lower arches. The bucket is a bow-shaped load-bearing part that protrudes in layers from the top of the roof. Mortise and tenon are used to join the arch to the bucket. Specifically, start from the word, write the meaning of the content to understand, or put the word bucket arch here or put bucket arch and vice versa bucket arch. When you search, you will find words with the same meaning in the pictures of this part of our work.

Sheng signifies The rising or lifting portion of the arch and is referred to by this name. The gradual slope or upward curve that gives the arch its unique form is included. The sheng aids in distributing the structure's weight and offers initial support. The meaning of the text will be evident upon considering the details of this term.

Ang means The gong component denotes the horizontally spanning, curving, or arching element of the structure that extends between two supporting points. It distributes pressures outward and downward to the supports while bearing the weight imposed on it. The meaning of the text will be evident upon considering the details of this term.

Dou denotes the rising or raising portion of the arch, and ang indicates. It entails the vertical expansion at the crown or apex of the arch, increasing the structure's total height. This element increases the inner area of the arch and helps it support higher weights. The meaning of the text will be evident upon considering the details of this term.

Gong stands for the fighting or bracing part of the bucket arch, whereas Dou symbolizes it. To resist lateral stresses and keep the stability of the arch, it requires a variety of reinforcements and stabilizing components, such as supporting beams, brackets, or other structures. The meaning of the text will be evident upon considering the details of this term.

1.6.2 Furniture grouped by household use means

Furniture in appliances and facilities is necessary to sustain daily living, participate in production, and engage in social activities. Furniture often refers to significant things like sofas, beds, tables, and closets. The development and innovation of furniture continue to follow the period's trends. There are several categories, materials, variants, and purposes. It is a crucial base for creating a living and working place. Furniture is categorized into categories based on its use, such as for seating, sleeping, storage, or adornment. Chairs, tables, sofas, beds, cabinets, and bookcases are a few examples of furniture.

1.6.3 Furniture in the souvenir group means

Souvenirs are usually purchased in small quantities to reflect individual, cultural

and cultural values. This article refers to small furniture and small product furniture that are related to traditional culture. Products, furniture and furniture, and users, household products, small, courtyard lamps and lanterns, products, incense burners, and other contact media with experience-like bucket arch structure characteristics, to meet the cultural needs and emotional needs of users.

1.6.4 Mortise and tenon structure means

In Chinese cultural history, mortise and tenon joints first appeared in wooden building structures, which are more resilient and have load-bearing capacity and seismic resistance(Dafeng et al., 2008).The mortise-and-tenon construction results from the use of wood in constructing wooden buildings. Mortise and tenon construction is a method of joining wooden components in a concave and convex manner, with the "tenon" being the projecting part of the structure and the "mortise" being the groove in the concave counterpart. (Yufei, 2020)

1.7 Research Benefits

1.7.1 Obtain the compass of furniture design codes from the introduction of Chinese architectural structures (Bucket arch) for use in other related furniture designs.

1.7.2 The design technique may be used to create goods that combine furniture and Chinese architectural elements.

1.7.3 Prototypes of furniture products that can be used as houses or parks, including structures that can change the shape of the internal main body or parts.

1.7.4 Has exhibited works, from introducing the concept of architectural structure (Bucket arch) into contemporary design guidelines, to disseminating home product design guidelines.

1.7.5 Obtain a method that can be patented and led to the establishment of an industry.

CHAPTER 2
REVIEW OF LITERATURE

In this chapter, We will study and research in the fields of documents, textbooks, research, and internet search. Related Articles Creative product design of traditional Chinese architectural components based on customers' demands in diverse sectors. Redesigning Chinese Building Structures to Add Value to Users Today's consumers must investigate the difficulties linked with new designs. The following are included.

2.1 The concept and theory of mortise and tenon and bucket arch

2.2 Concepts and theories related to product design

2.3 Research on bucket arch and mortise and tenon joints with innovative design

2.4 Materials and production methods

2.5 Related research

2.1 The concept and theory of mortise and tenon and bucket arch

2.1.1 Traditional Chinese ancient architectural theory

2.1.1.1 Cultural characteristics of ancient Chinese architecture

Traditional Chinese culture emphasizes the harmony between man and the natural world. The ancients also brought the idea of heaven and man coexisting into conventional antique architecture. The application of traditional architectural elements, such as sloping roofs and wooden structures, as well as the integration of traditional ancient architectural elements with the cultural background of modern architecture, are necessary for modern architecture to continue and sublimate the background and connotation of the building at the spiritual and structural levels. (Fang et al., 2001)

2.1.1.2 The intrinsic characteristics of traditional Chinese ancient architecture

Ancient Chinese architecture, a predominantly timber-frame system, is known as the representative of the Oriental building system for its long history, its most significant number and extremely rich scientific and cultural connotations. The characteristics and advantages of this structural system are, for example, the earthquake resistance of the flexible frame structure, the rational arrangement of interior space variations according to needs, the flexibility of window and door settings, the ease of construction and maintenance and demolition, the variety of roof variations. (Liu et al., 2005)

2.1.1.3 The relationship between mortise and arch

When the clever way of joining wooden constructions known as "mortise and tenon construction" first appeared in ancient China is unknown. Based on the archaeological findings, the He Mudu site in Yu Yao, Zhejiang, appears at least 7,000 years old. The mortise and tenon can be said to be a great creation that has enabled timber-framed buildings to survive for over 7,000 years (or more). The mortise and tenon form was also used extensively in bridge building, furniture, agricultural tools and wooden vehicles. The "Arch" is a unique combination of mortise and tenon technology that arose throughout this miraculous evolution of the "mortise and tenon." Early on, the straightforward

bracing, projection, and roofing parts progressively evolved into a complicated structural system with modalities,' which later became a crucial structural feature of both big and small, necessary buildings. (Feio et al., 2014)

2.1.1.4 Digital modeling of the wooden structure of Hualin Temple

According to fieldwork by scholars, Hualin Temple was built during the Qianlong period of the Northern Song Dynasty. Fuzhou was still governed by the Wuyue Kingdom, one of the Ten Kingdoms of the Five Dynasties. The first investigation of China's cultural treasures was carried out in 1958. The majestic and historic Hualin Temple Hall has been dubbed "the oldest wooden edifice south of the Yangtze River" by cultural heritage specialists. The Hualin Temple Hall is China's seventh-oldest building and the oldest wooden structure south of the Yangtze River. (Whitehand et al., 2011)

Figure 3 Exterior of Hualin Temple and arch structure
Source: Photographed by Guangzhou Li, (2020)

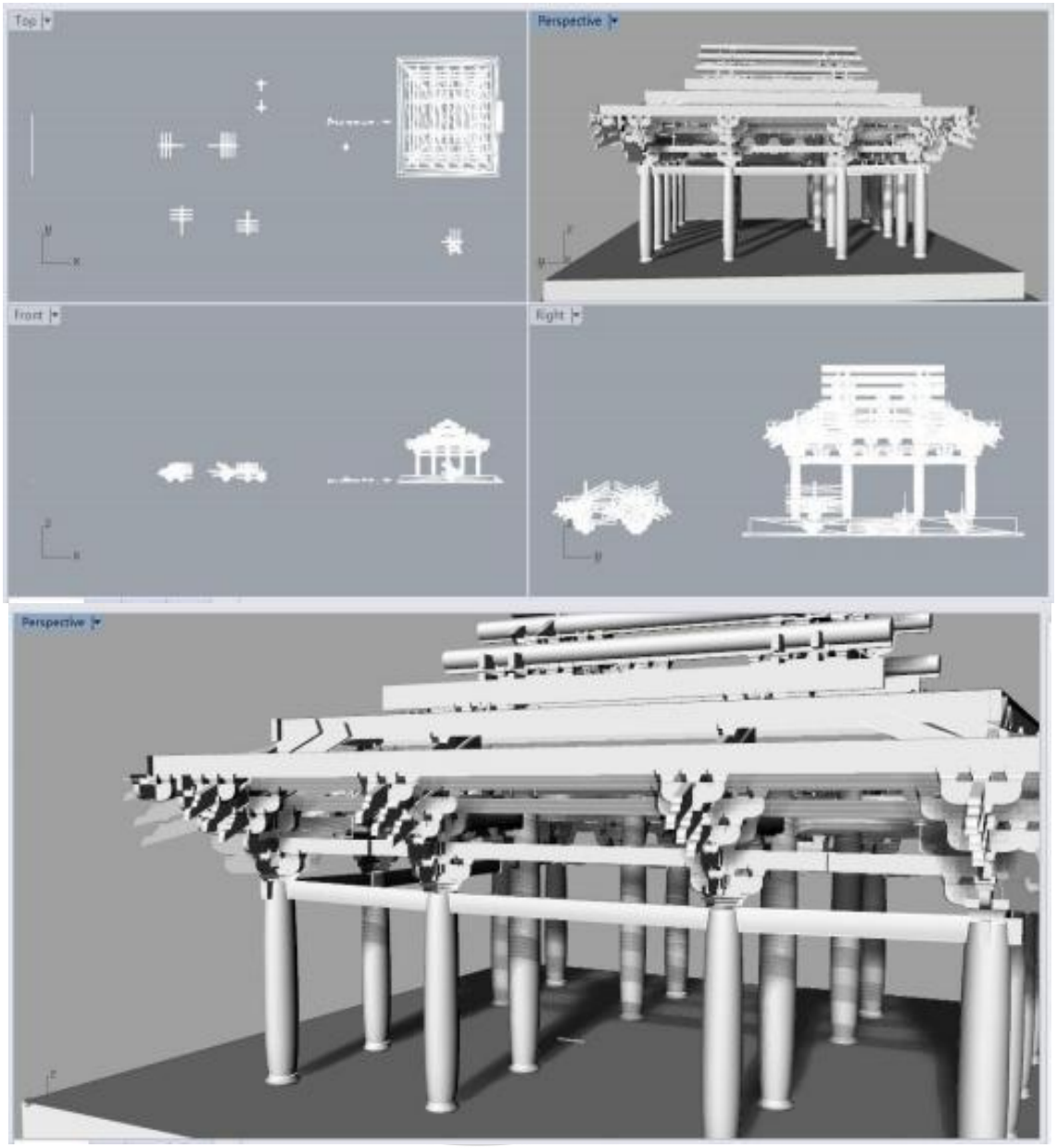


Figure 4 Hualin Temple Architectural Structure 3D Model

Source: Designed by Guangzhou Li, (2020)

2.1.1.5 The concept and importance of the bucket arch structure

Chinese architecture is characterized by its arches. The square wooden block between the arch and the arch, on top of the column, between the frontal square and the eaves purlins, or between the frames is referred to as a bucket. The "arch of the bucket" initially emerged about three thousand years ago, during the Shang and Zhou dynasties; at that time, bronze sculptures usually showed building parts. For instance, the capital is positioned atop four small square columns created from the "order arch's" four feet. Then, between the two columns, a horizontal square is applied inside the mouth of the capital arch, on which two square blocks are placed, similar to a loose bucket and the capital arch

together carrying the upper version of the seat. The bucket occupies a special place in ancient Chinese architecture, and the arch must be used in all critical and monumental buildings. The primary function of the arch is load-bearing and earthquake resistant. According to the proverb, "a wall that falls does not collapse," the arch was crucial in maintaining the structural integrity of old-style timber buildings. This construction and the contemporary beam-and-post frame structure are pretty similar. Because the frame nodes are not stiff, the building's rigidity is coordinated. The arch, a standard component of the mortise and tenon joint, serves as a conduit for the distribution of forces. The arch maintains equilibrium and stability by supporting the eaves' weight uniformly. The arch, a standard mortise and tenon joint component, serves as a middleman for transmitting forces, which is essential for an earthquake-resistant structure. The design resembles contemporary beam-and-column framed constructions a lot. The frame nodes' lack of rigid joining ensures the coordination of the building's stiffness. The mortise and tenon jointed space structure will "loosen" but not "break apart" in the case of a large earthquake, absorbing the seismic energy and significantly decreasing the seismic load on the entire home, serving as seismic resistance. (Dai et al., 2019)

2.1.2 Study of the development of the arch in various historical

2.1.2.1 Bucket arches in early archaeology

Bronze objects from the Shang and Zhou dynasties often reflect partial images of the architecture of the period, such as the short square pillars on the four legs of the ' Ling Gui ' (shown in Figure 5), which appear to have been constructed in the style of a bucket arch. These materials were primarily utilised in the same way and in the same mix to build later eaves pillars. We have excellent grounds to believe that the arch may have existed above the pillars at the end of the Shang dynasty because, more crucially, the manufacturing date of the "Ling ru" is just twenty years after King Wu destroyed the Shang. (Li, 2011)

Figure 5 Shang Zhou Bronze Ware "Ling Gui" Shape

Source: Image quoted from Mr. Liu Dunzhen, A History of Ancient Chinese Architecture.

Figure 6 Bucket arches on the Bronze Square Table of Zhongshan Kingdom
Source: BaoMI, (2020)

The case is a small table used by ancient Chinese to sit on the ground. It was discovered in 1077 in the tomb of the 'wrong' Warring States king of Zhongshan in Sanji Village, Pingshan County, Hebei Province, China. At its discovery, the surface was already corrupt, and only the base remained. It is currently housed in the Hebei Provincial Museum in China—length 47.5 cm, width 47 cm, height 36.2 cm, ring base diameter 31.8 cm. The entire design of the object is cast into parts by pottery casting, using a total of 186 pieces of pottery, which were cast and welded several times (40 casting joints and 60 welding points) to create a finished product of such a complex structure. It is also the earliest example of the application of the arch from the Warring States period found in China. It expresses the strength and beauty of the arch to its fullest extent, reflecting the wisdom of the ancients more than two thousand years ago. This artefact is an authentic reproduction of the timber architecture of the period, using bronze to restore the form of the wooden arch authentically. The cross-disciplinary use of the arch's modelling language in this era shows that the artisans of the time were already highly skilled in using this structure. The ability to create and innovate across content and form profoundly impacted aesthetics and design innovation at the time and in later generations. It is of outstanding aesthetic, artistic and structural significance to the study of the arch. (Wu, 2004)

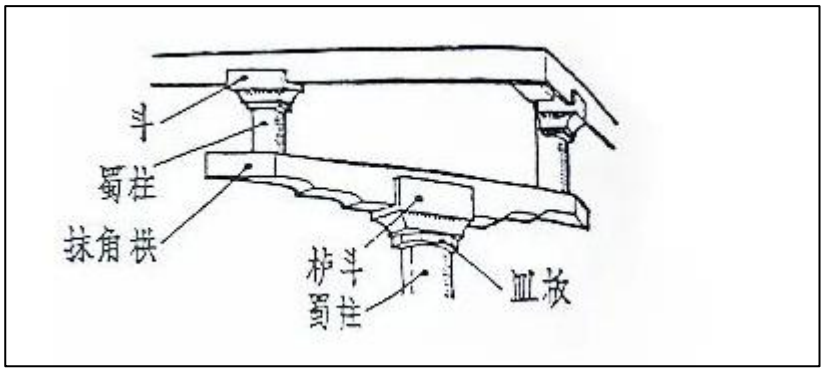


Figure 7 Bucket arch at the corner of the copper scheme

Source: The Evolution History and Characteristics of Dou Yu, Architect Magazine, 2023

A two-litre bucket with the image of a short column beneath it, the bucket, and its bottom is clearly expressed, the body has been curved, and the head of the chestnut is oblique can be seen on the copper scheme that was discovered in Pingshan County, Hebei Province, during the Warring States era. By the Warring States era, cuts and crossbars had been developed, and the combined bucket was employed on corner columns. This is demonstrated in particular by selecting quite a stick on the head of the four-corner dragon in the copper case.

2.1.2.2 Qin dynasty beam frame bucket arch

In the single wooden building, according to the archaeological excavation materials of Xianyang Palace, the maximum span of the interior is nearly 20 meters. The north and south walls of the palace use two opposite pilasters (the distance between the two columns is 1 meter, the distance between the column groups is 3.58~4.15 meters, and the section of the column is 38 x 40 cm), which may be a composite beam frame composed of beam frames to solve the problem of large span. The single-pillar hall of Xianyang No. 1 Palace, due to the central column, the length of its beams does not exceed 7 meters. A diagonal beam with a 45° direction and a height of 1/4 is adopted, and its length is about 10 meters. The above problems could be solved in terms of materials and technology at that time. The burial pits in general buildings and mausoleums, the span is mostly 3~5 meters, and simple roof trusses or simple support beams can be used. The detailed structure of the beam structure is no longer available.

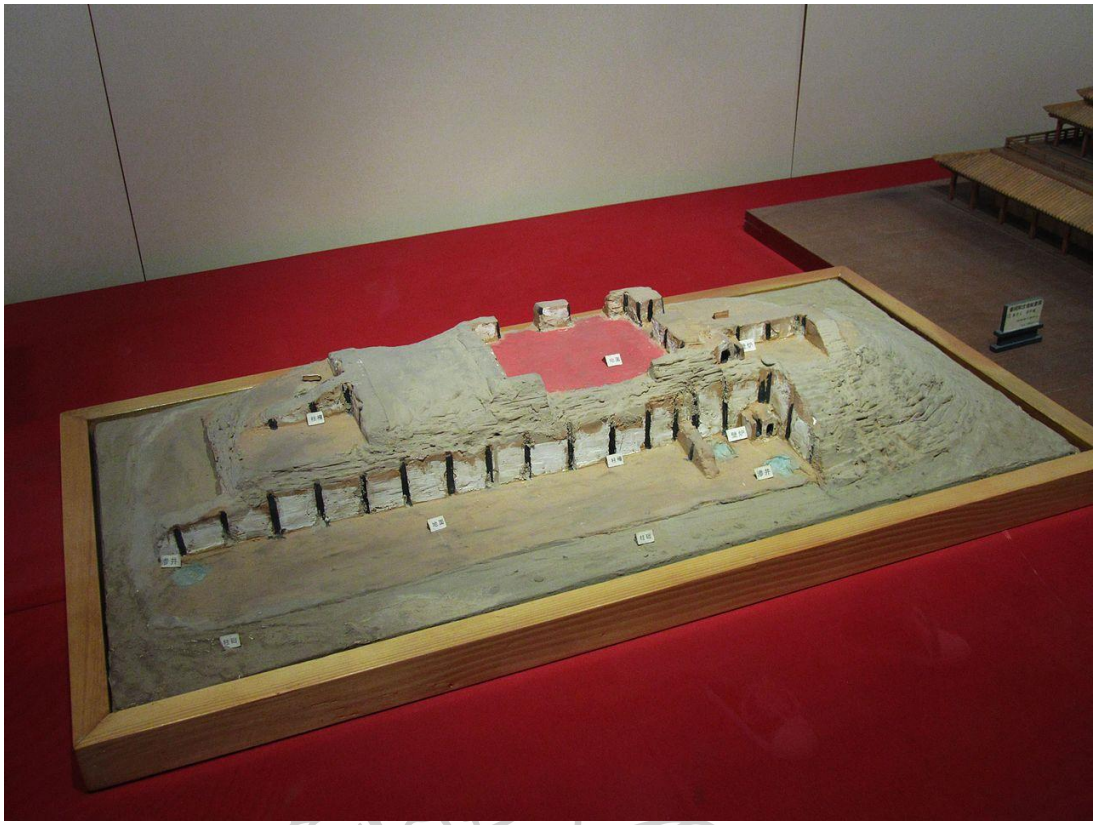


Figure 8 Model of the ruins of Xianyang Palace No. 1
Source: Lovers of culture, 2019

2.1.2.3 The arch in the Han Dynasty "Que"

The Han Dynasty is a crucial time in Chinese history for developing ancient architecture and its legacy for succeeding generations. Stone shrines, gates, burial chambers, portrait masonry, murals, and architectural vessels that have been documented and still exist can provide additional research materials. The Warring States' widespread application of Douyu and the usage of several Douyu groups during the Eastern Han Dynasty expanded the number of Douyu kinds. They diversified its appearance, the foundation for developing the Western Han Dynasty. The main building block of ancient Chinese construction, the one-bucket three-litre bucket, has undergone a significant structural evolution from a relatively simple one-bucket two-litre bucket to a one-bucket three-litre bucket. This made a significant contribution to Douli's growth throughout the Han Dynasty. The Han Que is a unique architectural form in China, with 37 Han Que currently in existence. They are mainly located in seven provinces and cities, including Beijing, Shandong, Henan, Sichuan, Chongqing, Anhui and Gansu. They are an irreplaceable window into the history, society, culture, architecture, art, calligraphy, carving and folklore of the Han Dynasty, and are of great historical, artistic and documentary value.

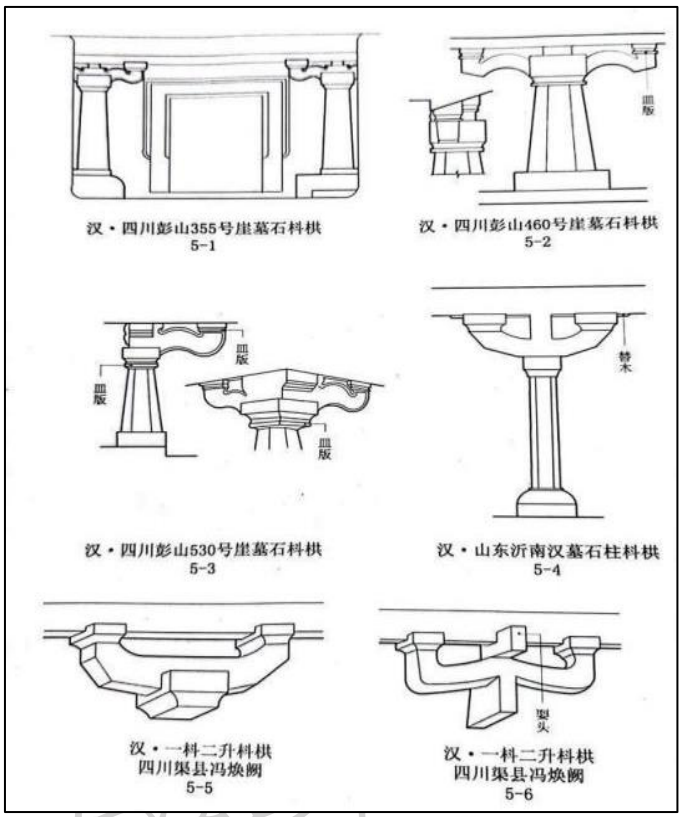


Figure 9 The arch structure of the Han Que, Note: Image quoted from

Source: Mr. Liu Dunzhen, History of Ancient Chinese Architecture

Figure 10 Han Que in the Museum of Ancient Architecture, Beijing

Source: Photographed by Guangzhou Li,(2020)

From an architectural point of view, the Han Que is the entity of Han Dynasty ground-level buildings that we can see today, apart from the ruins of the Great Wall of the Han Dynasty, reflecting from one side the architectural style and architectural thinking of the Han Dynasty. The architectural structure of the Han Que is generally composed of four parts: the base, the body, the building and the roof of the Que. Although the southern queue differs from the northern one in terms of architectural form, as the south is rainy and humid, the architectural style reflects the architectural form of wooden structure, especially the building part of the queue is particularly prominent. Most of the traditional Chinese wooden architectural constructions can be found on the wooden structure, such as beams, squares, rafters, bucket arches, and tile monuments can be found.(Xie, 2020)

The arch is a unique architectural component of traditional Chinese architecture. The basic form of bucket arch in Han quo is one bucket and two litres, i.e. there are two loose buckets on the arch, such as Ya'an Gao Yi quo in Sichuan, Yang's quo in Mianyang, Ding Fang quo in Zhong County, Chongqing, and Gan Jing Gou quo. (Liu, 2022)There is also a bucket of three litres, such as Gongcao Que and Huang Shengqing Que in Pingyi, Shandong. Due to the hierarchy of Chinese feudal society, the construction of arches 'was only allowed in palaces, temples and other high-class buildings on the columns and the square of the inner and outer eaves'. In this sense, these preserved Han quoins, with their 'arch', are at least of the 'high' class. (Cheng & Cheng, 2022)2.1.2.4 The bucket arch of the Southern and Northern dynasties, and the Sui dynasty

2.1.2.4 The Southern and Northern dynasties' bucket arch, the Sui dynasty

The shape of the bucket arch is like the character "人(human)" that first appeared during the Northern and Southern Dynasties, with the discovery of Cave 9 at Yungang, Datong, Shanxi, Cave 5 at Maiji Mountain, Tianshui, Longmen Guyang Cave, Luoyang, Henan, and others. Longmen Guyang Cave, Luoyang, Henan; Cave 9 at Yungang, Datong, Shanxi; Cave 275 at Mogao Cave, Dunhuang, Gansu; Cave 7 at South Langtang Mountain, Magxian, Hebei; and Cave 9 at Yungang, Datong. Only the Song Yue Temple Pagoda from the Northern Wei Dynasty (520-525) in Dengfeng, Henan Province, survives from the Northern and Southern Dynasties, and there is no archival image of the entire pagoda. The combination of a human arch and a two-litre arch in the North and South Dynasties demonstrates that the arch was more sophisticated than the Han period. (Ring et al., 2012)

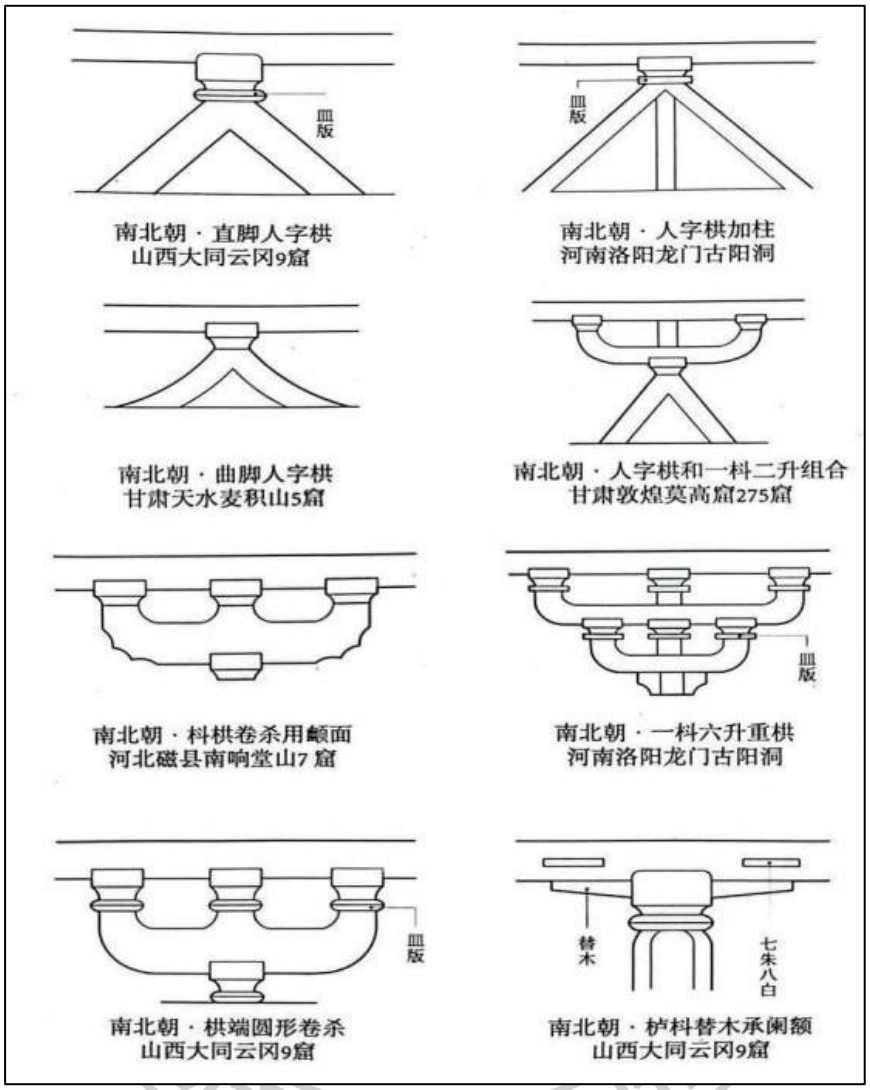


Figure 11 Human Arch in the Northern and Southern Dynasties Caves

Source: Image cited from Liu Dunzhen, A History of Ancient Chinese Architecture

The Sui dynasty was short-lived, and fewer buildings remain, with only the Four Gates Pagoda in Licheng, Shandong, a one-storey stone pagoda. Created in the eleventh to nineteenth years of the Sui dynasty (591-599 AD), the Anji Bridge in Zhao County, Hebei, was built with a leaf-rolling man-arch (Figure 10). The 16th cave of the Tianlong Mountain Grottoes in Taiyuan, Shandong, is a relatively simple arch (Figure 11). The Horyuji Temple's five-story pagoda in Japan was constructed in the third year of the Sui dynasty (607 AD) (Tanabashi, 1960). The five-story pagoda is now the oldest wooden building in existence. The Horyuji Five-storey Pagoda and the Horyuji Golden Hall used the same arch when constructed in 607 AD (Figure 12). There are no surviving examples of Japanese pagodas from the Sui era in China, but this one was constructed in Japan. (Hanazato et al., 2010)

Figure 12 There is a herringbone arch in Anji Bridge

Source: Han Zhenyuan, Yuncheng Daily, 2020

Figure 13 Porch of Cave 16, Tianlong Mountain Grotto

Source: Photograph，by Li Yuqun/Li Gang, 2003.https://tls.uchicago.edu/zh-hans/content/%E7%AC%AC-16-%E7%AA%9F

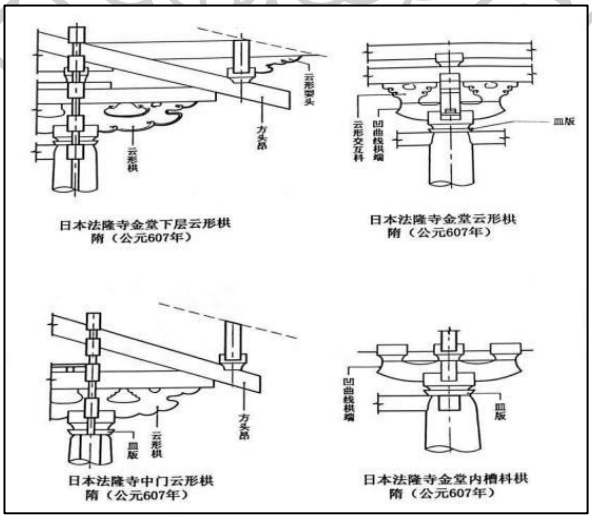


Figure 14 Style of arch in Horyuji Temple, Japan China

Source: Image quoted from Mr. Liu Dunzhen's "Liu Works (I) (Sui Dynasty period, Dunzhen's Collected

2.1.2.5 The arch in ancient buildings of the Tang Dynasty

The Great Hall of Nanchan Temple, constructed in Wutai County, Shanxi, during the third year of the Tang dynasty (782 AD), is one of the two Tang-period structures still standing in China. The Buddhist temple's East Hall was built in AD 87, the eleventh year of Dazhong, Emperor Xuan Zong, in Wutai County, Shanxi. The only Tang-era building still intact in Japan is the Golden Hall of Tang Zhaoti Temple in Nara, built in the first year of the Tang dynasty (760 AD). The temple was built in 760 AD, the first year of the Tang dynasty. (Rujivacharakul, 2014) (Wang, 2012) (Kidder Jr, 2016)

The size of the douli during the Tang Dynasty: The development of the douyu changed from large to small from physical observation. The most obvious change is the ratio of the façade height of the bucket to the column height, and the height of the Tang Dynasty bucket is 40%~50% of the column height. The ratio of the two in subsequent generations gradually decreased, which is one of the important bases for the dating of ancient buildings.

Figure 15 East Hall of Foguang Temple and bucket arch Structure
Source: https://baijiahao.baidu.com/s?id=1674164128028160566&wfr=spider&for=pc

Figure 16 The Golden Hall of the Tangchouti Temple in Nara
Source: https://baijiahao.baidu.com/s?id=1674164128028160566&wfr=spider&for=pc

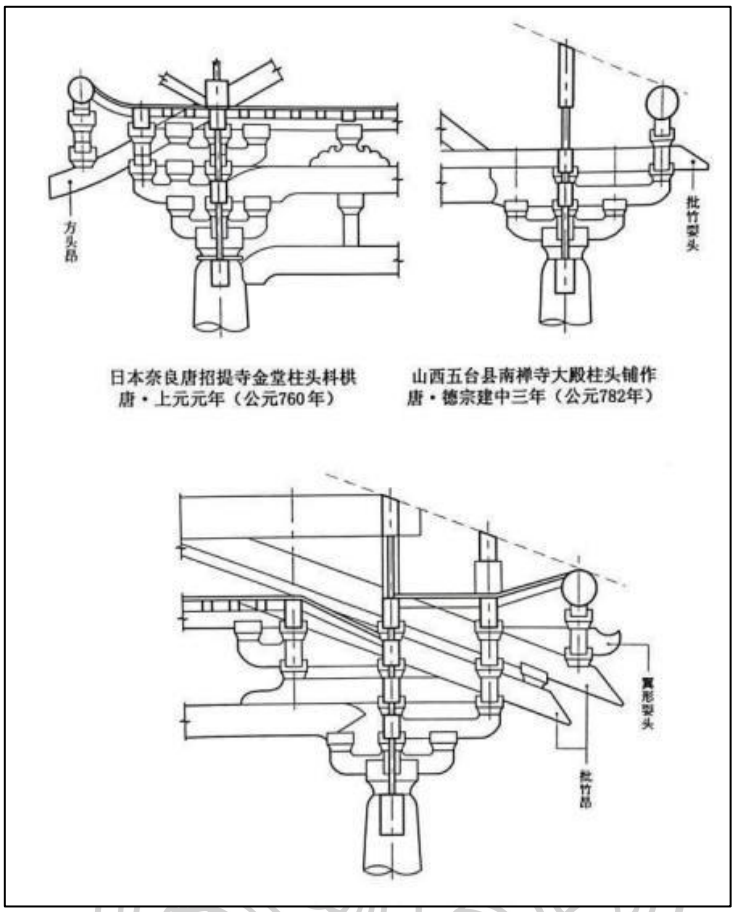


Figure 17 Elevation of three temple bucket arches

Source: https://baijiahao.baidu.com/s?id=1674164128028160566&wfr=spider&for=pc

2.1.2.6 The arch of the Song, Liao, Jin and Yuan periods

Song, Liao, Jin, basically belong to the same period, ethnic minorities and Han culture are integrated with each other, and the architectural style also has many similarities, so it is explained in one section.

"Yingzao fashion," a survey of the building techniques utilized until the second year of the Chongning era in the Northern Song Dynasty (1103 AD), was published by Li Jin. The structure, hierarchy, titles, order, dimensions, and recommended practices of this classic work were published. According to the "Yingzao fashi," there are eight types of material that are used to gauge the size of a home, and this is where the arch hierarchy is built. (Li et al., 2013)

The oldest and most lavishly illustrated treatise on the design of state-owned structures is called Yingzao fashion, or "Standards and models for architecture" in Chinese. On the imperial direction, it was put together by Li Jie, Director of the Palace Buildings (jiangzuojian Shao Jian), during the Northern Song era (960–1126) and presented to the king in 1100.

In 1103, the initial print was released. It offers helpful guidance on how the government should organize building materials and labour (guan fang ganglia, "construction work and material inside the Pass and in

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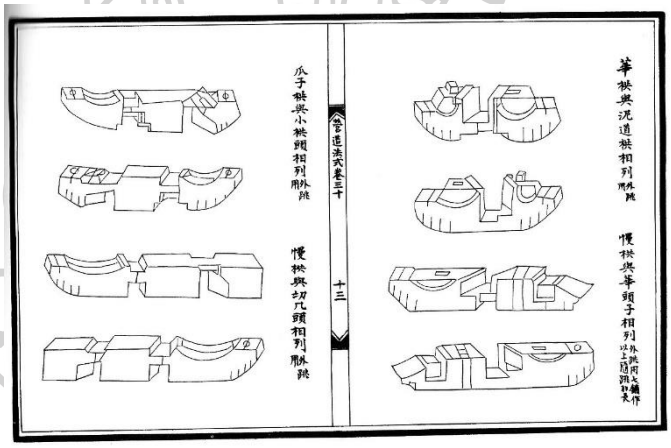


Figure 18 "Yingzao fashi" expressed in images

Source: "Building the French Style" bucket arch, image by Wikimedia Commons

In the Liao Dynasty, the oblique bucket arch began to be used, the huge bucket arch is the characteristics of Liao Dynasty architecture, the measurement of the size of the bucket is based on the ratio of the height of the front façade of the bucket to the column height, the height of the early Liao bucket is 40% ~ 50% of the column height, maintaining the proportional relationship between the two in the Tang Dynasty. After the middle of the Liao Dynasty, it still maintained a large proportional relationship, and the ratio of the two was more than 30%. For example, the main hall of Shanxi Datong Huayan Temple is 43% of the height of the column, and the Daxiong treasure hall of Datong Shanhua Temple is 40%

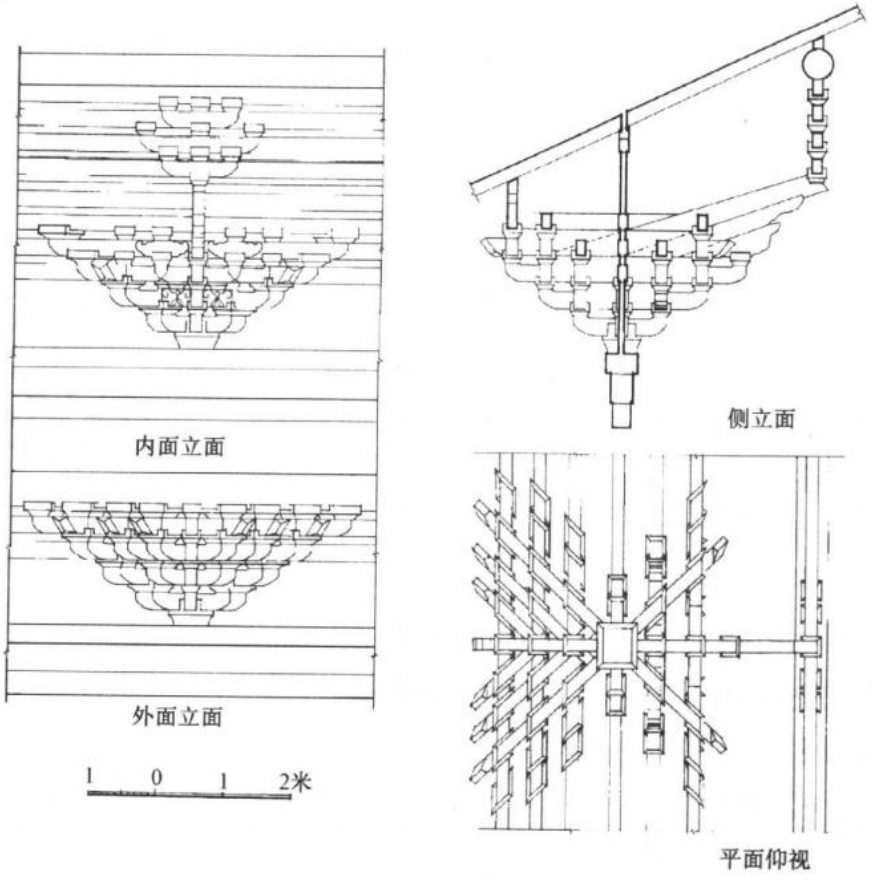


Figure 19 Shanhua Temple diagonal arch

Source: https://www.sohu.com/a/384990300_99892258

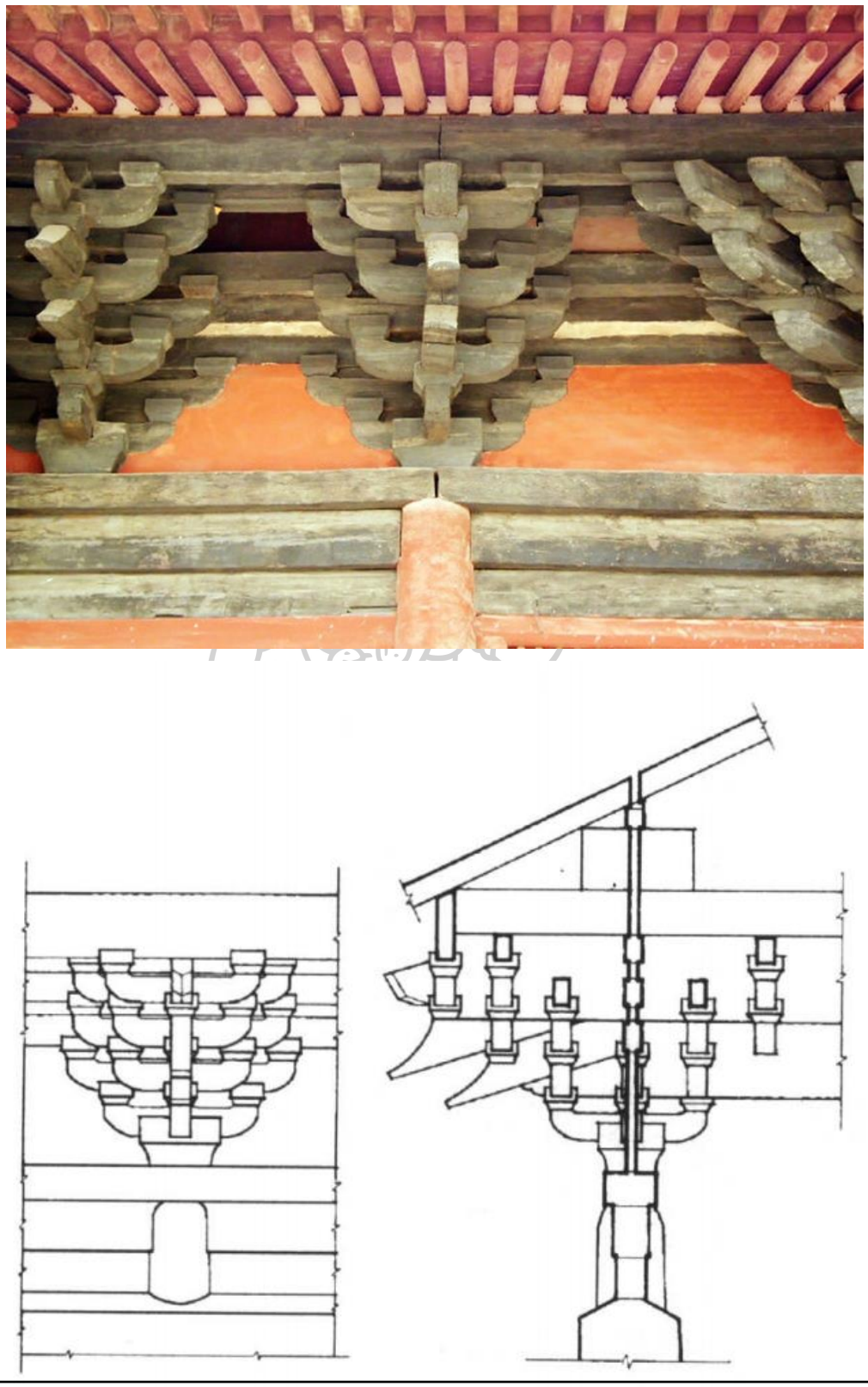


Figure 20 Shanhua Temple pillar arch front and side elevation drawing

Source: https://www.sohu.com/a/384990300_99892258

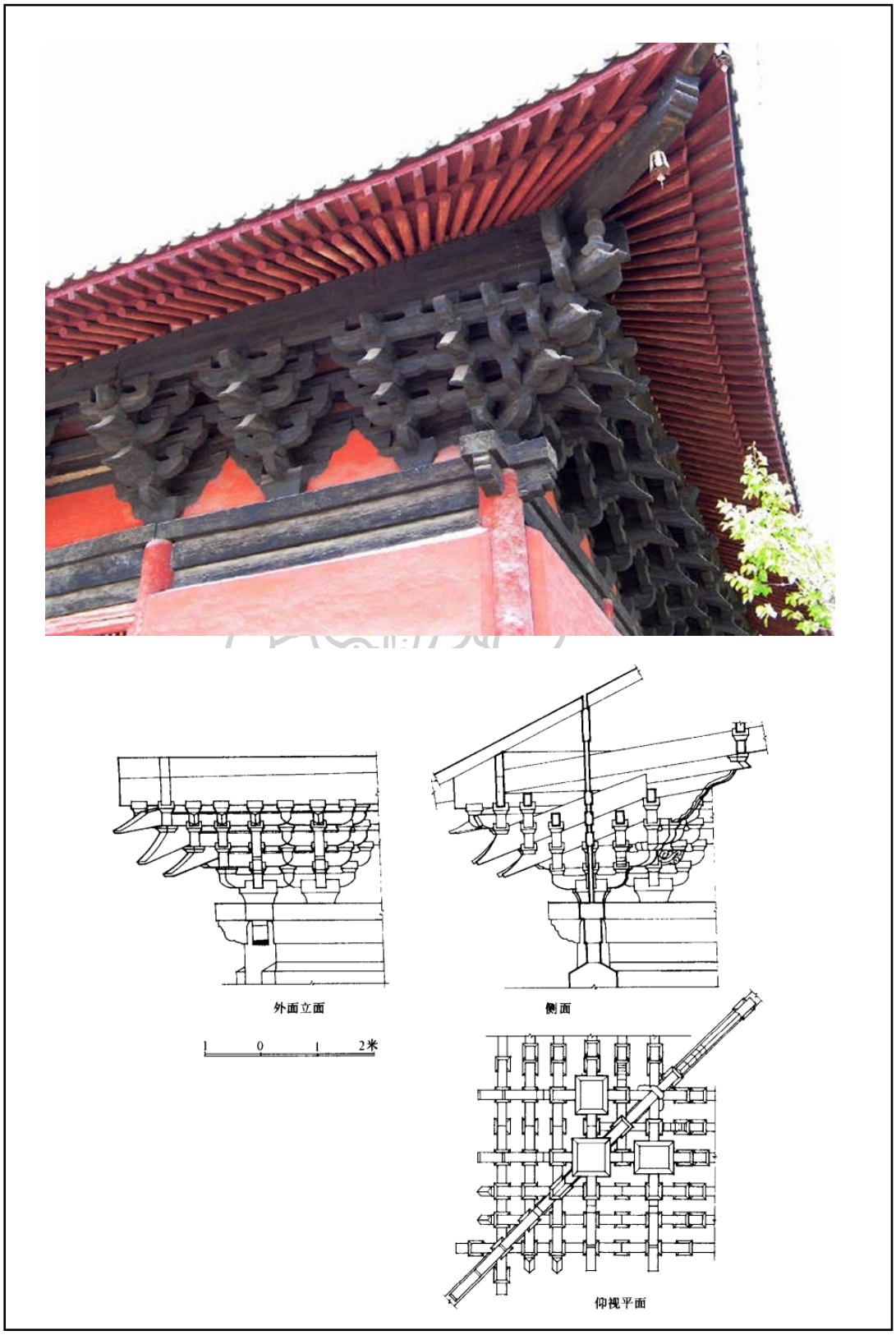


Figure 21 Side elevation of the outer eaves arch of Shanhua Temple

Source: https://www.sohu.com/a/384990300_99892258

Although the Jin Dynasty's bucket arch is considerably smaller than those of the Tang and Song eras, the design is essentially the same. The only relative higher object is the bucket.

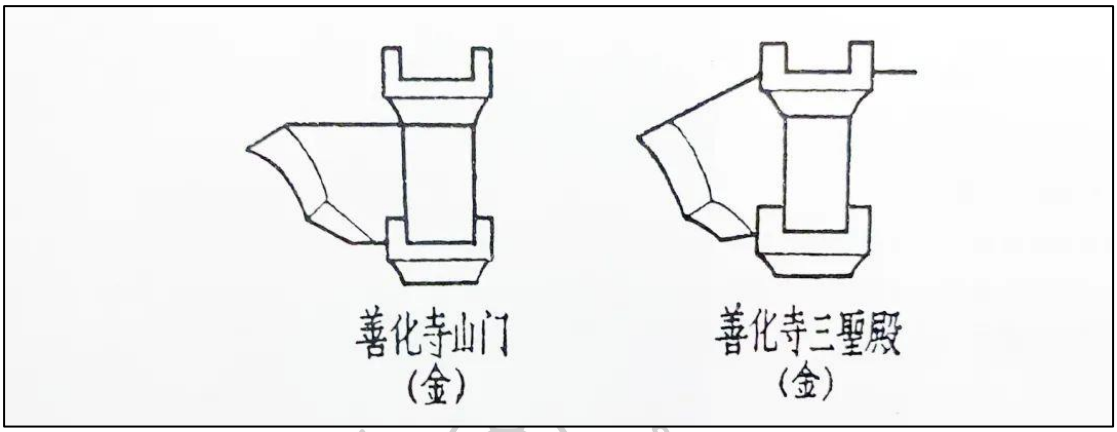


Figure 22 Jin Dynasty building bucket arch structure facade
Source: The fourth issue of "Cultural Relics" in 1965

2.1.2.7 The arch of Yuan Dynasty

The bucket arches underwent great changes in the Yuan Dynasty, and douyu began to use false ang, and there were examples of douyu using angs for the first jump. But there are also tween bucket arches that use false angs for the first jump, while the second layer is raised diagonally up, and the rear tail is raised, still maintaining its leverage. During this period, there are still many buildings that still use Zhenang, so when identifying Yuan Dynasty buildings, we must pay attention to this evolution and detailed practice of douyu. The style and number of jumps of the column head bucket arch and the tween bucket arch of the Yuan Dynasty building are the same. In the Yuan Dynasty, buildings with false angs were often tweened bucket arches with real angs, and column head bucket arches with false angs. The number of tween bucket arches has increased, and the distance between the bucket arches is not equal.

Figure 23 Yuan Dynasty fake Ang shape
Source: https://www.163.com/dy/article/HV2MT1JN0515AJG5.html

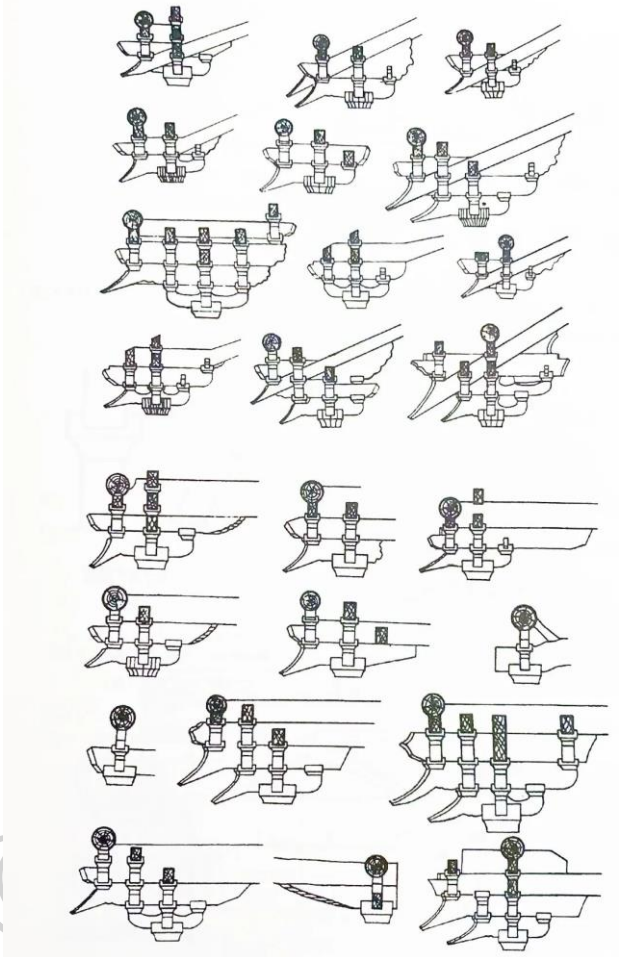


Figure 24 Yuan Dynasty architectural bucket arch style
Source: "Ancient Architecture Stone Inscription Collection", 1999 edition

2.1.2.8 The arch of the Ming and Qing dynasties

The Ming Dynasty bucket arch's overall evolution moved from huge to tiny, and it employed Xiangang (false ang) individually, which may have been the first application of oblique ang. "Ruyi Douyu" first arose in the middle of the Ming Dynasty; the oldest example is the Zhenwu Pavilion in Jingliaotai, Rong County, Guangxi. The general trend of the development of douyu is from large to small. The height of the front façade (the vertical height from the bottom of the bucket to the bottom of the cornice) about the height of the eaves column in the same structure is a proxy for the bucket's size. During the Tang and Song dynasties, the ratio was between 40 and 50 per cent, 25 per cent during the Yuan and 20 per cent during the Ming. The Qing Dynasty's official structure was much smaller than previously. Only 12% of the eaves pillars, or a fourth of the height of the Tang Dynasty, are higher than the façade of Beijing's old official Taihe Hall. This does not place a cap on the height of the façade during this period in local manual architecture; the tallest façades reach 33% to 36% of the eaves column, similar to the proportion of bucket height to column height during the Song Dynasty.

Therefore, when identifying ancient local architecture, it is necessary to look not only at the height of the douli, but also at the shape and architectural technique of the douli.The Ming dynasty bucket is in a position to take over from the Yuan dynasty bucket arch and hand over to the Qing dynasty bucket arch. In the Qing dynasty, the arch changed considerably in terms of name, construction, appearance and size, and most of the names are different, and the prominent names are also different. (Shao et al., 2022)

The enormous wooden arches of the Ming and Qing eras government buildings have seen fewer alterations, but the little wooden works and the interior eaves are colourfully decorated. Excellent algae wells are used in many royal structures, and bucket arch involvement is required. In the four Ming Dynasty pavilions representing spring, summer, autumn and winter in the imperial garden of the Forbidden City, Wanchun Pavilion, Fubi Pavilion, Qianqiu Pavilion, and Chengrui Pavilion, the large wooden fighting arch and the small wooden fighting arch silently tell the flow of time in the round place; In the Taihe Hall, which shows the dignity of imperial power, the high hanging algae well and the Pilu hats with bucket arches on both sides effectively adjust the separation of indoor space and the environmental atmosphere. The Hall of Taihe is too high, but in the similar arrangement of the Nourishing Heart Hall and the Nourishing Hall in the place where the emperor lives and works in a relatively small scale and scale, it can make the people in it feel the hierarchy and etiquette.

Figure 25 Forbidden City Taihe Hall Mojing Bucket arch style
Source: https://www.sohu.com/a/646938404_120647287

2.1.2.9 The arch of the modern period

Figure 26 Sun Yat-sen Memorial Hall Bucket arch structure
Source: Photographed by Guangzhou Li,(2020)

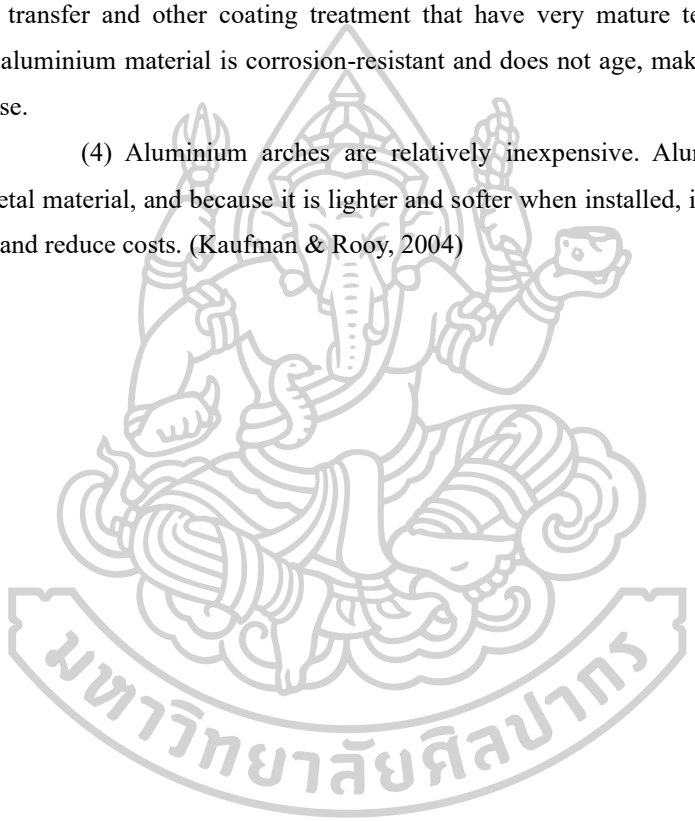
With the current level of productivity and technology offered comes the performance of building materials and the level of construction offered. The arch no longer assumes the role of a load-bearing building but serves as a decorative ancient architectural element. The materials are varied and include aluminium alloy and cement. In Tibetan antique architecture, the use of aluminium alloy to make the arch structure style has emerged.(Yu, 2020) Advantages of modern aluminium bucket arches.

(1) The material of the aluminium alloy arch is light, and the seismic strength is up to standard; because the current building structure is dominated by frame and shear wall structure, the central role of imitation arch is for aesthetic and decorative purposes, none of which has a load-bearing function, therefore, there is no indicator requirement of seismic strength.

(2) Aluminium alloy bucket arch is easy to process and not easy to corrode. In addition, the aluminium alloy material is taught soft and has a slightly lower melting point, making it easy to dissolve for casting.

(3) The welding process required for aluminium arches is also relatively easy. At the same time, it is more convenient for later finishing, including surface anodising, fluorocarbon spraying, heat transfer and other coating treatment that have very mature technology applications. Moreover, the aluminium material is corrosion-resistant and does not age, making it suitable for long-term outdoor use.

(4) Aluminium arches are relatively inexpensive. Aluminium is a relatively inexpensive metal material, and because it is lighter and softer when installed, it can save much money on installation and reduce costs. (Kaufman & Rooy, 2004)



2.1.3 Structural analysis of the arch and generalisation of design elements

This chapter mainly uses CAD methods to draw two-dimensional bucket arch images to learn the bucket arch structure.

2.1.3.1 Study of different types of bucket arches

(1) One-dou, three-sheng of bucket arch

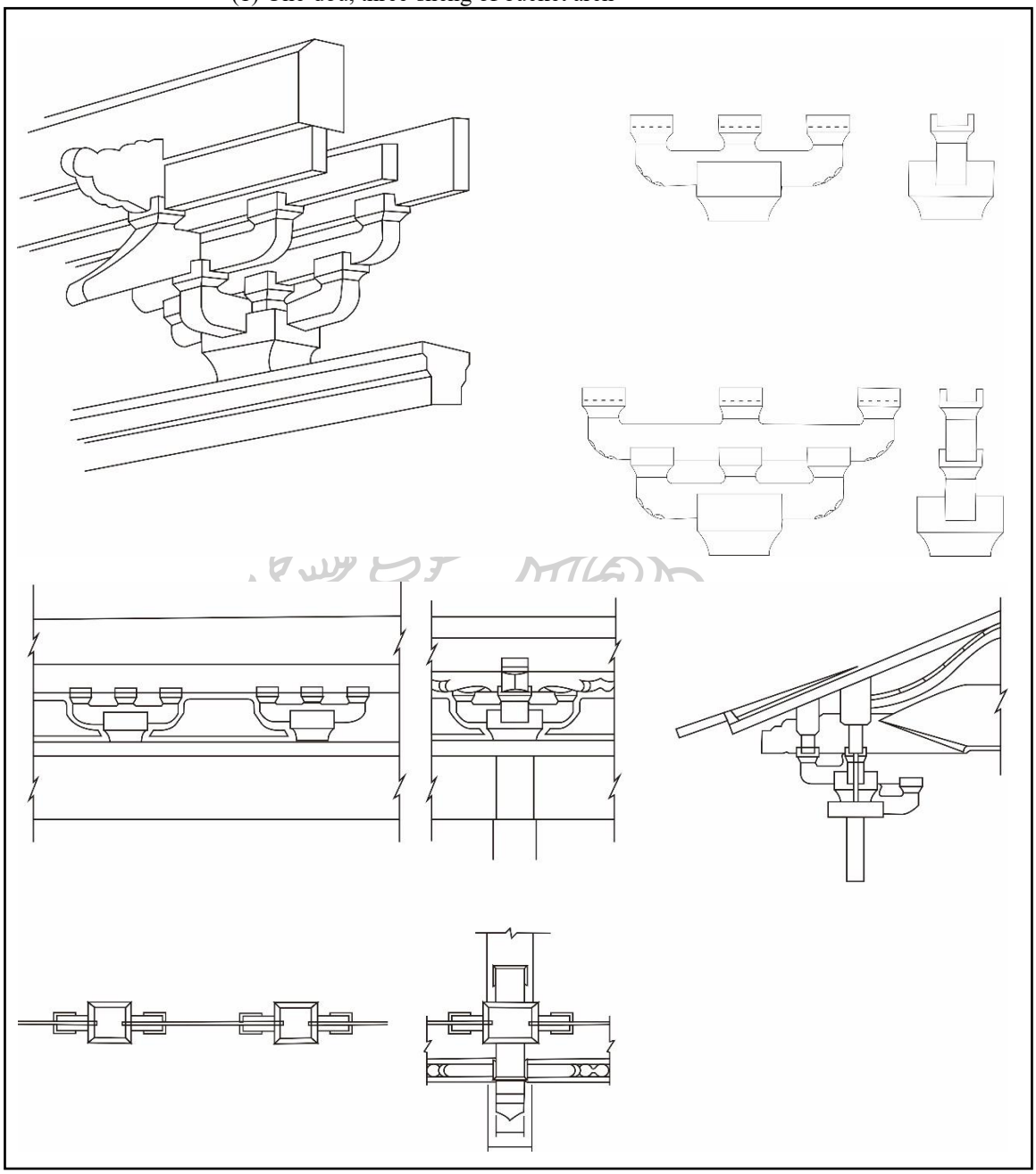


Figure 27 Side elevation of the one-dou, three-sheng arch

Source: Designed by Guangzhou Li (2020)

(2) One-dou, Six-sheng of bucket arch

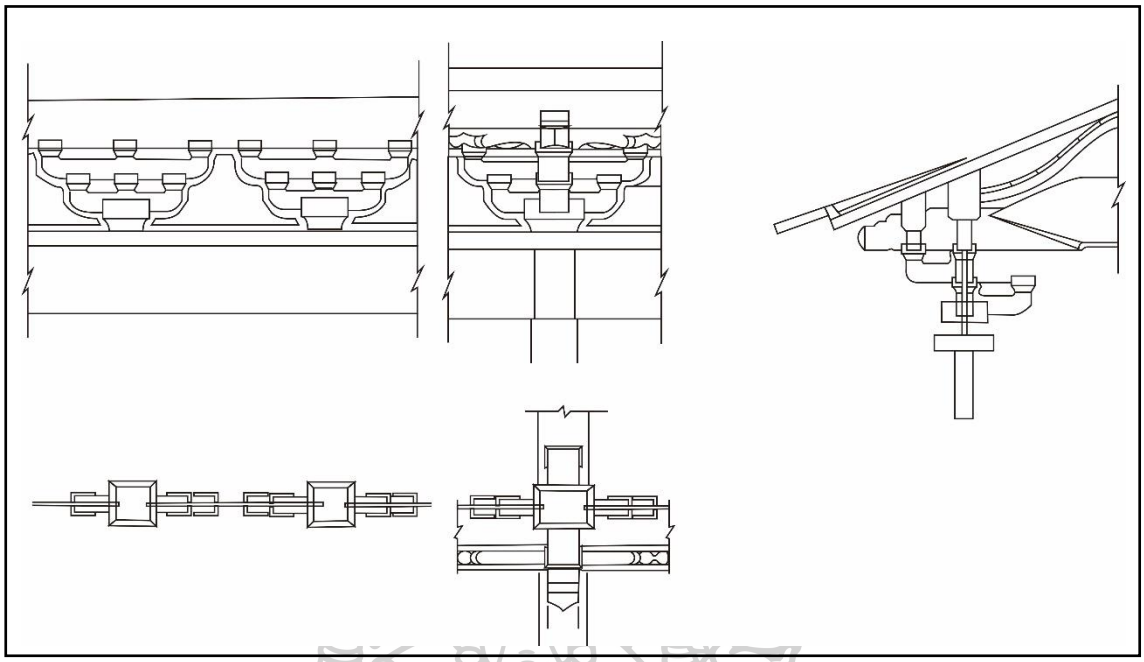


Figure 28 Side elevation of a six -litre bucket arch

Source: Designed by Guangzhou Li (2020)

(3)Ding bucket arch

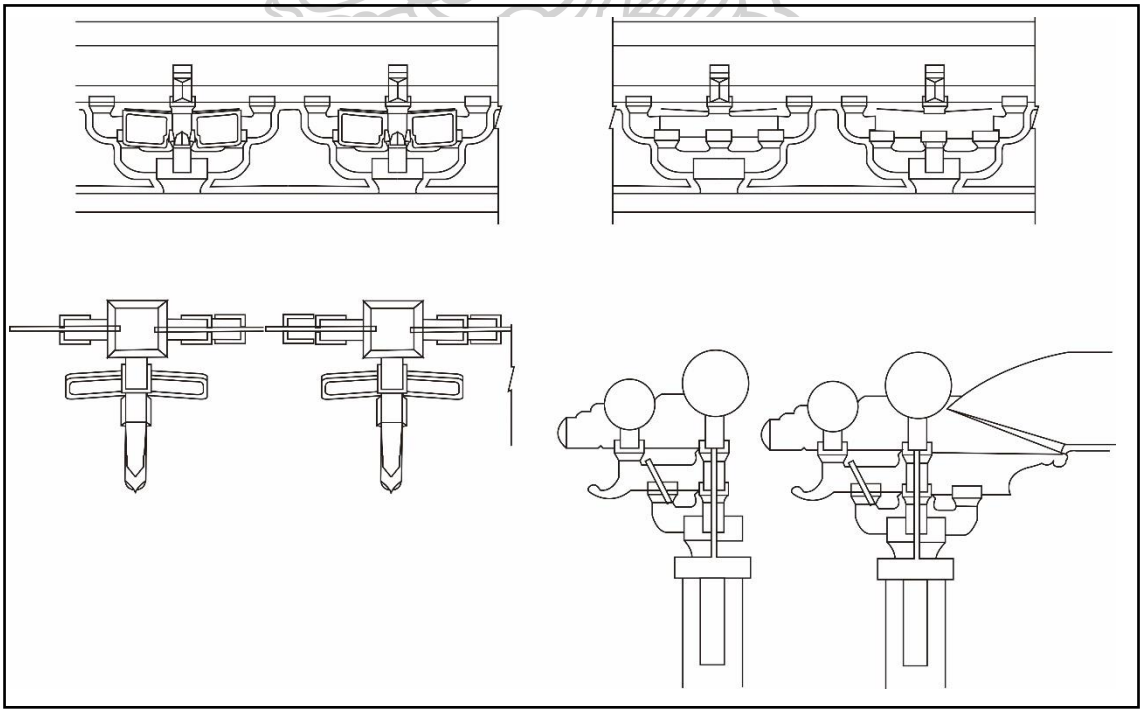


Figure 29 Side elevation of ding bat arch

Source: Designed by Guangzhou Li (2020)

(4) Cross arch

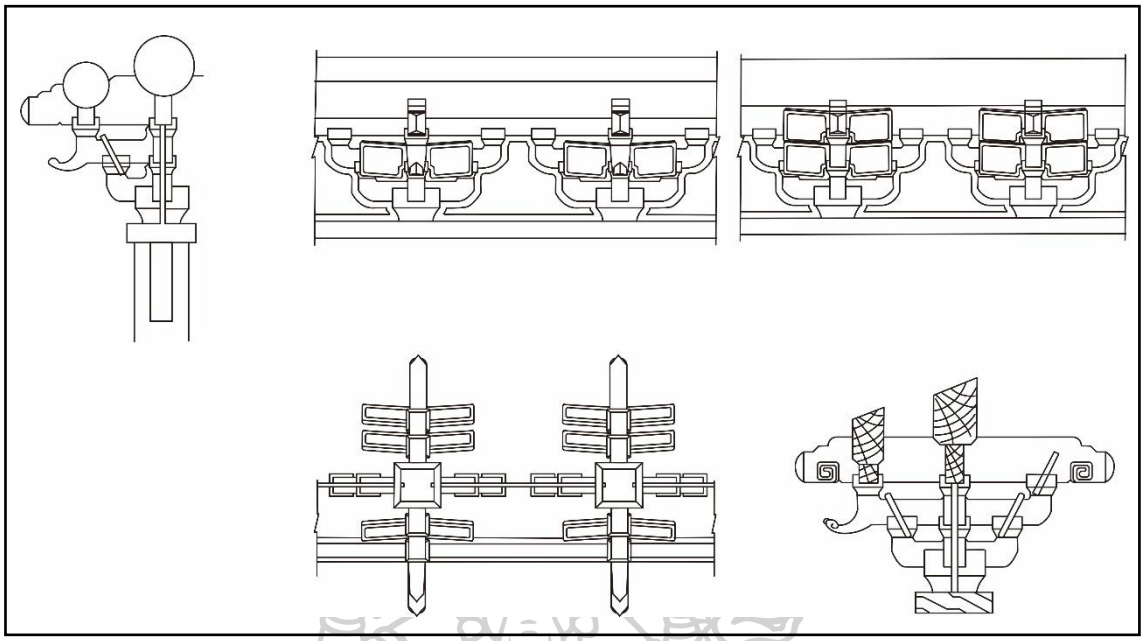


Figure 30 Side elevation of the cross arch

Source: Designed by Guangzhou Li (2020)

(5) Eaves corner bucket arch

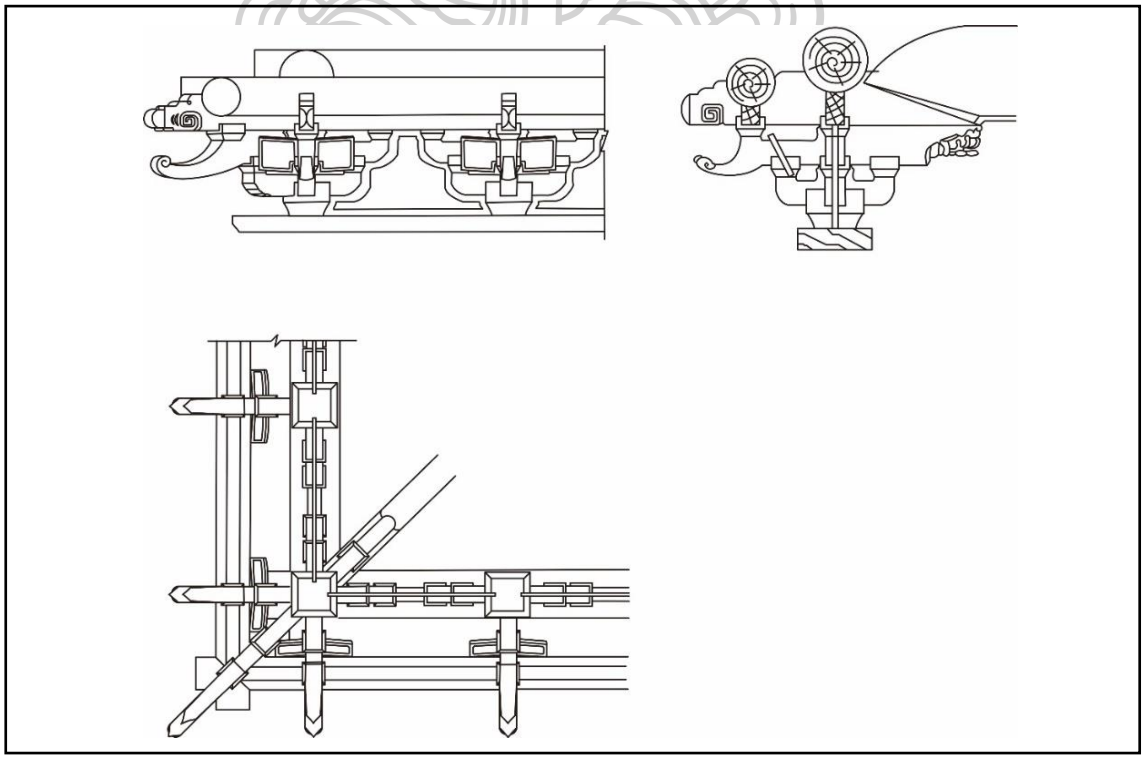


Figure 31 Top view and side elevation of corner arch

Source: Designed by Guangzhou Li (2020)

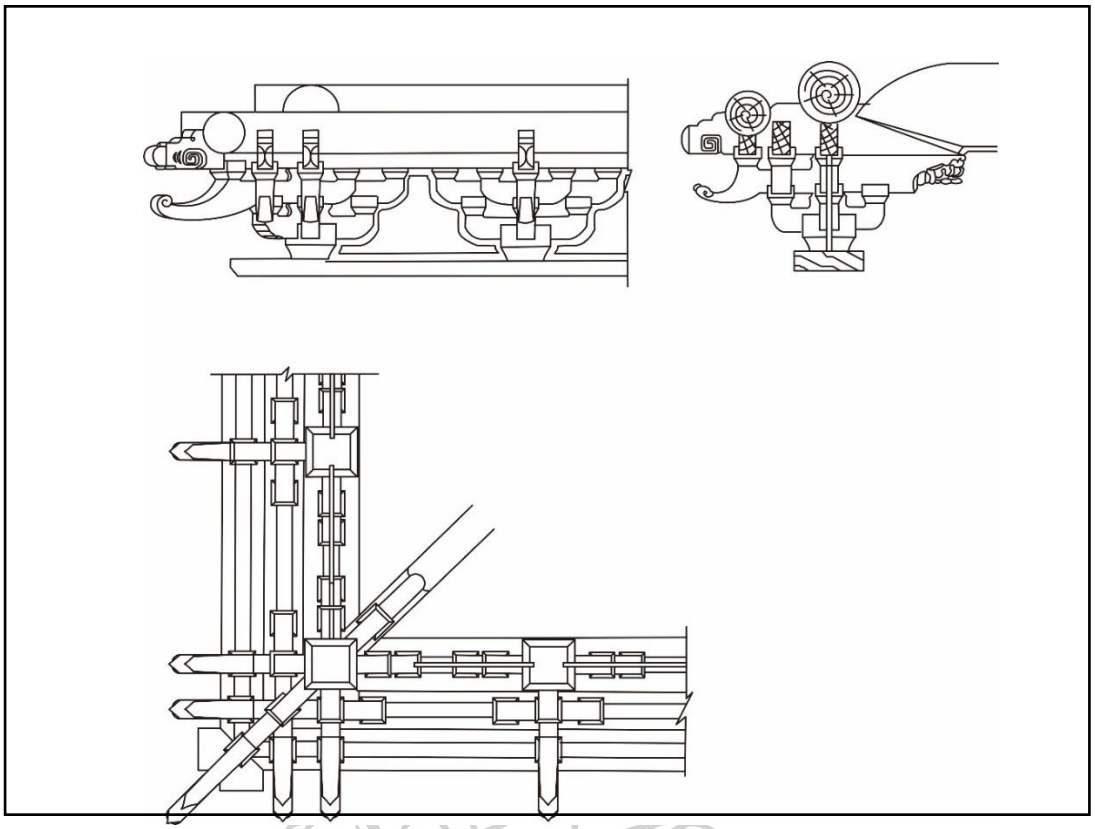


Figure 31 Top view and side elevation of corner arch（comlifued）

Source: Designed by Guangzhou Li (2020)

2.1.3.2 Specification of different bucket arch dimensions

Table 1 Luban ruler and metric size conversion table used in bucket arch

1 Luban ruler = 27.5cm	
7 inch=200mm	2.5-inch=70mm
5 inch=140mm	2 inch=60mm
3.5 inch=100mm	1.5-inch=40mm
3 inch=80mm	1 inch=30mm

Table 2 Dimensions of different grades of wood for the four-six bucket arch

Song Dynasty (construction of French style) material grade (bucket arch material, timber width)	Section dimension of material used in Song Dynasty H D		Scope of application
	Size specificati on of Song Dynasty (cun)	Convert to international size (cm)	
First level	9 × 6	28.8cm x19.2cm	Hall body 9- 11, deputy steps and hall hostage room than the hall reduced first, gallery room
Second level	8.25 x 5.5	27.8cm x17.6cm	Hall 5-7, auxiliary steps, house, corridor with the first class materials
Third level	7.5 × 5	24.0cm x16.0cm	Three double eaves, five halls, seven rooms with
Fourth level	7.2 ×4.8	23.4cm x15.4cm	There are three halls and five halls
Fifth level	6.6 ×4.4	21. 1cm x14. 1cm	The hall is three small, the hall is three large
Sixth level	6 ×4	19.2cm x12.8cm	Pavilion, small hall
Seventh level	5.25 x 3.5	17.2cm x11.2cm	Small halls, small pavilions
The eighth level	5 × 3.3	16.0cm x10.6cm	Barracks
The ninth level	4.5 × 3	14.4cm x 9.6cm	Inside the temple, small pavilions and arches
The tenth level	1.8 × 1.2	5.8cm x 3.8cm	Temple inside the algae well, Buddha way account bucket arch with

(1 Song dynasty ruler = 32cm)

Table 3 Dimensions of different grades of wood for the five-seven bucket arch

The Engineering Practice of the Qing Dynasty Material grade(Material and nozzle used for bucket arch)	Section size of material used in Qing Dynasty H D		Scope of application
	Dimensions of the Qing Dynasty (cun)	Convert to international size (cm)	
First level	8.4 ×6	26.9cm×19.2cm	No instances were seen
Second level	7.7 × 5.52	24.6cm×17.6cm	No instances were seen
Third level	7 × 5	22.4cm×16.0cm	No instances were seen
Fourth level	6.3× 4.5	20.2cm×14.4cm	The watch tower on either side of a city gate
Fifth level	5.6×4	17.9cm×12.8cm	turret
Sixth level	4.9×3.5	15.7cm×11.2cm	Audience hall
Seventh level	4.2×3	13.4cm×9.6cm	palace
Eighth level	3.5 × 2.5	11.2cm×8.0cm	hall
Ninth level	2.8× 2	8.96cm×6.4cm	pavilion
Tenth level	2.1×1.5	6.72cm×4.8cm	Hanging flower door, pavilion class small buildings
Eleventh level	1.4 ×1	4.48cm×3.2cm	Alga well, decoration shop

(1 Qing dynasty ruler = 32cm)

Figure 32 Model of the arch in the Museum of Ancient Architecture, Beijing

Source: Photograph by Guangzhou Li,(2020)

Figure 33 Dimensions and specifications of the timber for bucket archs

Source: Photograph by Guangzhou Li,(2020)

2.1.4 Analysis of the bucket arch base structure components

2.1.4.1 Bucket arch foundation components - buckets

The bucket is a cube-shaped block of wood, resembling a bucket, with a wide top and a bottom debt, with a one -, two - or cross-shaped opening for the arch or ang.

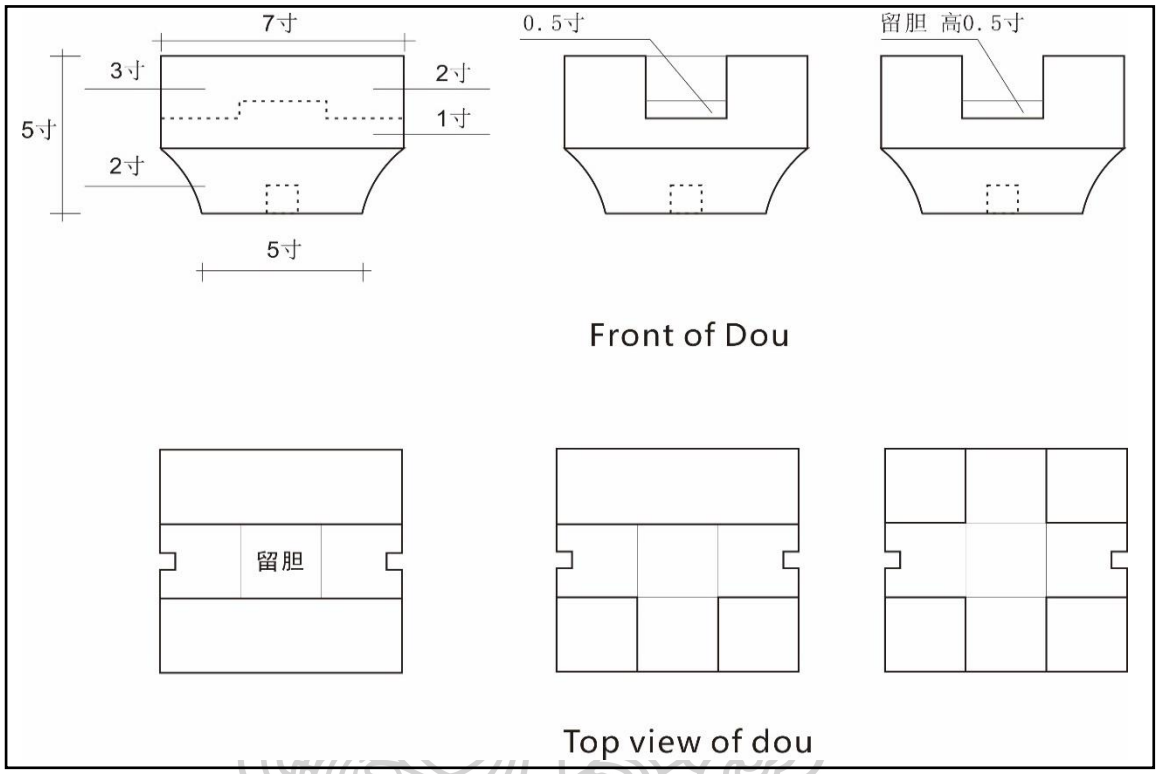


Figure 34 Assorted bucket practices

Source: Designed by Guangzhou Li (2020)

2.1.4.2 Bucket arch base structure components - rising

The lung is the same shape as the bucket, but half the size of the bucket, and is placed above the bucket or ang, with an opening at the top to receive them.

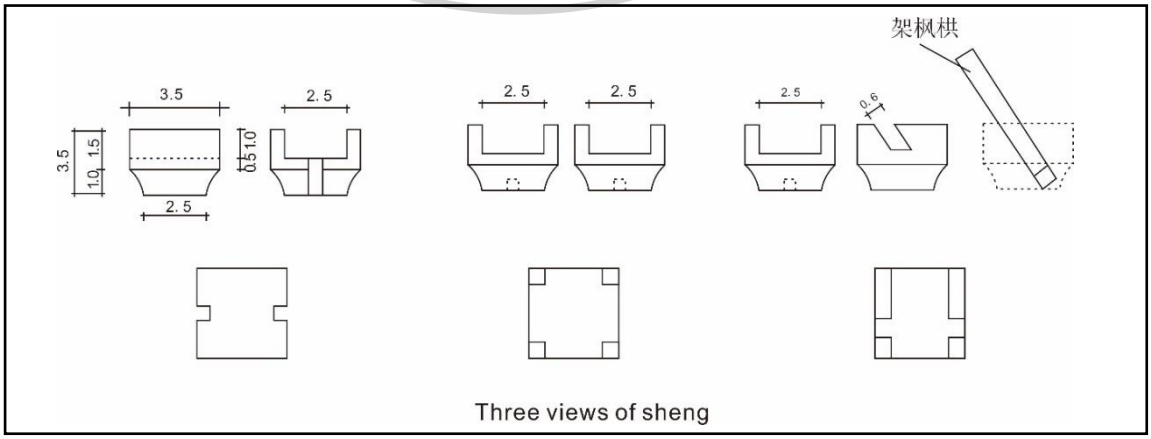


Figure 35 Assorted litres approach

Source: Designed by Guangzhou Li(2020)

2.1.4.3 Arch foundation components - arch

It resembles a bow and arrow and has a rectangular cross -section, being a transversely stressed element erected on top of a bucket or ladder.

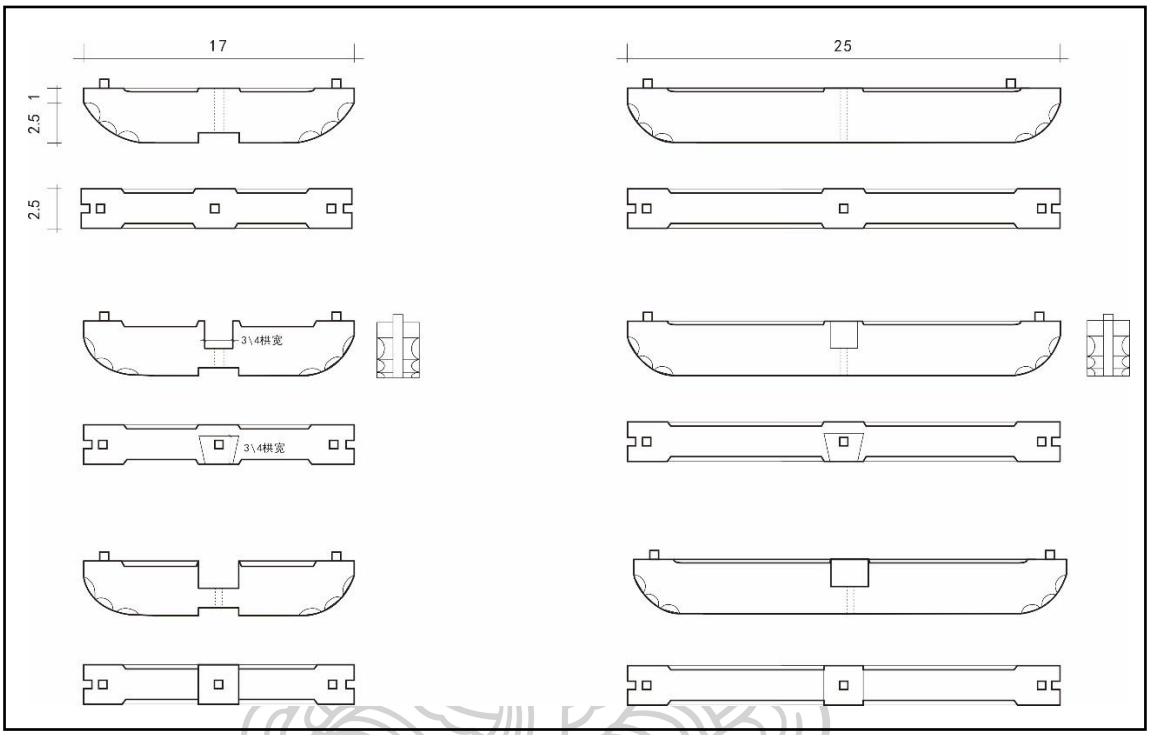


Figure 36 The practice of the one arch, ding arch and cross arch

Source::Designed by Guangzhou Li (2020)

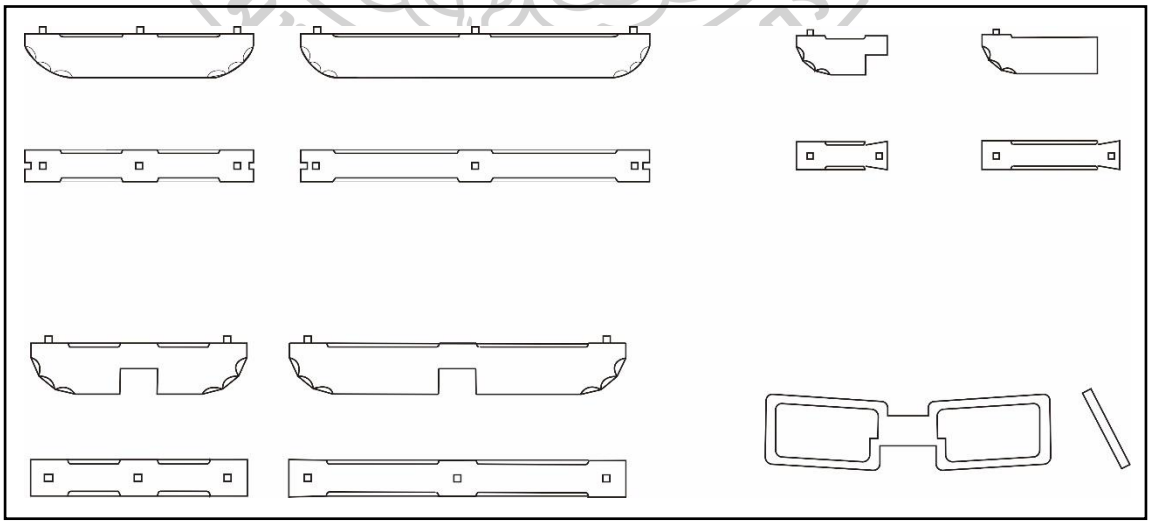


Figure 37 Practice of trussed arch and maple arch.

Source: Designed by Guangzhou Li (2020)

2.1.4.4 Bucket arch base structure components - Ang

The arch is perpendicular to the direction of the trusses, with the arch head extended diagonally downwards.

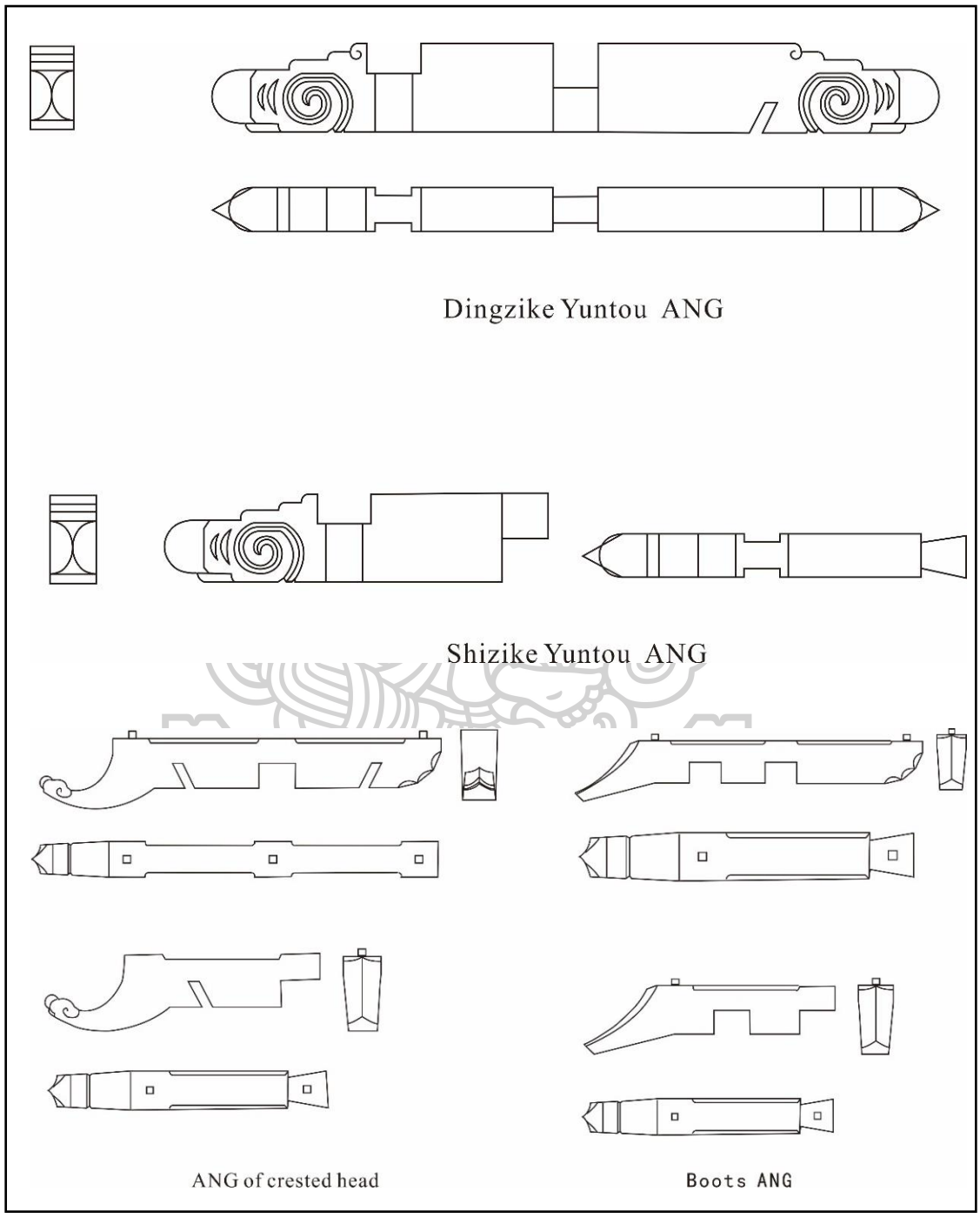


Figure 38 Various ang practices

Source: Designed by Guangzhou Li(2020)

2.1.5 Overview of mortise and tenon construction and relatedresearch

2.1.5.1 Overview of mortise and tenon construction

The term "tenon" refers to the projecting element of the structure, while the term "dong" refers to the groove in the concave counterpart. Mortise and tenon construction is a way of combining wooden components in a concave and convex manner. Traditional Chinese culture includes the fine and varied mortise and tenon technique that reflects old Chinese knowledge. Therefore, someone has to improve upon the age-old technique of mortising and tenoning while also innovating more. To show the fusion, inheritance, and innovation of ancient and modern cultures, more and more designers are now including mortise and tenon elements in their creative design products, such as jewellery designs, children's puzzle toys, children's puzzle tables, and furniture designs. (Chao & Chuang, 2021)

2.1.5.2 The origin of mortise and tenon construction

In the Stone Age, people worldwide could take refuge in caves and nests if metal tools were not available. Both of these ways of life inevitably involved handling wood. The emergence of the mortise and tenon was made possible by the invention of piercing technology and the development of stone manufacturing techniques, which were mastered naturally over a long period.

With the culmination of human creative ingenuity, wooden mortise and tenon joints were unearthed in Leipzig, Germany; see Figure 39. remains from more than 7,000 years ago. Mortise and tenon joints were employed to create the timber parts of these structures. Mortise and tenon construction was progressively used in furniture during the Spring and Autumn and Warring States periods in China, as seen in Figure 40, where it was also discovered. Traditional Chinese wooden furniture has a long history and the most ethnically distinctive traditional culture, which has also profoundly influenced other countries in the Han cultural circle. It reflects the working and living conditions of ancient people, putting their diligence and wisdom to full use and producing countless pieces of handcrafted furniture of traditional culture, artistic emotions, and aesthetic beauty that have come to be studied and are also categorized as cultural heritage and craft heritage. (Wang & Han, 2016)

Figure 39 Neolithic mortise and tenon structure, unearthed in Alz, Germany

Source: https://m.thepaper.cn/newsDetail_forward_21321081

Figure 40 The mortise and tenon structure found in the Hemudu period
Source: Zhejiang Province, China

Since the Sui dynasty, traditional Chinese furniture products have gradually moved away from box-type auxiliary nails and separated from natural spray-painted craft box-and-panel furniture, gradually forming pure wood-line furniture, especially after the Song dynasty, which saw unprecedented structural development. In the context of the time's economic and social development environment, mortise and tenon construction was the more familiar way of joining the various parts of traditional Chinese wooden furniture. Mortise-and-tenon furniture presents the visual effect of integrated furniture. It reminds ancient culture of the concept of 'tolerance', the harmonious coexistence of parts and the unity of the whole. It not only fulfils a functional need but also reflects an ancient worldview and design thinking consistent with nature's harmonious coexistence. (Enqin, 2015)

2.1.5.3 The cultural connotations of mortise and tenon construction

The design process is an essential element of traditional Chinese culture. As a 'design', it is the conceptual process by which the artisan or designer achieves the purpose of planning, the imagination into reality, the two -dimensional space to a three-dimensional stage, and the microscopic means of solving problems. The design of wooden furniture in mortise and tenon construction is a creative activity that combines aesthetic, philosophical and humanistic concepts. Mortise and tenon construction not only satisfies the function of use but also has a symbolic and moral cultural connotation. The whole process of wooden furniture fully reflects the spiritual and aesthetic pursuits of traditional Chinese material culture. In Confucianism, "Ren" is the basis for beauty, and "Good" is the basis for beauty. "Ren' is about following the ethical level of design, respecting the nature of wood, allowing it to be used in its rawest beauty, not causing damage to the environment, and achieving and maintaining a state of the balance; 'good' should be about using wood in a practical, intelligent and precise way, allowing the furniture to cater for the wood, rather than making the most of it, rather than making the

most of the material. In the bright mortise and tenon construction of wooden furniture, ancient artisans continued to explore the design of chair furniture, hands and feet to enhance the furniture's robustness and structural logic, function and beauty. (Hu & Xie, 2019)

Ancient artisans made objects combining shape and decoration with a solid aesthetic concept in shape: a combination of curves and straight lines, cross variations, rigid structure, smooth lines, appropriate scale, unique expression and rhythm. The overall contour of the wooden furniture still conveys the ancient treatment of people doing things, reflected in the corner processing on the furniture, which is beautifully rounded and does not give the impression of abruptness. On the contrary, the beautiful contours of the furniture can give a sense of psychological stability and visual pleasure.

A unique design that unites concave and convex portions on two components, mortise and tenon construction, was the primary building method in ancient Chinese architecture, furniture, and other implements. The mortise and tenon joint is a clever design brimming with old Chinese knowledge. The mortise and tenon method is primarily utilized in mahogany furniture and is referred to as the "soul" of mahogany furniture; the projecting component of the construction is known as the "tenon," while the recessed part is known as the "dong." The interlocking of mortise and tenon joints creates a precise connection between two pieces of wood. Chinese woodwork has been recognized, improved, and passed down for its ever-evolving, brilliant, and enchanting design. The mortise and tenon are not just a structural expression but also a representation of tradition, knowledge, and design principles. The classic mortise and tenon construction method may be more innovatively inherited in the current design, showing ancient and modern culture's fusion, inheritance, and creativity.(Zhang et al., 2021)

2.1.5.4 Classification of mortise and tenon construction

(1) Combinations of face and edge combinations

The main form of construction is the use of slotting as the main body and then the use of mortise and tenon to fit and structurally connect them.(Xue et al., 2019)

Figure 41 Free combination of mortise and tenon face edges

Source: https://baijiahao.baidu.com/s?id=1602059641232037382&wfr=spider&for=pc

(2) The structure of the "point"

In furniture design, this structure is mainly used for legs, handrails and support frames. Its small tenon head characterises it. It is mainly used to combine horizontal and vertical timbers, angular joints, crossed joints and extended joints of straight and curved timbers. They are used to produce shoulder tenons, double tenons, double clinch tenons, hook and loop tenons, wedge tenons, half tenons, and through tenons.(Guo & An, 2020)

Figure 42 Mortise and tenon structure connecting the head

Source: https://baijiahao.baidu.com/s?id=1602059641232037382&wfr=spider&for=pc

(3) Connection between component structures

They evolved from crosses. With the ability to connect three parts, this type of structure is mainly used in corner areas, such as the corner of square stools and cabinets.

Figure 43 Mortise and tenons for connections between components

Source: https://baijiahao.baidu.com/s?id=1602059641232037382&wfr=spider&for=pc

2.2 Concepts and theories related to emotive design

2.2.1 Mortise and tenon construction - Lupin lock

Using the more than 2,400-year-old mortise and tenon building method, Lu Ban was the first artisan to create a toy, the Lu Ban Lock. However, the Lu Ban Lock was too complex for kids to play with, so after being disassembled and its mortise and tenon design studied, a more kid-friendly mortise and tenon block was created. The mortise and tenon joint structure gives the tenon and tenon building blocks ever-changing combinations, making them structured and entertaining while allowing children to develop their intelligence through play, practice, and thought. These building blocks also become the child's growing partner and play a crucial role in the child's development. It is not only a toy for fun, but (Ying, 2016)

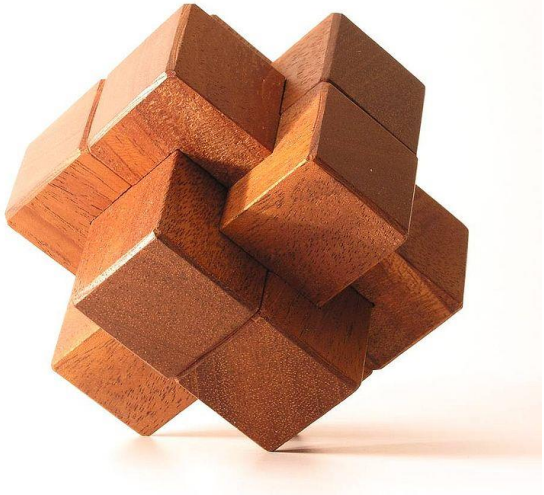


Figure 44 Luban lock
Source: https://zh.wikipedia.org/zh-hans/%E9%AD%AF%E7%8F%AD%E9%8E%96

2.2.2 Mortise and tenon construction - Ming dynasty furniture

The Ming dynasty was established in 1368 by the Ming Emperor. The Ming dynasty accumulated water resources from the outset of its rule. It promoted land reclamation, which made it feasible to murder the nomad herders.

The rapid recovery and development of destroyed agricultural production was followed by the rapid development of handicrafts and commerce, and international trade to Korea, Japan, South Asia, Central Asia, East Africa and Europe. Due to rising productivity, the growth of the commodity economy, and an increase in the number of craftsmen and free traders by the middle of the Ming Dynasty, capitalism had taken root. As a result of the economic boom, handicraft industries such as construction, textiles, shipbuilding and ceramics reached a considerable level. At the end of the Ming Dynasty, there was also work on the construction of gardens, "Garden Ye", which summarised the experience of the art of gardening. The furniture of the Ming dynasty also developed tremendously with the construction of many garden buildings. In addition to meeting the needs of people's daily lives, this period's furniture types and styles were also more closely linked to the buildings, generally in the halls, study rooms and bedrooms. There were several standard furniture configurations with the concept of complete furniture sets. When building a house, the depth, openness and use of the building are taken into account, as well as the type, style and scale of the furniture and the configuration of the set. (Rong & Wei, 2018)

2.2.2.1 Classification of Ming furniture

The furniture of the Ming dynasty, based on the tradition of the Song dynasty furniture, was developed and innovated, not only with a wide range of types and styles but also with exquisite materials, simple and generous shapes, strict production, reasonable structure, gradually formed a stable and distinctive Ming furniture style, the development of traditional Chinese furniture reached the top, Ming furniture categories, according to the use of the function can be divided into the following six categories;

(1) Chairs and stools: with pier, lamp hanging chair, circle, cross chair, machine stool, round stool, and official chair.

(2) Several cases: coffee table, incense, bookcase, flat head case, warped head case, case, piano table, table of offerings, eight fairy table, crescent table.

(3) Cabinets: There are stuffed cabinets, official leather boxes, bright cabinets.

(4) Beds: Frame beds, Luohan beds and plucked beds.

(5) Stand: Lamp stands, flower stands, basin stands, coat racks, mirror stands.

(6) Screens and pedestals: pedestals, enclosing screens, insect screens,stove pedestals, vase pedestals.

2.2.2.2 Ming furniture product styles and techniques

During the Ming Dynasty, Zheng He made seven trips to the South China Sea so that our country and Southeast Asian countries are closely associated with frequent trade; these areas produce high-quality wood, such as huanghuali, rosewood, chicken wing wood, nan wood and other supplies. Due to the Ming Dynasty's use of these complex species to do furniture, the Ming Dynasty furniture is also known as hardwood furniture. The use of wood in Ming dynasty furniture is prudent in the production of furniture to take complete account of the wood texture and natural colour; the surface treatment is usually waxed or decorated with transparent lacquer rather than using oil-based lacquer finish, which is a significant feature of Ming dynasty furniture. This is a prominent feature of Ming furniture, which is beautifully shaped and varied, with fine artistry and strict structure. The work of the Ming dynasty was not only good, but it was also a good tool. In the Ming dynasty, smelting techniques were so advanced that sharp tools could be produced. The use of hardwood to make beautiful furniture was made possible by the availability of advanced woodworking tools. There were many different tools, such as the Tron, the push planer, the starting line planer, and the centipede.; there were also many types of saws, "the long one cut wood, the short one cut wood, the most teeth cut bamboo".

In this context, the skilled artisans of the Ming dynasty created a range of innovative, varied and well-constructed furniture using a framed structure, in keeping with the unique style of wood construction in China. The Ming style furniture is of frame construction, in keeping with the unique style of wood construction in China. The structure was created according to the needs of the shape, with a variety of structures, such as Ming, tedious, birch, half, long and short, dovetail birch, chucking and the 'save the edge' technique. This not only enriched the shape of the furniture but also made it strong and durable, and we can still see it in real life today, despite the centuries. In short, the achievements of the Ming furniture industry are unparalleled and have captivated many Western designers. (Liu & Leng, 2019)

Figure 45 Sample drawings of different types of Ming furniture

Source: https://www.sohu.com/a/449073718467296

2.2.3 Innovative design of tenon and tenon and bucket arch

2.2.3.1 Use 3D printing to study bucket arch

The researcher has developed multiple types of arch culture teaching tools design in the early stage. At this stage, mainly through the means of 3D printing, the traditional Chinese architectural arch and mortise and tenon structure are quickly transformed into the form of easy-to-accept assembling toys for young people. In addition, the arch and mortise and tenon structure literature is classified and made into manual assembling toys so that the research subjects can be more easily interested in the cultural content of the research.

1) The bucket arch on the corner of the eaves
2) It is expressed in the form of miniature models
3) It is conducive to close observation and assembly

1) The bucket arch on the eaves
2) It is expressed in the form of miniature models
3) It is conducive to close observation and assembly

1) The bucket arch on the front side of the eaves 2) It is expressed in the form of miniature models 3) It is conducive to close observation and assembly

1) Column bucket arch structure
2) Expressed in miniature model
3) It is conducive to close observation and assembly

Figure 46 Example, guide to decoding data using images and descriptions

Source :Designed by Guangzhou Li（2020）

Figure 47 Using 3D printing technology to study the structure of bucket arches

Source :Designed by Guangzhou Li（2020）

Figure 48 Using 3D printing to demonstrate the tenon and tenon structure

Source :Designed by Guangzhou Li（2020）

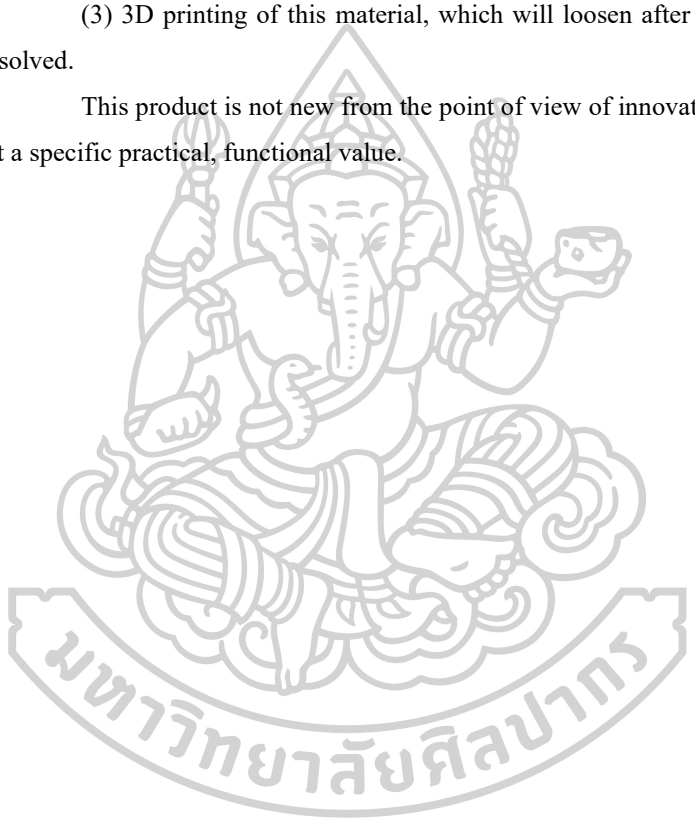
The above two groups of educational tools for disseminating ancient Chinese architecture and culture were designed through 120 scientific and educational activities, nearly 350 people participated in the experience, and 280 good feedbacks were obtained through consumer use feedback, expert interviews and research. From the percentage of data, the following observations were made.

(1) This design project deserves attention and promotion to primary and secondary school student groups.

(2) The need to focus on a few representative products for focus due to the variety and to increase the experience through product instruction manuals.

(3) 3D printing of this material, which will loosen after repeated insertion over time, can be resolved.

This product is not new from the point of view of innovative design research and needs to reflect a specific practical, functional value.



Representative bucket arch and its decomposition in tang Dynasty

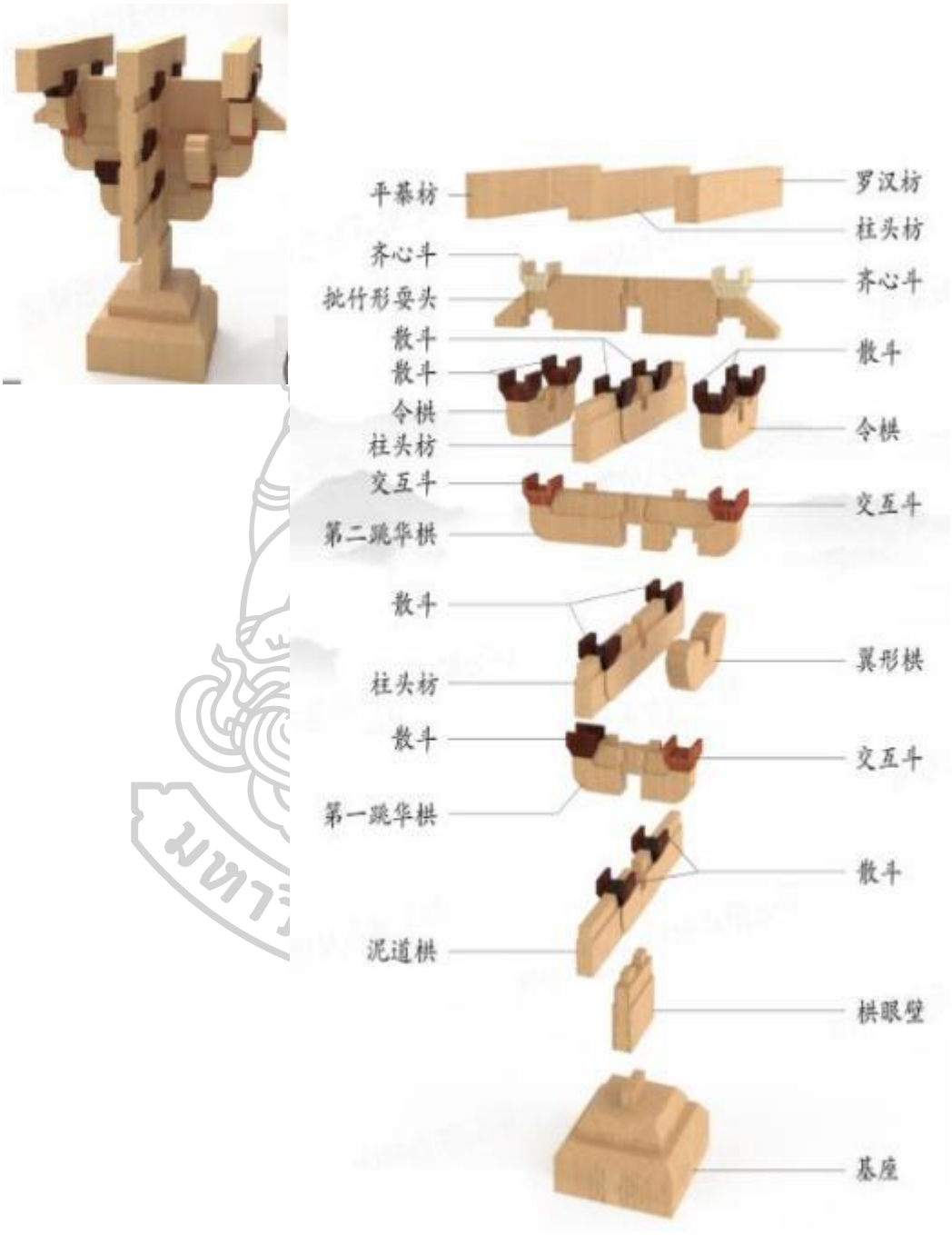


Figure 49 Illustration of product usage

Source: Designed by Guangzhou Li,(2020)

Representative bucket arch and its decomposition in Song Dynasty Song dynasty four-pavilion arch and its decomposition

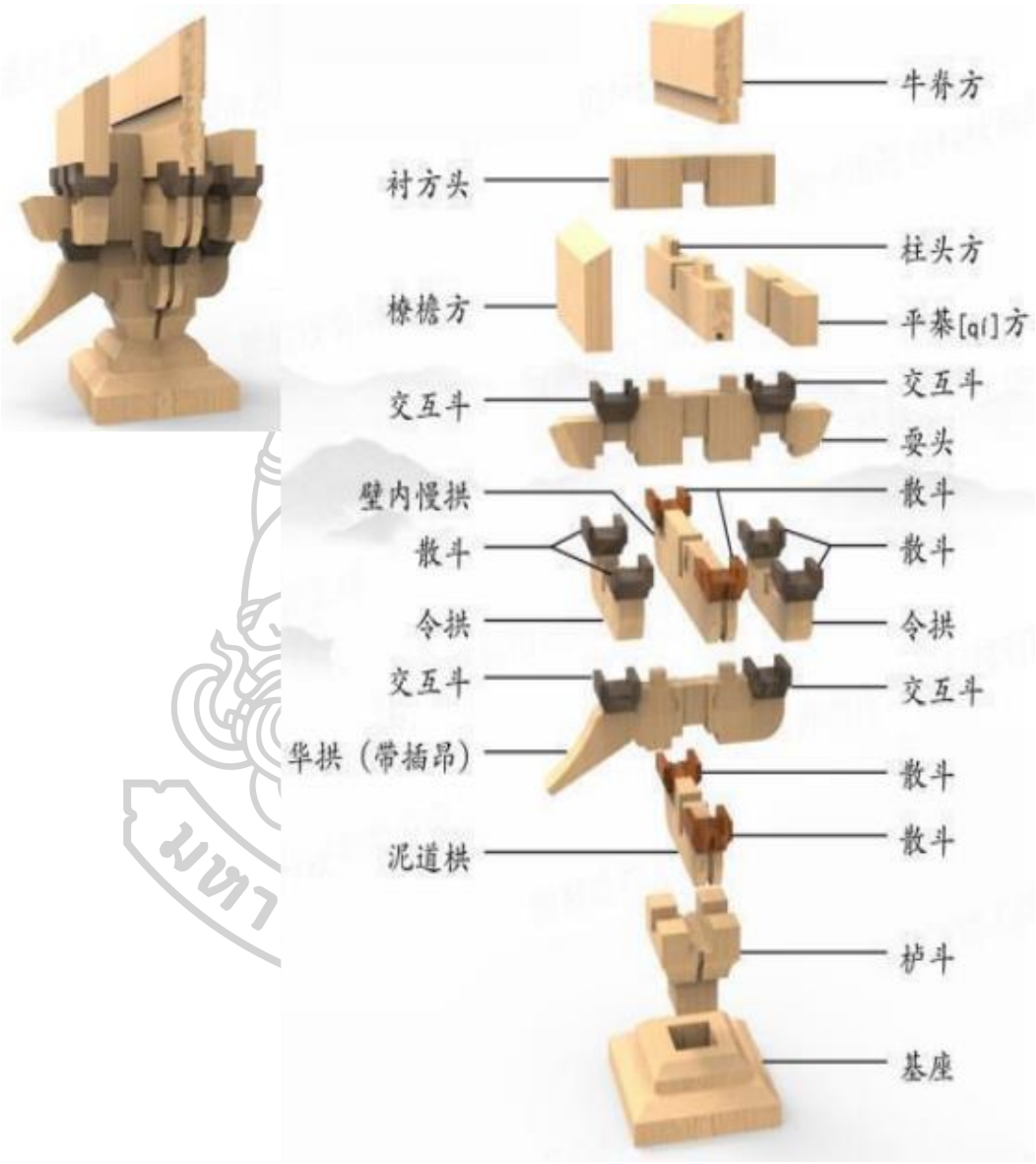


Figure 50 Illustration of product usage

Source: Designed by Guangzhou Li,(2020)

Representative bucket arch and its decomposition in the qing Dynasty

Qing dynasty single-angled triple-stepped pillar-head arch and its decomposition

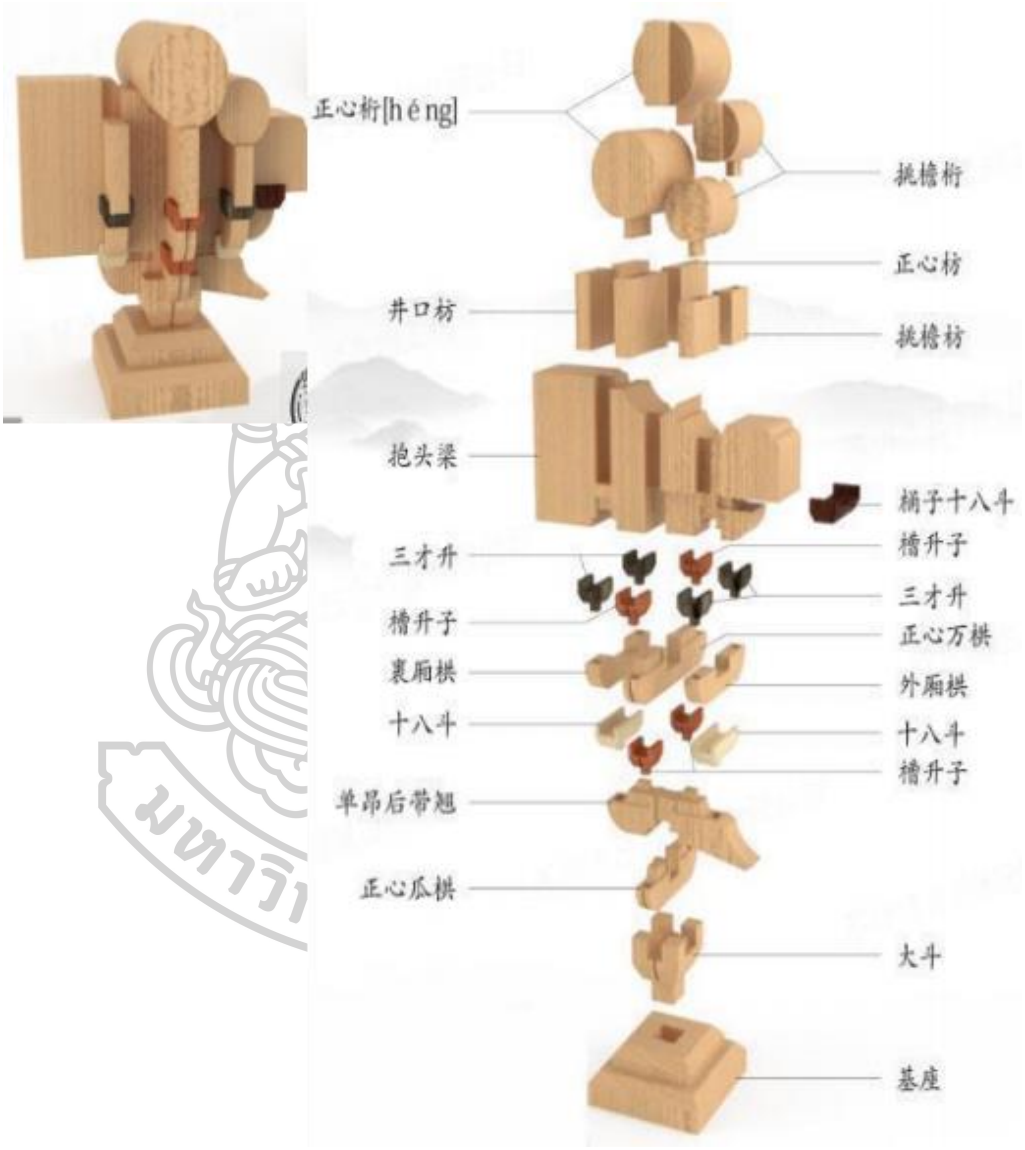


Figure 51 Illustration of product usage

Source::Designed by Guangzhou Li,(2020)

2.2.3.2 Mortise and tenon structure innovative product application

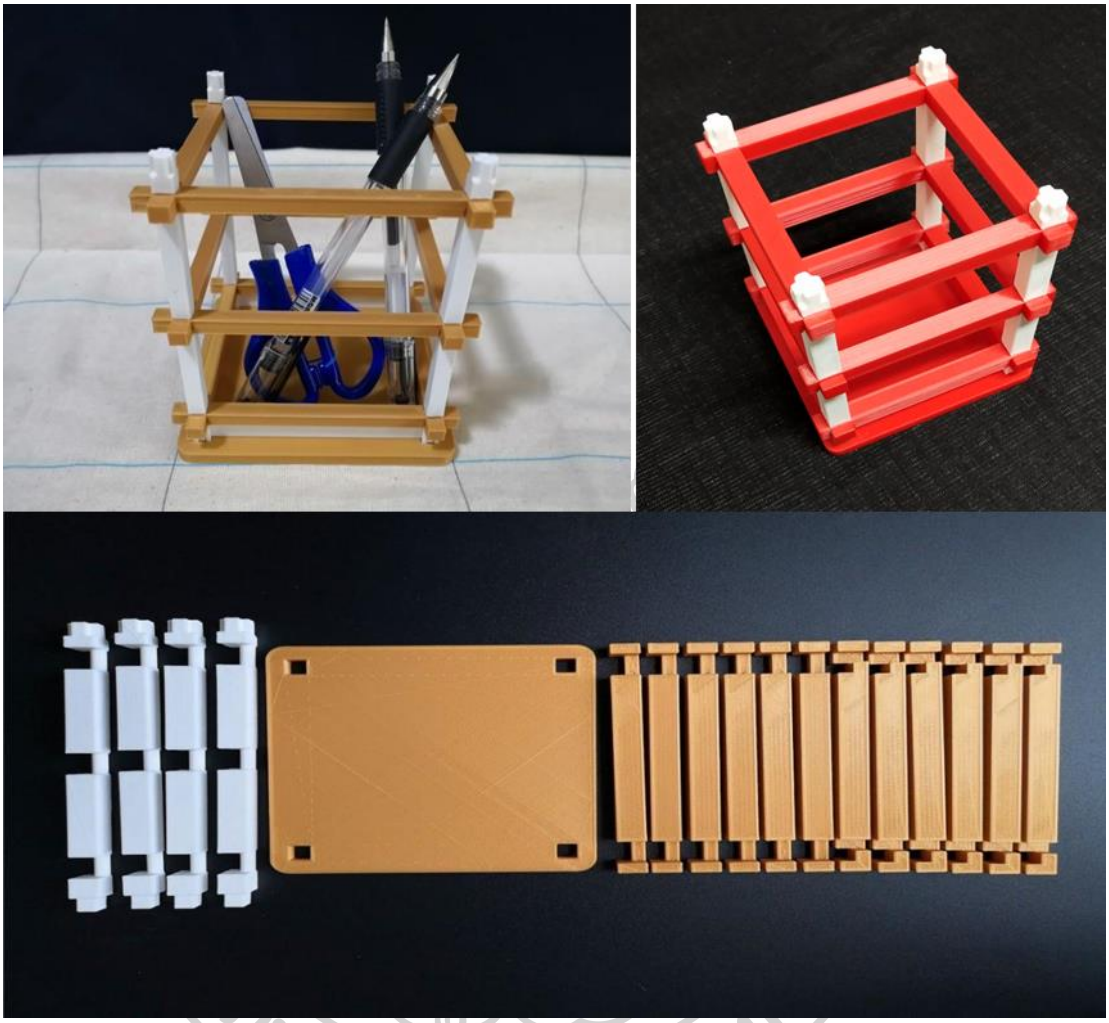


Figure 52 Mortise and tenon construction penholder design

Source: Designed by Guangzhou Li,(2020)

Product characteristics:From a wide range of mortise and tenon construction, using the tripartite group is a more flexible and skilful way of handling the mortise and tenon. The product is a living pencil holder. Educational and fun.

Figure 53 Suzhou window pattern mortise and tenon lamps

Source: Design, by Guangzhou Li,(2020)

Product Features:

An educational product with a mortise and tenon construction suitable for all ages, this lamp consists of 18 components with a three-bar lupin lock as the main structure of its outer frame. It can be joined to assemble a practical and beautiful lamp Lupin lock and mortise and tenon construction.

The shade section, i.e. the front, back, left, and right sides, is made of a hollow ice crack pattern - a cultural element of Suzhou gardens. Ice cracks are widely used in the hollow pattern of window panes in traditional garden buildings, through which people can see a blurred view of the garden. Without a uniform and regular shape, ice cracks are natural cracks that encompass the ever-changing nature and symbolize natural harmony and beauty. When illuminated, this texture not only covers the dazzling light but also meets the lighting needs, displaying different shapes and giving people infinite space for reverie, making them feel like they are in a sea of creativity; when not in use, it can also be used as a beautiful decoration. During the assembly and disassembly of the lamp, users can learn about

Suzhou garden culture, experience the wisdom and charm of mortise and tenon construction and enjoy the lighting. This lamp combines traditional culture with modern technology and art, showing Chinese wisdom.

Summary of preliminary research into innovative products of mortise and tenon and arch construction.

(1) After 300 consumers, the feedback from the science education experience is that products with practicality are in the highest demand

(2) Consumers are no longer ready to utilize the product a second time. Therefore only the popularization of science and the instruction of mortise and tenon construction is no longer adequate to suit their demands. So, product research requires a more significant economic value requirement.

(3) There is a demand for products that are functional for living and office use, which continues to increase in the survey, and in this phase, we put product functionality first

(4) New pen holders and new lamps are designed to satisfy consumers' need for social interaction, their willingness to share the use of the product with those around them, and projecting the behavioural and reflective levels of emotional design.

(5) In terms of production methods, as it is still in the design phase, 3D printing is the most beneficial way to carry out design verification

(6) The colour choice of Chinese red is conducive to strengthening consumers' sense of colour identity, while some younger consumers believe that a gradient colour can be used to meet social needs better

(7) The material is still PLA, compatible with the 3D printing production method.

2.3 Research on bucket arch and mortise and tenon joints with innovative design

2.3.1 Load-bearing characteristics of bucket arch structure

The vertical compressive behavior of the eccentrically oriented bucket arch connectors was investigated.

The racking performance of three eccentrically aligned bucket arch connections scaled at 1:3.4 was assessed in this paper by combining vertical compression and lateral cyclic loads.

Through a comparative study, the effects of vertical compression loading and the composite action effect were assessed in this work.

This study employs an experimental approach to assess the compressive and racking performance of eccentrically aligned bucket arch connectors in Chinese architecture. A scale factor of 1:3.4 was used to construct four scaled specimens, which were then tested using static compressive and cyclic lateral loads. The modes and load-displacement (or hysteresis) curves of the bucket arch connections and the impacts of the composite action effect. It investigated how the composite action effect and vertical compression loads affected the bucket arch connections and the damage modes and load-displacement (or hysteresis) curves. The load-displacement curve of the eccentrically aligned bucket arch connection was almost bilinear, and the breaking of the cap block loosened the lateral constraint that prevented the connection from overturning and resulted in a change in vertical stiffness. According to the bucket arch connection's concentric vertical initial compressive rigidity was close to 70%. A predictive model was created to forecast the initial stiffness, yield load, and maximum load of double bucket arch connections based on test results for concentrically aligned bucket arch connections. Initial stiffness, yield load, and maximum load of double bucket arch connections were found to be, respectively, 262%, 332%, and 373% higher than those of single bucket arch connections. When the shear-key interlocked straight beams and infill panel work together, the lateral stiffness and energy dissipation capacity may increase by more than 55%. However, the vertical load improved by the shear keys and the infill panel can increase the lateral stiffness by more than 55% and the energy dissipation capacity by more than 70%, even though such composite action decreases with the deterioration of the contact surfaces of the straight beams and the plastic deformation of the infill panel. The vertical stress made the connections more rigid and improved their capacity to release energy, primarily through friction

force. For instance, a 120% increase in vertical compression stress can lead to a 50% or more significant increase in lateral stiffness and a 130% increase in energy dissipation capacity.(Wu et al., 2018)

2.3.2 The Evolution and Research Progress of the Arch Structure

The bucket arch, a distinctive design in old Chinese timber frame structures, is frequently employed in famous structures, including temples, palaces, and historic gardens. It has a decorative purpose on the one hand and serves as a transition between the column and the roof on the other, transferring some of the force from the roof to the column to provide bearing and energy. On the one hand, it serves a decorative purpose, and on the other side, it can convey some of the stress on the roof to the column, where it can act as a bearing and energy dissipator. The bucket arches are increasingly being replaced with concrete structures instead of wood ones to conserve wood, protect the environment, and consider building fire resistance, durability, and post-maintenance requirements.

According to the position of the bucket arch on the building, it is divided into three categories:

It refers to the bucket arch sitting on the eaves pillar, which mainly acts as the supporting It refers to the bucket arch sitting on the eaves pillar, which mainly acts as the supporting beam frame and has a certain bearing function in the structure function.

On the forehead between the columns, it is called the bracket set between columns. It is mainly placed on the forehead of the column to play a decorative role.

It is known as the bracket set on corner and is located at the top of the corner column. Compared with the above two types of bucket arches, the horn is relatively complicated in structure and is in two different directions, so that, there are two exteriors at the same time.

The bucket arch serves the following purposes:

Between the column and the beam, the bucket arch bridges the gap from the top of the column to the roof truss for weight transfer. It passes the roof's weight from the upper frame and roof down to the beam or pillars, where those structures subsequently support it. It sustains the weight delivered to the beam or pillars from the roof and upper frame, which then passes the weight to the foundation.

The function of protruding the eaves: The bucket arch will eaves the outermost layer of a certain distance, making it a cantilever structure, so that the The overhang of eaves can also protect the bottom of columns and walls from erosion and erosion by rainwater. The overhang of eaves can also protect the bottom of columns and walls from erosion and erosion by rainwater.The function of reducing the span of beams: The bucket arch stands on the top of the column, and it spreads both sides indoor and outdoor at the same time. span between beams and pallets decreases obviously due to its protrusion toward depth.Energy dissipation and shock absorption are functions: Tenon and mortise join each bucket arch component, and the precise construction is depicted. The combination of tenon and mortise ensures the coordination of the building's rigidity. The tenon and mortise combination will be "loose" but not "scattered" during an earthquake. It absorbs the seismic energy and significantly lowers the building's overall seismic load.Decorative function: The structure of the bucket arch is exquisite and its shape is unique. The bucket arch is outwardly picked up to make it look more beautiful.

Figure 54 Bucket arch structure in architecture

Source: http://www.nfgjz.com/765.html

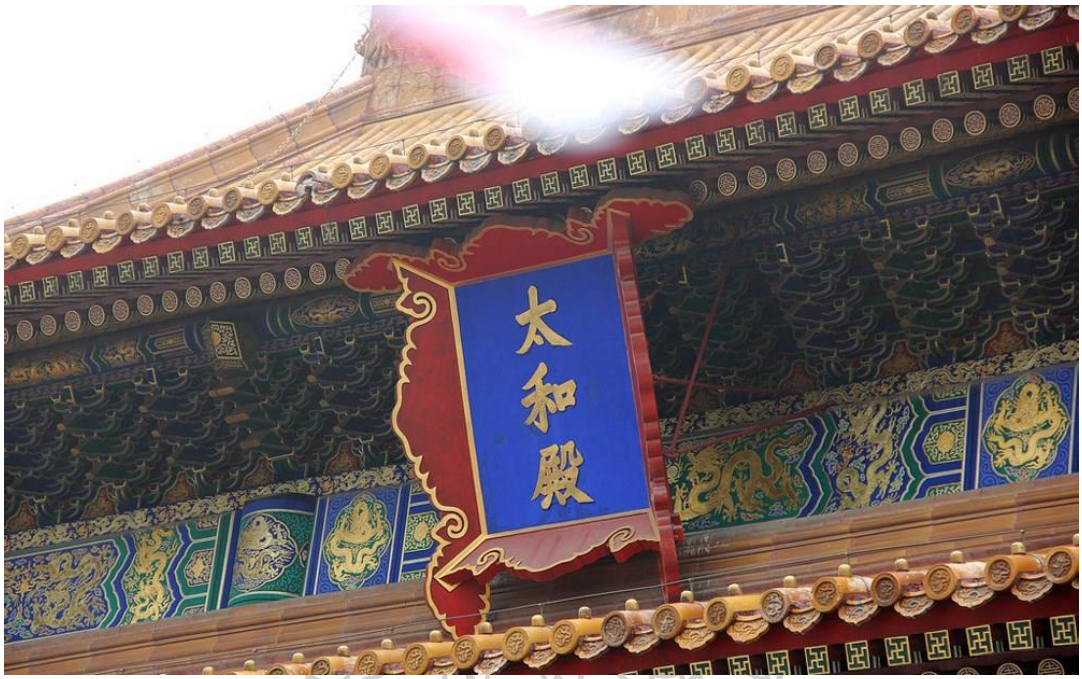


Figure 55 Decorative effect.

Source: By :chenchen800205,www.nipic.com

Although the wooden bucket arch's construction is more expansive and elegant due to the manner it overhangs, it also has unique seismic properties. Even though the wooden bucket arch's construction has a more elegant overhang and unique seismic performance features, mortise-and-tenon connections are used between them, causing the building structure to need more energy as it is being built. However, the drawbacks of wooden structures gradually became apparent as our investigation into the wooden structure of ancient structures progressed. Major flaws in fire, insect, and corrosion control also constrain the evolution of wooden structures in modern civilization. There are serious defects in anti-corrosion, fire prevention and insect prevention, which also restrict the development of wooden structures in today's society.

2.3.3 Innovative mortise and tenon construction design

The mortise and tenon structure is used as the starting point for this article, which then examines its structural properties, style, and uses advantages, studies how it is used in the design of cultural and creative products, and discusses the creation of the following products in conjunction with the use of the tenon and tenon structure in product design. The mortise and tenon structure is the

foundation for this article, which then explores its structural characteristics, aesthetics, and functional benefits. It also looks at how it is applied to the design of cultural and creative products, and it covers the development of the following products in conjunction with the application of the tenon and tenon structure in product design. Discuss the challenges in the production of current and future products, such as form, function, and usability, as well as the usage of mortise and tenon construction in the design of cultural and creative things. When included in product design, the mortise and tenon structure should be utilized in a way that complies with the rules and principles of design. Design professionals using the tenon and tenon construction might use this as guidance. Give references for design experts who employ mortise and tenon structures and product design.(Liu & Leng, 2019)

Advantages of mortise and tenon structure in product design

1) Modular design

2) Structural modeling innovation

3) Green design

Application research by Mortise & Tenon combined with clever and creative product design. Today, many cultural and artistic objects deftly combine usefulness with tenon and mortise structures in their construction. Today, many cultural and creative products skillfully combine their purposes with mortise and mortise architecture. The design selected the sycee tenon mortise and tenon joint structure (dovetail) technique to split, which will be separated into two portions responsible for fulfilling the demands of the card to serve the function of the card case better. Consider the card case design in Figure 5 as an illustration. Swap the clamp for the tenon's weight to prevent the business card from slipping. The two parts that carry business cards are designed to be lightweight and portable. They have an interface interlocking dovetail tenon trapezoid design, are simple to assemble and disassemble, and are appropriate for all age groups. The construction of the business card can be designed to keep displacement from compromising the product's structural integrity in the transverse direction. Update, lengthen product lifespan, replace specific components as required, merge fundamental designs for following product function updates, and make goods more aesthetically pleasing and helpful.

Figure 56 Innovative card box design using mortise and tenon structure

Source: Guangzhou Academy of Fine Arts Life Design Studio 2009 works, instructors: Zhang Jian, Lu Wenying

Instead of just superimposing and resolving design, form, and material issues, using mortise and tenon structure in creating cultural and artistic products is an issue that can be taken to a higher level. Be imaginative. Instead of simply superimposing and resolving design, shape, material, and other issues, using mortise and tenon construction in creating cultural and creative objects presents a challenge that may be raised—higher level design philosophy and thinking. Future research and debates on mortise and tenon product design are still required to provide results.

2.3.4 Innovative mortise and tenon construction with a green design idea

Given the new carbon reduction standards, some classic mortise and tenon constructions used in the furniture business are no longer appropriate. This essay investigates fresh concepts and techniques for designing contemporary mortise and tenon structures. Modern mortise and tenon furniture structures should use the reduction idea from green design. Modern mortise and tenon furniture structures should use the reduction idea from green design. The approach to using the idea of simplicity in the design of contemporary mortise and tenon constructions is also covered in the article. Modern mortise and tenon structures are designed using a novel method, and the design's status in development and trend are discussed. Combining green design with furniture design has critical practical ramifications in the modern world.(Wu et al., 2021)

2.3.5 Furniture made with a Swastika mortise and tenon construction

This method incorporates the rich cultural value of old symbols while integrating cutting-edge notions by using the mortise and tenon construction as a core design framework. The analysis delves into the attributes encompassing design aesthetics, ornamentation, and symbolic implications. By dissecting the attributes of form, embellishment, and meaning, a synthesis of distinctive elements is extracted, consolidating pivotal design keywords for application and expansion. This process establishes a fundamental template for furniture products, employing the mortise and tenon joint technique as the core foundation. Through a meticulous screening process aligned with durability and material requisites, viable mortise and tenon configurations emerge, culminating in the comprehensive assembly of the furniture's structural integrity. This systematic procedure not only shapes the entirety of mortise and tenon furniture construction but also steers the tangible production phases. Notably, within the context of bookcase design, the fusion of traditional symbolic elements seamlessly within the tenon structure validates the viability and efficacy of this methodology, offering valuable insights for the exploration of analogous tenon-based design endeavors. (Liang & Fan, 2022)

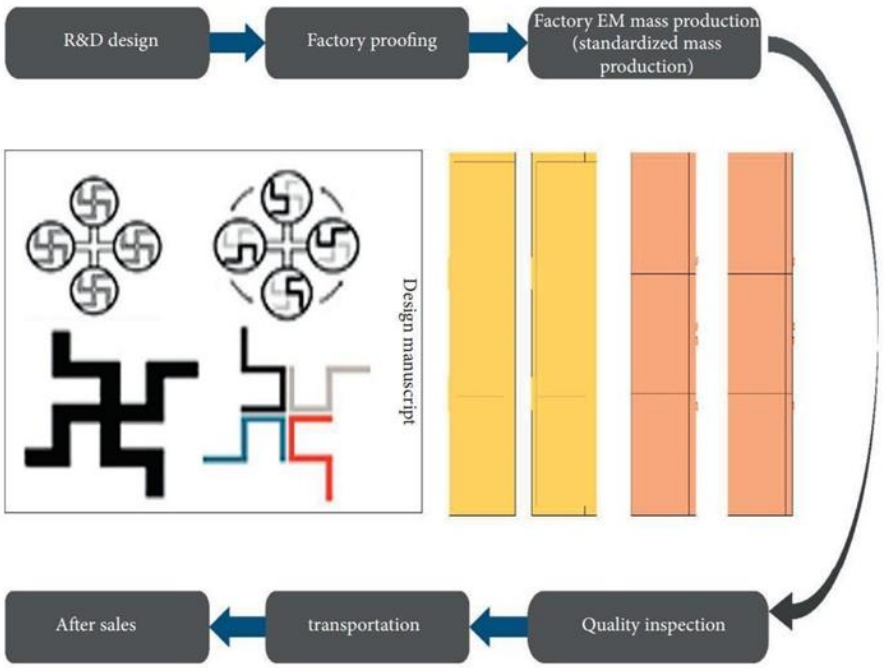


Figure 57 Production flow chart of custom furniture

Source: Lijuan Liang, Yafei Fan, Hindawi ,Advances in Multimedia Volume 2022.

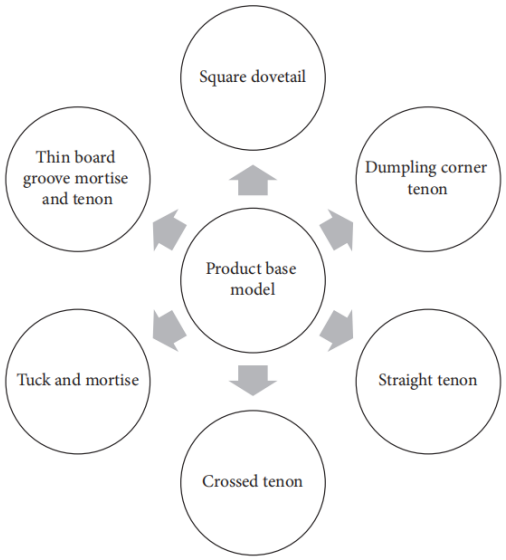


Figure 58 Tenon structure analysis

Source: Lijuan Liang, Yafei Fan, Hindawi ,Advances in Multimedia Volume 2022.

Result Analysis and Discussion

1) In-depth research on traditional culture and the tenon structure.

2) Externalizing the Tenon Structure.

3) Following Modern Design Concepts

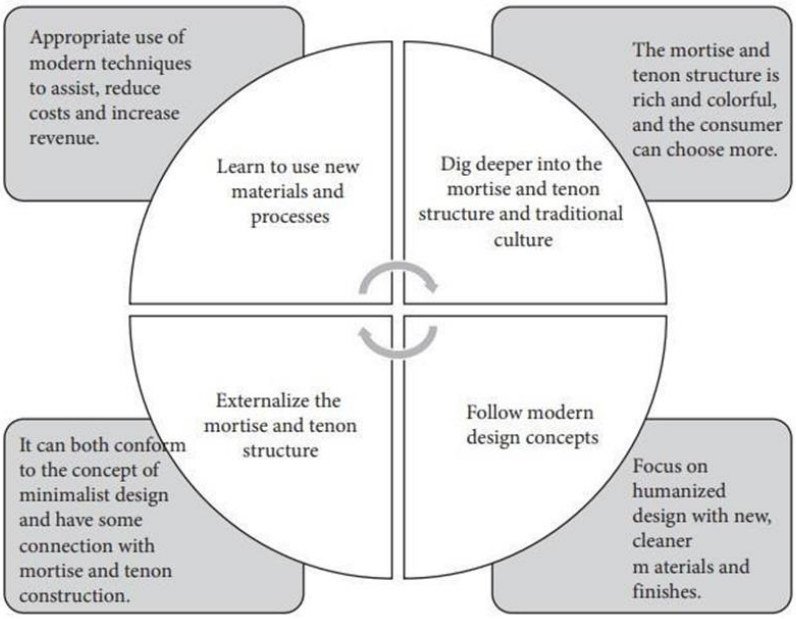


Figure 59 Modern Home Design Models

Source: Lijuan Liang, Yafei Fan, Hindawi ,Advances in Multimedia Volume 2022.

Chinese traditional furniture and culture both benefit from using mortise and tenon construction. Chinese traditional furniture and culture both benefit from using mortise and tenon construction. Furniture with a tenon and tenon construction is precious culturally. Tenon and tenon construction is combined with a current, well-liked design. Refined and made more straightforward. They are also utilized in contemporary product design. In this study, the swastika shape is improved and made more straightforward. Then it is utilized in the creation of modern mortise and tenon furniture. Product creation. A novel strategy The blending of traditional symbol culture with mortise and tenon furniture design helps promote mortise and tenon design in modern mortise and tenon structure furniture. Theoretically, the design stimulates innovation while preserving Chinese traditional culture and supports furniture creation with the same type of mortise and tenon construction. We have done some studies on redesigning conventional furniture with a mortise and tenon and tenon construction using conventional artistry and contemporary styles. It must optimize the task from a technological, material, and design idea standpoint. The ability to optimize from the viewpoints of technology, materials, and design concepts is required for future employment. By using mortise and tenon structures in furniture design, we may more effectively inherit their design principles and improve the outcomes of furniture design—the market's growth.

2.4 Materials and production methods add information in this section

2.4.1 The application of 3D printing materials in creative products

3D printing is an innovative technology that has revolutionized many industries, including the creative industry. Here are some of the most common 3D printing materials used in the creation of creative products

2.4.1.1 Advantages of 3D printing in design

The development of products has been transformed by 3D printing technology, which offers several benefits to designers at the outset of the product design process. Here are a few benefits of using 3D printing at the beginning of the product design process:

(1) Rapid prototyping: Using 3D printing, designers can swiftly produce actual prototypes of their creations, enabling them to test and improve their concepts before going on to production. As a result, product development takes less time and costs less money.

(2) Cost-effective: 3D printing makes it possible to create elaborate and sophisticated designs without the need of costly tools and machinery, which can be prohibitively expensive in the early phases of product development.

(3) Customization: 3D printing allows for easy customization of designs, making it possible to create products that are tailored to specific customer needs and preferences.

(4) Design optimization: 3D printing allows designers to easily modify and optimize their designs, based on feedback from testing and prototyping, helping to create products that are more efficient, functional, and user-friendly.

(5) Visualization: 3D printing allows designers to create physical models of their designs, helping them to better visualize and communicate their ideas to stakeholders, such as investors and clients.

(6) Iteration: 3D printing allows for rapid iteration and refinement of designs, helping designers to quickly iterate on their ideas and create better products.

Overall, the use of 3D printing in the early stage of product design provides many advantages for designers, including rapid prototyping, cost-effectiveness, customization, design optimization, visualization, and iteration, allowing them to create better products in less time and with less cost.

2.4.1.2 Characteristics of 3D printing materials

(1) PLA (polylactic acid): Made from renewable materials like cornstarch or sugarcane, PLA is a biodegradable thermoplastic substance. It's a well-liked option for 3D printing since it's simple to use, environmentally beneficial, and emits few pollutants.

(2) ABS (acrylonitrile-butadiene-styrene): ABS is a robust, long-lasting, and heat-resistant thermoplastic substance. Due to the fact that it makes high-quality prints and is simple to use, it is frequently utilized for 3D printing.

(3) Nylon: This synthetic polymer is renowned for its durability, flexibility, and strength. Due to the fact that it creates prints that are both sturdy and light, it is a common material for 3D printing.

(4) TPU (thermoplastic polyurethane), a flexible and elastic material, is commonly

used in 3D printing to create flexible objects like phone cases and toys.

(5) Metal: 3D printing with metal is a relatively new technology that allows for the creation of complex and intricate metal objects. Metal 3D printing materials include stainless steel, aluminum, copper, and titanium.

(6) Wood: 3D printing with wood filament produces objects that have a natural and organic look and feel. The wood filament is made by combining wood particles with a binding agent, which is then 3D printed into the desired shape.

Table 4 Classification of different 3D printing materials

Material form	Main application process	Main Material Category
liquid	SLA,DLP	Photosensitive resin, ceramic paste
powder	SLS,MJF	nylon powder, nylon fiber
powder	SLM	Aluminum alloy, bronze, stainless steel
Wire	FDM	ABS,PC, PLA Wax

The use of 3D printing materials in creative products has opened up new possibilities for designers and artists to create intricate and unique designs that were not possible with traditional manufacturing methods. With 3D printing, designers can create custom-made products with high precision, complex shapes, and intricate details.

2.4.2 The Application of Conventional Materials in Cultural and Artistic Creation

China produces a vast range of cultural and creative goods, and the materials and manufacturing techniques employed might differ significantly depending on the particular product.

Traditional materials and modern man-made materials have many differences in color, texture and other characteristics, and have unique characteristics. For example, the bamboo material is exquisite and elegant, and the bamboo structure is hollow. After a long period of erosion, the stone material will show a different sense of historical thickness, and the surface will also produce uneven changes. The wood will have unique grain and growth characteristics, giving the product a natural feel. Under the effect of temperature, the color and texture of the surface of ceramics will be different, these

are the physical characteristics of traditional materials. The following highlights the traditional wood materials used in the study:

Wood is a versatile and popular material used in the creation of creative products and furniture. Here are some of the common applications of wood and the characteristics that make it a popular choice:

Furniture: Wood is a popular choice for furniture making because it's durable, sturdy, and has a natural beauty. Different types of wood have distinct grain patterns, colors, and textures that can add character and warmth to furniture pieces. Wood furniture can range from traditional to modern styles, depending on the type of wood and the design.

Decorative objects: Wood is also used in the creation of decorative objects, such as vases, bowls, and sculptures. The natural texture and warmth of wood can add an organic and rustic feel to decorative objects, making them a popular choice for home decor.

Characteristics of wood as a material:

Durability: Wood is a strong and durable material that can last for many years if properly cared for.

Warmth and natural beauty: Wood has a natural warmth and beauty that can add character and charm to furniture and decorative objects.

Versatility: Wood can be cut, carved, and shaped into a wide range of designs and styles.

Sustainability: Many types of wood are renewable resources that can be sustainably harvested.

Variation: Different types of wood have unique grain patterns, colors, and textures, which can add interest and variation to creative products.

Overall, wood is a popular choice for creative products and furniture due to its durability, natural beauty, versatility, and sustainability.

2.4.3 Advantages of creating products using wood materials

Wood is a popular material choice for creative products and furniture, and mortise and tenon and bucket arch structures are two traditional woodworking techniques that can offer several advantages in the construction of wooden products.

2.4.3.1 Advantages of wood production mortise and tenon products

(1) Strength and durability: Mortise and tenon joints create a strong and durable connection between wooden pieces, making them ideal for furniture and other products that require stability and longevity.

(2) Aesthetics: Mortise and tenon joints are a traditional woodworking technique that can add a unique and aesthetically pleasing look to wooden products.

(3) Flexibility: Mortise and tenon joints can be used to create a wide variety of wooden products with different designs, shapes, and sizes, providing flexibility in product design.

2.4.3.2 Advantages of wood production bucket arch products

(1) Strength and stability: Bucket arch structures distribute weight evenly and efficiently, making them ideal for building sturdy and stable wooden products, such as chairs, benches, and tables.

(2) Aesthetics: Bucket arch structures have a unique and attractive appearance that can add visual interest to wooden products.

(3) Comfort: Bucket arch structures provide a comfortable and supportive seating surface, making them ideal for furniture that requires ergonomic design.

(4) Versatility: Bucket arch structures can be used to create a wide range of wooden products with different shapes and designs, providing versatility in product design.

Overall, using wood materials with mortise and tenon joints and bucket arch structures can offer several advantages in the construction of creative products, including strength, durability, aesthetics, flexibility, comfort, and versatility.

2.4.4 Application to the production process of tenon and tenon and bucket arch structure wood

When it comes to wood materials, the selection of the right type of wood is crucial to the success of the project. Some popular options include oak, maple, cherry, and walnut, which are known

for their strength and durability.

In terms of production tools, a range of specialized tools are required for cutting, shaping, and joining wood pieces. Some common tools used in mortise and tenon production include chisels, saws, and drills. For bucket arch structures, specialized jigs and clamps are often used to hold the wooden beams in place during assembly. Other important tools include hammers, screwdrivers, and measuring devices such as tape measures and squares.

According to the researchers' on-the-spot survey of the wood furniture manufacturing process in Nantong, Jiangsu, the production process of wooden furniture may vary depending on the type of furniture produced and the materials used. However, the general steps involved in the production process are as follows:

(1) Design: The first step in the production process is the design phase, where the furniture is conceptualized and blueprints or designs are created.

(2) Material Selection: Once the design is complete, appropriate wood and other materials will be selected based on their properties, availability and cost.

(3) Cutting and shaping: After the wood has been chosen, it is cut and shaped with a range of equipment, including saws, planers, and routers, to get the appropriate size and shape.

(4) Joinery: The different pieces of wood are then joined together using various joinery techniques such as mortises, dovetails and biscuit joints.

(5) Sanding and finishing: After the joinery is complete, the furniture is sanded to create a smooth surface, then a coat of stain, paint or varnish is applied to protect the wood and enhance its appearance.

(6) Assembly: The last step in the production process is to assemble the various parts of the furniture.

Quality control is crucial to ensuring that the finished product fulfills the necessary requirements and standards throughout the production process. This might entail putting the furniture through strength and durability tests as well as checking that it conforms with all applicable regulations.

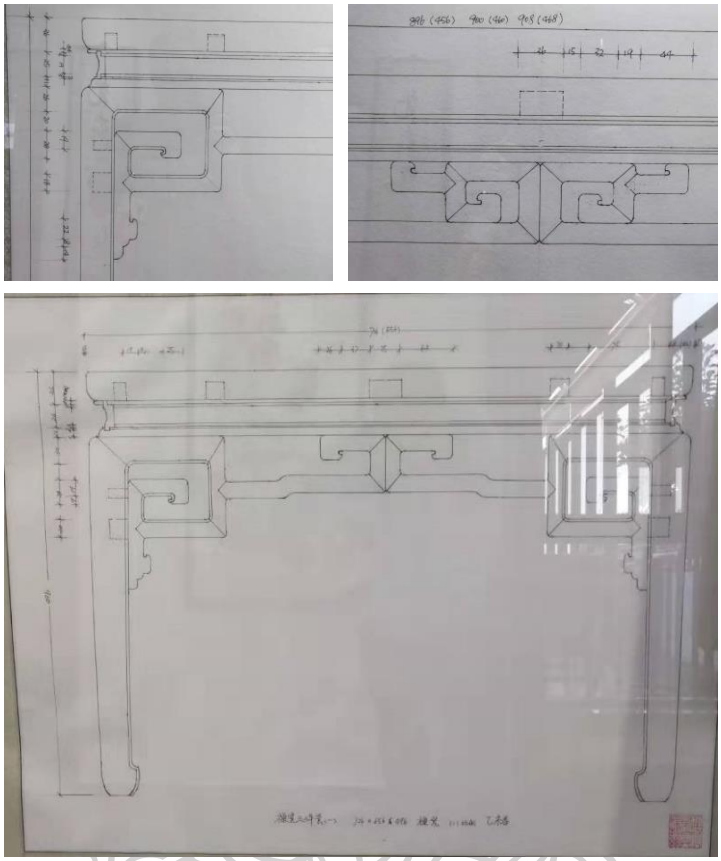


Figure 60 Drawing of mahogany furniture in Nantong, Jiangsu

Source: Photo taken by Guangzhou Li,(2020)

Figure 61 Mahogany furniture mortise and tenon structure, in Nantong area

Source: Photo taken by Guangzhou Li,(2020)

Figure 62 Tools for making mortise and tenon

Source: Photo taken by Guangzhou Li,(2020)

2.5 Related research

2.5.1 Cultural and creative product positioning methods

The issue of product positioning should be your first point of concern when designing a product. Product positioning refers to how a product is designed, who it is meant for, how they will use it, and its key characteristics (i.e., selling aspects like utility and emotional appeal). For the product creation to have significant commercial value, the target user must be chosen as the target consumer group; exceptional individuals have no reference value and must understand the everyday demands of a quantifiable target consumer group. (Wu, 2021)

Before developing a product, ask three questions. Dimension one is the target consumer group, which mainly includes target customers, scenarios, channels, prices and frequencies. Dimension two is the product vehicle, which mainly includes opportunities, growth points, features, materials, processes and costs. Finally, dimension 3 is the cultural appeal of the product, based on the three dimensions of culture: visual presentation, use process and emotional appeal, highlighting the aesthetic, interactive, experiential, communication and other cultural elements of innovation. The thinking model for cultural and creative product innovation that was employed in this work is illustrated below, as shown by the diagram.

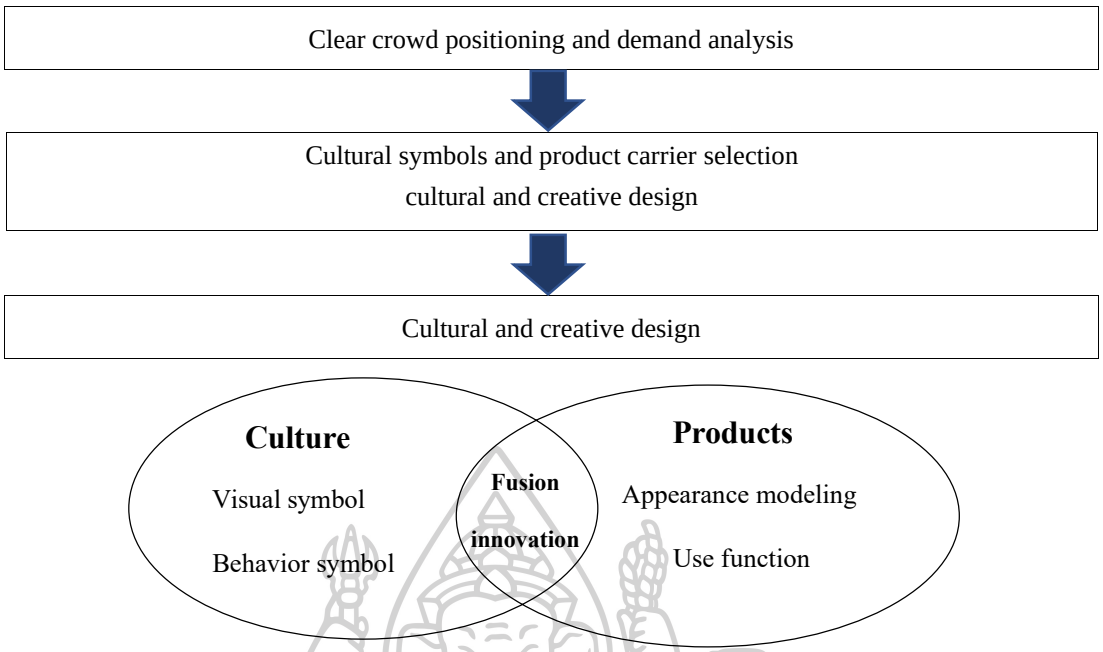


Figure 63 The relationship between cultural elements and product design

Source: Designed by Guangzhou Li,(2022)

2.5.2 Classification of cultural elements

2.5.2.1 Concept of the KJ method

The KJ method, also known as the Affinity Diagram, compiles facts, opinions, and ideas about problems in the field and uses the interrelationships to create a generalized diagram to organize complex phenomena, comprehend the essence, and find a solution. This is a method of organising the textual and linguistic data in a confusing state, using their intrinsic interrelationships (affinity), and then finding new ways of solving the problem. The participants' experiences, knowledge, and ideas are gathered during a conversation and classified in words or language to take coordinated action to address the problem. A method that combines induction, categorisation, and brainstorming. The brainstorming method is a metaphor for a situation when the mind is hectic and deviates from the usual to produce many original ideas. (Kawakita, 1975)

2.5.2.2 KJ method on product cultural attributes

The literature focuses on the cultural imagery characteristics of Huizhou architecture as an example and investigates the perception and recognition of the imagery attributes conveyed by the culture in the sample within the three levels by the relevant corporate designers and

university design students and records them on the relevant small pieces of paper. Due to the different perceptions of each research participant, the number of evaluation items obtained is significant and needs to be further consolidated and streamlined.(Li & Lin, 2021)

The KJ method allows for the collection of verbal and written information on unknown issues, questions or ideas and using their intrinsic interrelationships to summarise and merge them to sort out a clear picture from a complex phenomenon and find the fundamental solution to the problem. Given this, the KJ method can further sort out the user's perception of the characteristics conveyed in the sample, merge and simplify the same research items to summarise and filter out the various evaluation items of the Huizhou architectural culture, and construct an analysis model of the characteristics of Huizhou architectural culture, see Figure 65.

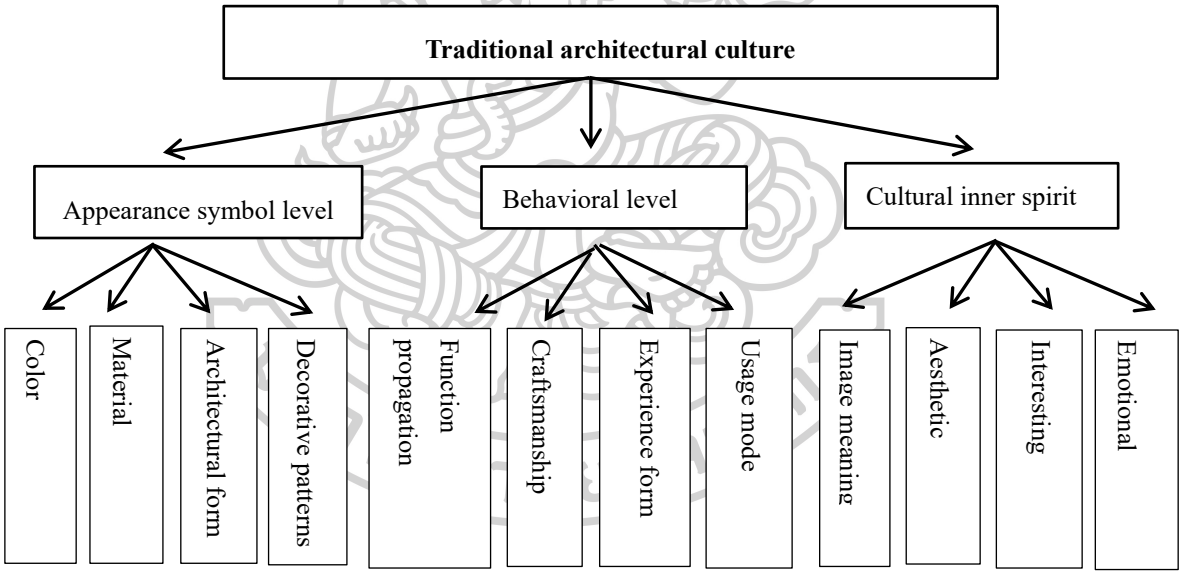


Figure 64 Decomposition Model of Architectural Cultural Characteristics

Source: Designed by Guangzhou Li, (2022)

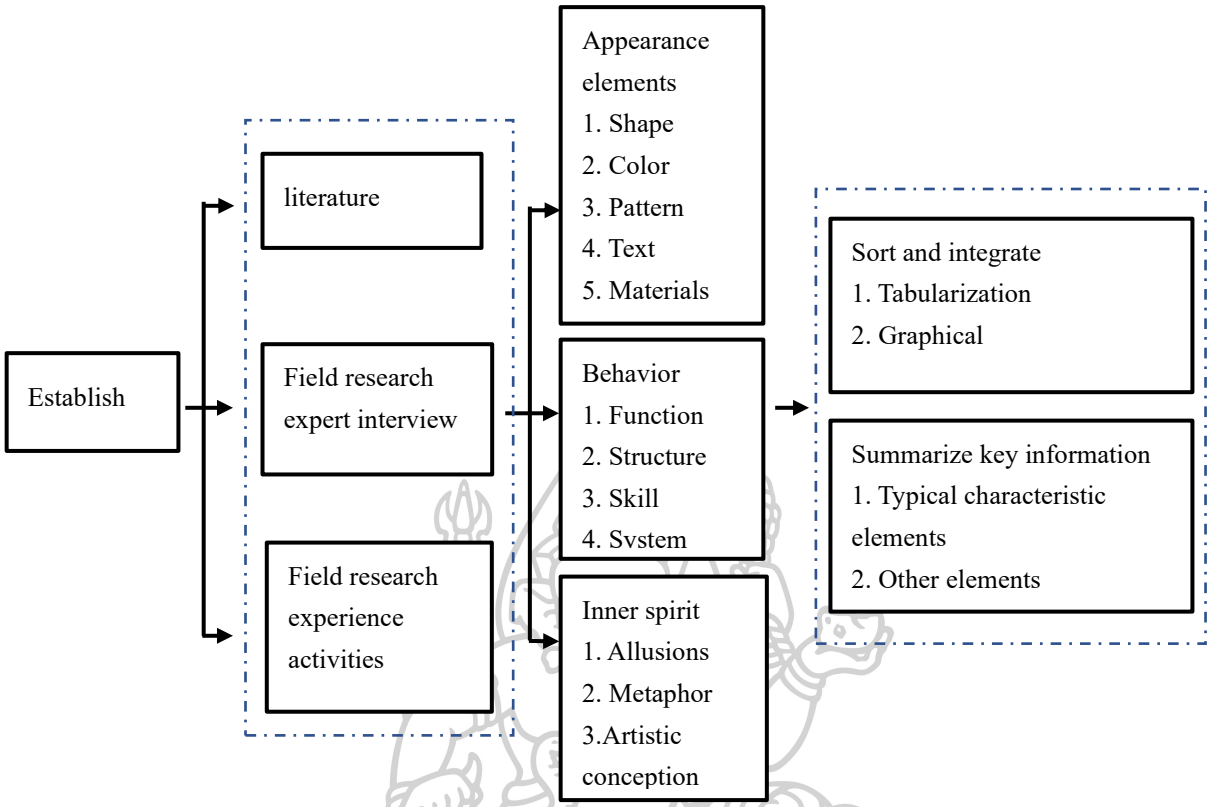


Figure 65 Extraction Mode of User Emotional Experience Elements

Source: Designed by Guangzhou Li, (2022)

2.5.3 Satisfaction analysis of cultural imagery using the fuzzy Kano model

This section describes many parts of the study work on surveys, interviews, and procedures used for data gathering and analysis. It focuses on using the Kano model for quantitative data research. The first is a questionnaire, which is the most significant and direct means to get first-hand information on users, consumption, and products.

In order to analyze users' needs for cultural attributes and create a fuzzy Kano questionnaire, a fuzzy Kano model was introduced. The fuzzy Kano questionnaire asks both affirmative and negative questions to determine the utility of the user's need, or whether the user is satisfied if the need is met and whether they are unsatisfied if it is not. To determine the kind of demand the user has, the linear relationship between the two is also examined. Excitatory needs are separated from necessary needs (M) and desirable needs (O), undifferentiated requirements (I), reverse needs (R), and undifferentiated needs (O) in the results.

2.5.3.1 Principles of the KANO model

Professor Noe of the Tokyo Institute of Technology developed the KANO model in 1984 as a method for categorizing and ranking customer wants in order to show how a good or service affects customer satisfaction. It offers a practical method for creating goods and services that please consumers. The non-linear connection between product performance and customer satisfaction is embodied by the KANO model. The quality kinds of various product attributes may be clarified by using the KANO model to research cultural and creative products, and diverse customer preferences for cultural attributes of cultural and creative products can be deduced.(Xu et al., 2009)

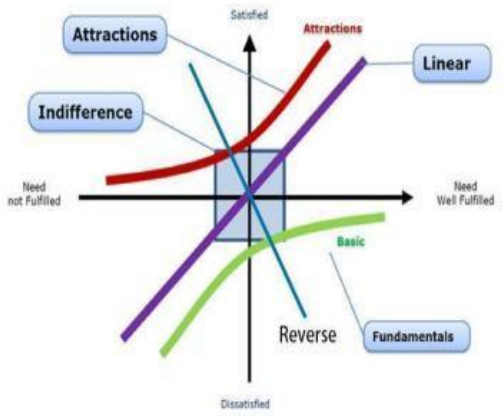


Figure 66 KANO model

2.5.3.2 Likert scale concepts

Likert scales are frequently used to gauge attitudes, views, or perceptions in the social sciences, psychology, and market research. Using a scale that ranges from strongly agree to strongly disagree, respondents are asked to rate how strongly they agree or disagree with a statement. Asking respondents to score their degree of agreement or disagreement with a statement on a scale that spans from strongly agree to strongly disagree or any other variation is the fundamental idea behind a Likert scale. (Joshi et al., 2015)

Likert scales are a standard format for survey rating. Respondents rate quality on a scale of five to seven, from excellent to mediocre or from best to worst. have frequently constructed a pyramid with four levels of measurement using the data received from these surveys:

(1) Nominal data: The lowest level of measurement is used to indicate categories without numerical representation.

(2) Ordinal data: Data that does not allow for the measuring of distance but does allow for the ranking or ordering of responses.

(3) Interval data: Usually integer data that enables ordering and distance measurement.

(4) Data that allows for meaningful ordering, separation, decimals, and fractions between variables is referred to as ratio data.

Table 5 Likert Scale Response Categories

Scale	1	2	3	4	5
	Never	Seldom	Sometimes	Often	Always
	Strongly	Disagree	Neutral	Agree	Strong Agree
	Not important at all	Unimportant	Neutral	Important	Most Important at all

2.5.4 Research on innovative design of cultural application furniture

This chapter mainly focuses on the relevant work content of the "Chinese Style" furniture group project practice to explain the application of cultural elements to innovative furniture product design. The furniture group first sorted out the scope of "Chinese style" furniture design, which includes not only the refinement of traditional furniture itself but also traditional aesthetics, traditional architecture, traditional craftsmanship, etc., covering all aspects of Chinese traditional culture, as well as comparison and reference with foreign furniture styles. The work of the furniture group is to refine the concept of "Chinese style" on this basis and apply it to furniture design. "Chinese style" furniture that conforms to contemporary behaviour and aesthetics is inevitably the inheritance and rebellion of traditional "Chinese style" furniture, that is, the process of de-stylization. Inherited traditional genes that are naturally perpetuated under contemporary behaviour and aesthetics; The rebellion is to remove the outdated concepts in traditional furniture and, at the same time, learn from the positive factors in the history of foreign furniture, especially the various trends and concepts that have profoundly influenced the world's modern design, and integrate them into contemporary "Chinese style" furniture design. In addition, the rebellion needs to revolve around the behaviour of contemporary people (daily life), explore reasonable scale, connect with modern production and manufacturing systems, and specific structure, material,

process details, etc., can be used as entry points for research.(Yaqin & Xiangdong, 2021)

The furniture group completed about 50 designs by the middle of the project, and here are five examples to discuss how the design of destylized "Chinese-style" furniture is approached. The first work is an armchair, pictured below:

Figure 67 Product name "Chinese Chair" Design: Wan Wei

Source: WAN Wei, YU Lizhan , HU Yuming. Style and De-stylization: Reflections on the Practice of "Chinese Style" Furniture Design[J]. Furniture & Interior, 2022.

The entry point of design is the "digging gap" in traditional furniture. "The introverted corner of the square foot, cut off by about a quarter, retains more traces of the gate pedestal or the gate bed than the ordinary horseshoe foot" (Shixiang, 2002). It can be seen that the excavation is a structural form derived from ancient furniture, because the frame structure system replaces the box plate structural system, the excavation loss of its structural significance, but its traces can still be seen in the Ming and Qing dynasty furniture. The designer hopes to improve this unique symbol of ancient Chinese furniture, so that it can not only continue the traditional characteristics, but also adapt to modern production, and also adapt to the behavioral needs of contemporary people, so as to achieve the purpose of de-stylization. First of all, because considering the technical requirements of subsequent wrapping leather, the concave shape is abandoned, and only the overall shape of the legs and feet is required to retain the missing form. Secondly, the frame structure of traditional furniture is abandoned, there is no horizontal fang and dental plate, and the legs and feet are directly connected into a similar shape to the door, because modern technology can fully meet the structural strength requirements. Third, the upper part of the chair adopts

the form of overall enclosure and soft bag, which is consistent with the legs and feet of the lower part, although it is not shaped by the "line" that traditional furniture is good at, but the "back plate" with the protruding backrest retains the basic characteristics of the traditional backrest chair. In general, the lack of exploitation is only an entry point, the designer tries to break the inherent impression of the lack of comfort of Chinese furniture, hoping to combine the comfort of the soft body with the simple sculptural shape, and integrate the simplified traditional form, so as to achieve the purpose of de-stylization that is both rebellious and inherited, and design "Chinese style" furniture that meets the needs of contemporary behavior.

The second work, "Heyi", attempts to carry out modern integration and innovation of classic traditional styles, in which you can also see the rebellion and inheritance of tradition. The first is integration, the entry point of integration is to make the traditional style conform to the aesthetics of contemporary people, adapt to modern industrial production and low price; Innovation is reflected in materials and construction. The work combines the classic traditional style with the human form, using only two cropped curved plates to put together, one dark and one light to clarify the main purpose of the fusion. The structural relationship of the work is very clear, which is not expressed by traditional furniture, presenting a lively aesthetic experience. The product is shown in the figure below:

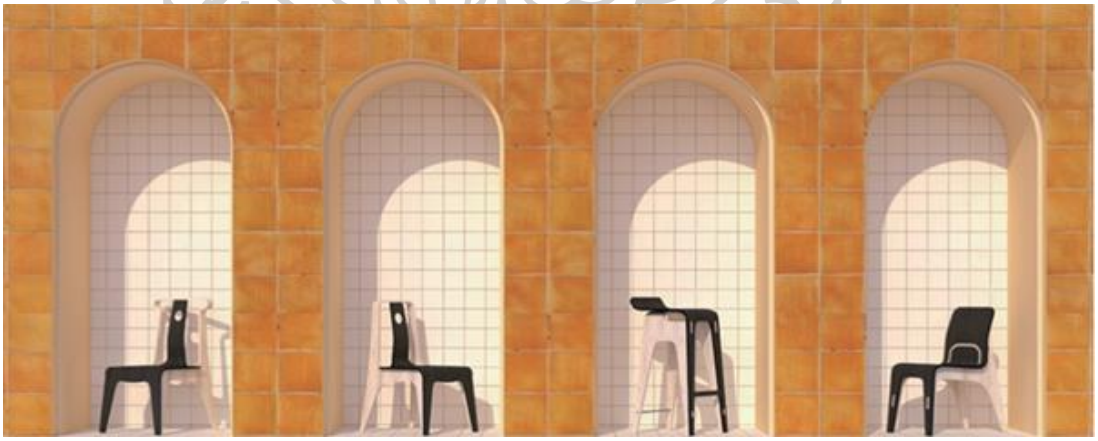


Figure 68 Product name "Heyi" Design: Zuo Siyang

Source: WAN Wei, YU Lizhan , HU Yuming. Style and De-stylization: Reflections on the Practice of "Chinese Style" Furniture Design[J]. Furniture & Interior, 2022.

The third work, "The Beard-shaped Stool", is based on the ancient Chinese vessel three-legged beard. The three-legged beard was first made into pottery, and later made into bronze, bronze, porcelain and jade, and is one of the classic styles of ancient Chinese utensils. The designer hopes to apply the classic traditional style with universal aesthetic identity in addition to furniture to furniture, which can not only enrich the form of contemporary "Chinese style" furniture design, but also arouse the strong interest of contemporary Chinese people in traditional aesthetics. Specifically, the stool retains a plump three-legged shape, connecting the three-legged with a hemispherical body, and the upper part of the hemispherical body as the stool surface; The production adopts the form of FRP shell paint, which is rich in color and light; It can be used as a stool or as a side table. Through the way of style transfer, without considering the inherent style of traditional furniture, exploring other classic "Chinese style" elements other than traditional furniture, combined with contemporary aesthetics and life scenes, this is also a design attempt to both rebel against and inherit tradition. The product is shown in the figure below:

Figure 69 "The Beard Stool" Design: Wan Wei

Source: WAN Wei, YU Lizhan , HU Yuming. Style and De-stylization: Reflections on the Practice of "Chinese Style" Furniture Design[J]. Furniture & Interior, 2022.

The fourth work, "Circle Chair", emphasizes the application of modern structure and craftsmanship in traditional styles. The design concept is derived from the traditional lap joining method of wood construction. On the whole, the chair retains the classic chair circle elements of the classical

furniture circle chair, but the chair circle section is not a traditional circle, but a continuously changing curved surface, reflecting obvious modern process characteristics; The legs are simplified to three, and the horizontal connection is a T-shaped structure that is not found in the traditional style, which is used to connect the three legs, and the beam at the connection directly runs through the curved plate of the leg, which is different from the traditional tenon, and is closer to the piercing practice in the wooden structure. The T-shaped structure, curved plate craftsmanship and three-legged shape reflect a strong modernist style, while the interspersed lap of the chair rim elements and components shows a significant "Chinese style", thus achieving the goal of rebellious and inherited destylization.

Figure 70 "Circle Chair" Design: Hu Yuming

Source: WAN Wei, YU Lizhan , HU Yuming. Style and De-stylization: Reflections on the Practice of "Chinese Style" Furniture Design[J]. Furniture & Interior, 2022.

In the fifth work "Clown Chair", the designer tries to integrate the foreign furniture style with the traditional Chinese style. On the basis of the classic design of the Windsor chair, the traditional Chinese style is integrated to make the Windsor chair have Chinese characteristics. The new style may expand the acceptance of the crowd and expand the scope of contemporary "Chinese" furniture design. The chair redesigns the backrest and armrests of the Windsor chair. The one-piece shape is similar to the edge of a traditional round chair; inspired by Italian designer Cano Morino Morino, the designer inserts the vertical support at the junction of the armrest and the backrest directly through the seat surface To the two rear legs, simplifying the structural system while obtaining better mechanical properties. The whole body of the seat is painted in black, which makes the new style appear subtle and elegant, enriching the traditional aesthetic meaning.

Figure 71 "Clown Chair" Design: Hu Yuming

Source: WAN Wei, YU Lizhan , HU Yuming. Style and De-stylization: Reflections on the Practice of "Chinese Style" Furniture Design[J]. Furniture & Interior, 2022.

The above five works are the furniture group's staged attempt and exploration of contemporary "Chinese style" furniture design, trying to design around the inheritance and rebellion of traditional culture as much as possible.(Wei et al., 2022) Initiated by Rong Design Library, the exhibition was initially unveiled at the spring 2019 MAISON & OBJET Paris Fashion Home Design Exhibition (M&O). Designer Yuan Yuan's lamps "unlock", inspired by the traditional Chinese "Luban lock". Invented by Lu Ban, the smartest carpenter in Chinese legend, the "Luban lock" is entirely connected by the tenon and tenon structure of the components, and both assembly and disassembly require wisdom. Yuan Yuan provides the beauty of light and shadow and form composition in "unlocking" and integrates fun into the process of thinking and experiencing the assembly of parts into lamps. Luban Lock, China's most famous traditional puzzle game, reflects a wooden tenon and tenon structure: the nodes between the components coincide with tenon and tenon to form an elastic framework. LEGO focuses on creativity, but the mortise and tenon structure is a problematic creation that integrates "solid geometry, physical mechanics, spatial imagination"

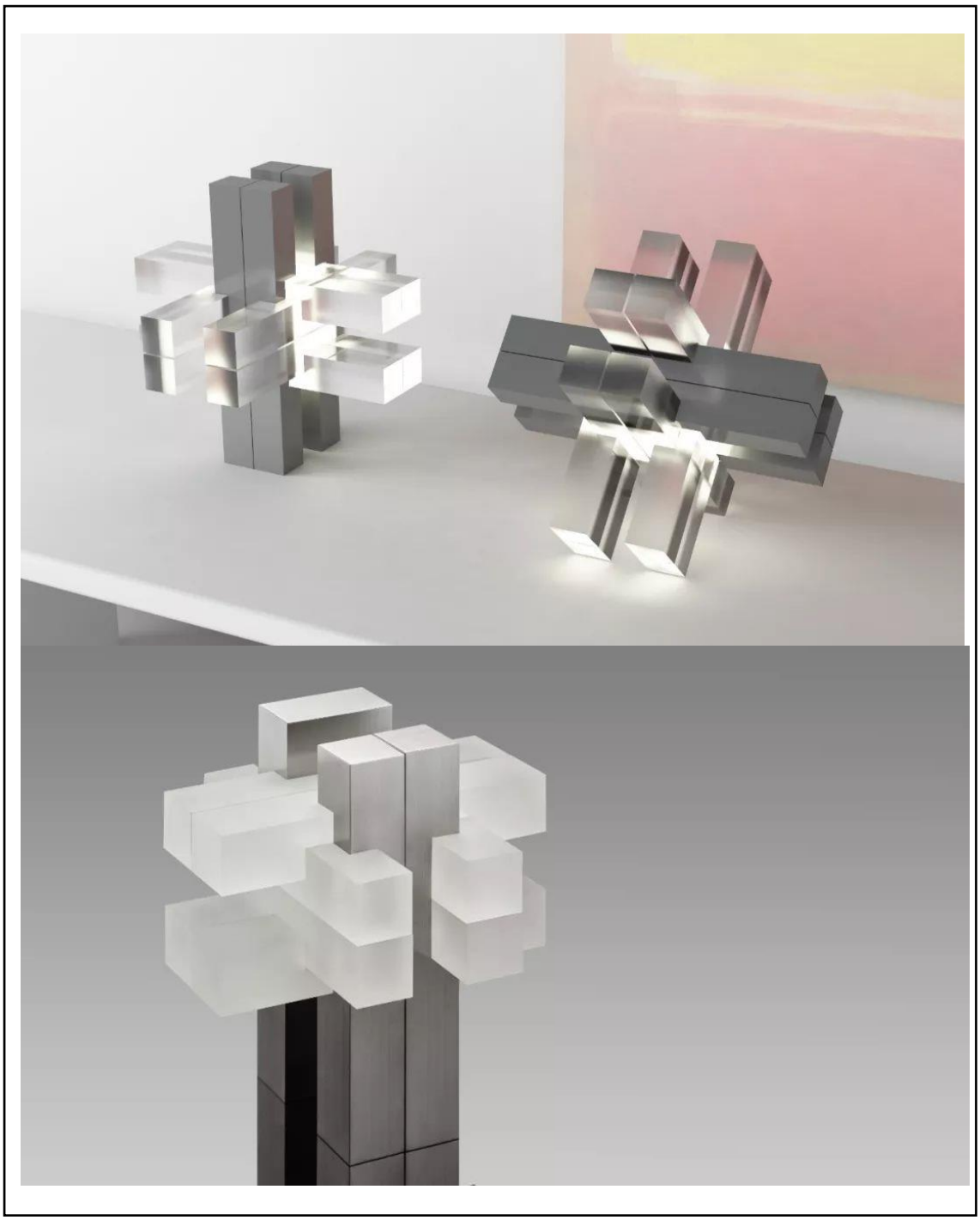


Figure 72 Product Name: Unlocked, designed by Yuan Yuan (2019)

Source: https://mp.weixin.qq.com/s/MvgkUM4edh9OEtMvAx4log

The piece below is by Hong Kong-based graphic designer Mike Wong, who is also inspired by the modular concept of mortise and tenon. The components that make up the DOooough shell are gears that can be interlocked with the concept of mortise and tenon structure: countless such polygonal variable card parts, interspersed and spliced through the structure of "mortise and tenon", can create colourful lampshades, and can also be infinitely extended into large private spaces according to different needs. This transformation is fundamentally due to the replacement and recombination of different components. The polygons decomposed from DOooough are the core of Mike's design, and countless of these deformable unit parts can be spliced together through the structure of "mortise and tenon" to create small lampshades, which can also be extended infinitely into large private spaces... This process relies on your imagination to create according to different needs. Mike turned DOooough into a toy that children can efficiently operate, allowing them to pass on the concept of "mortise and tenon invisibly". The exciting thing about DOooough is that when you light them up, the textures of the "gears" become visible and become the pattern of the shadows in the work.

Figure 73 DOooough shell lamp esigned by Mike Wong, (2019)

Source: https://mp.weixin.qq.com/s/MvgkUM4edh9OEtMvAx4log3366

CHAPTER 3

RESEARCH METHODOLOGY

From research work on the subject "Emotional design of Chinese traditional cultural creative products according to user needs", the researcher planned to carry out the research. From the study of information to create design requirements, including designing and studying the results obtained from the design, with the steps and tools created in the following parts.

3.1 Study data to create design requirements.

3.2 Stage of design Product development and prototyping.

3.3 A study of the satisfaction of the target group of consumers toward the product.

3.1 Study data to create design requirements.

Study Chinese historical and cultural information related to the architectural structure of ancient Chinese buildings in the past. during the dynasty Tang Dynasty, Song Dynasty, and Qing Dynasty.

3.1.1 Population and sample

3.1.1.1 Expert group

(1) Population is an expert who has been designing cultural designs for 10 consecutive years.

(2) The sample group is experts in the following areas:

- Expert in furniture product design and cultural research.

Pu Anguo, Professor of Art Department, Suzhou University of Education, Famous Ming and Qing dynasties furniture experts and arts and crafts scholars, member of the national arts and crafts expert database, member of Jiangsu province intangible cultural heritage expert committee.

- Specialists in culture and philosophy

Mo Junhua，Professor, vice dean of School of Art, Suzhou University of Science and Technology. Research direction is art theory, visual communication design.

- Environmental and interior design experts.

Meng Lin, Doctor, Associate professor, teacher of the Department of Environmental Art, School of Art, Soochow University. Research direction is Garden culture and historical direction.

- Specialists in environmental art and design, art and philosophy.

Feng Xianwei, Doctor, Associate professor of Changzhou Institute of Technology. Research direction is Environmental art and design, art and philosophy.

- Experts in product design and 3D printing research.

NO.1, Yang Yanshi, Associate Professor of Changshu Institute of Technology, Senior Engineer of 3D Printing. Research direction is Design theory, industrial design.

NO.2, Ruan Xiang qun, Product Supervisor of Suzhou Jianyi Design Co., Ltd. Research direction is Product design, 3D printing technology and product sales

3.1.1.2 People interested in cultural events

(1) Population groups are general consumers. who are interested in bringing identity from Chinese culture into product design

(2) The sample group is those who are interested in training skills from the Emotional Learning Test Set (Dou Gong) from Chinese architecture structures. Number of 269 people

3.1.2 How to create tools

Consultation with a research advisor at every stage since the design prototyping improvement and putting it to the real test Including tools to record observations and interviews by measuring and evaluating the effectiveness of the tools. (Create a tool through IOC determination. and/or certified consultants prior to use).

The examiner evaluated the questionnaires used.

Professor Mo Junhua

Associate Professor Yang Yan Shi

Associate Professor Dr. Xianwei Feng

Use IOC = (Np - Nd) / Np

Set the following marking objectives.

Np represents all target scores in the project plan

Nd means the number of targets inconsistent with the plan criteria for a consistency index of no less than 0.5 as follows.

Rating: +1 indicates confidence that the question is entirely consistent with the definition of the intended term.

Rating: 0 shows doubtful uncertainty that the master meets the plan objectives and intent of terms.

Rating: -1 suggests that the project plan is wholly inconsistent and that all goals are inconsistent with the plan By upgrading the questionnaire to a consistency index equal to 1.00.

3.1.3 Tools used in research

The testers are respondents with both open-ended and closed-ended information.

3.1.4 Method of collecting data

Distribute the questionnaire for the participants to write and answer. and the researcher collects the results himself

Recording both still images and videos during the training.

3.1.5 Data analysis methods

Information obtained from experts. Use the method of collecting qualitative

research results by writing method. individual lecture.

For the trainees used quantitative research. collect information from writing

to the questionnaire. Use quantitative research by using research statistics, mean (X), and standard deviation (SD.), including percentage (%) in data analysis

The data were analysed using the SPSS for Windows tool to derive percentages mean

and standard deviation values.The formula for standard deviation values.

Sample standard deviation = arithmetic square of the variance = S

S=sqrt(((x1-x)^2 +(x2-x)^2+..... (xn-x)^2)/(n-1))

The rating scale is based on the following rating criteria.

4.50 - 5.00 Indicates the highest level of opinion

3.50 - 4.49 Indicates a high level of opinion

2.50 - 3.49 Indicates a moderate opinion

1.50 - 2.49 Indicates very few opinions

1.00 - 1.49 indicates a minimal opinion

3.2 Stage of design Product development and prototyping.

The information in this section brings the conclusions obtained from the analysis to create the design requirements. There are steps in different sections as follows

3.2.1 Population and sample

The populations and samples in this section will be considered by experts in the relevant fields. which consists of

3.2.1.1 Expert group

(1) Population is an expert who has been designing cultural designs for 10 consecutive years.

(2) The sample group is experts in the following areas:

- Professor Pu Anguo, Director of China Ming Style Furniture Research Institute, Professor of Art Department, Suzhou University of Education. Famous Ming and Qing dynasties furniture experts and arts and crafts scholars, member of the national arts and crafts expert database, member of Jiangsu province intangible cultural heritage expert committee. Published monographs: "Chinese bird pattern" (1985), the Chinese zodiac atlas (1987), "wu culture history-wu craft culture," Chinese annatto furniture "(1996), "the Ming and qing furniture decoration art", "Ming and qing dynasties furniture appreciation", "Ming and qing dynasties su furniture ".

- Professor Mo Junhua, Vice dean of School of Art, Suzhou University of Science and Technology, master tutor, visiting scholar of University of Florence, Italy.Research direction: art theory, visual communication design. Published monographs "Gou Wu: The Vision of a Graphic Designer", "Painting meaning: Italy to Visit Learning"

Presided over the project of Schema Art of the Project of Humanities and

Social Science Planning Fund of the Ministry of Education.

- Dr. Associate professor Feng Xianwei, Associate professor of Changzhou Institute of Technology. Research direction: Environmental art and design, art and philosophy. Senior engineer, senior interior designer of China Interior Decoration Association, director of China Designers Association, member of the Art and Design Committee of the Vocational Education Travel Committee of Jiangsu Provincial Department of Culture and Tourism.

3.2.1.2 People interested in cultural events

(1) Population groups are general consumers. who are interested in bringing identity from Chinese culture into product design

(2) The sample group is those who are interested in training skills from the Emotional Learning Test Set (Dou Gong) from Chinese architecture structures. Number of 269 people

3.2.2 How to create tools

The design will consist of 3 phases:

Phase 1 included 12 new designs based on the data obtained from the study data.

Phase 2 has been developed and improved, leaving 3 approaches.

Phase 3 finalization and prototyping

Consult with an advisor Including creating a questionnaire to be used to assess by measuring and evaluating the effectiveness of the tool. (Build tools through IOC review and/or certified consultants prior to use.)

The examiner evaluated the questionnaires used.

Professor Mo Junhua

Associate Professor Yang Yan Shi

Associate Professor Dr. Xianwei Feng

Use IOC = (Np - Nd) / Np

Set the following marking objectives.

Np represents all target scores in the project plan

Nd means the number of targets inconsistent with the plan criteria for a consistency index of no less than 0.5 as follows.

Rating: +1 indicates confidence that the question is entirely consistent with the definition of the intended term.

Rating: 0 shows doubtful uncertainty that the master meets the plan objectives and intent of terms.

Rating: -1 suggests that the project plan is wholly inconsistent and that all goals are inconsistent with the plan By upgrading the questionnaire to a consistency index equal to 1.00

3.2.3 Tools used in research

The testers are respondents with both open-ended and closed-ended information.

3.2.4 Method of collecting data

Distribute the questionnaire for the participants to write and answer. and the researcher collects the results himself

Recording both still images and videos during the training.

3.2.5 Data analysis methods

Information obtained from experts. Use the method of collecting qualitative research results by writing method. individual lecture.

3.3 Research on target consumer satisfaction with the product

In this step, the created prototype will be used to study the satisfaction of interested target consumers. From January 10th to 15th, 2023, the product exhibition will be held in Suzhou, Jiangsu Province, China. The theme of the exhibition is "Using the Past for the Present: Exhibition of Design Achievements of Traditional Cultural and Creative Products".

3.3.1 Population and sample

People interested in cultural events

Population groups are general consumers. who are interested in bringing identity from Chinese culture into product design

The sample group was 223 people interested in products that brought the identity of Chinese culture in the past to be used in new designs.

3.3.2 How to create tools

Consult with the research advisor to create a questionnaire used to study the design results. and evaluate the effectiveness of the tool (Build tools through IOC review and/or qualified consultants prior to implementation.)

The examiner evaluated the questionnaires used.

Professor Mo Junhua

Associate Professor Yang Yan Shi

Associate Professor Dr. Xianwei Feng

Use IOC = (Np - Nd) / Np

Set the following marking objectives.

Np represents all target scores in the project plan

Nd means the number of targets inconsistent with the plan criteria for a consistency index of no less than 0.5 as follows.

Rating: +1 indicates confidence that the question is entirely consistent with the definition of the intended term.

Rating: 0 shows doubtful uncertainty that the master meets the plan objectives and intent of terms.

Rating: -1 suggests that the project plan is wholly inconsistent and that all goals are inconsistent with the plan By upgrading the questionnaire to a consistency index equal to 1.00.

The examiner evaluated the questionnaires used.

Professor Mo Junhua

Associate Professor Yang Yan Shi

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3.3.3 Tools used in research

The testers are respondents with both open-ended and closed-ended information.

3.3.4 Method of collecting data

Distribute the questionnaire for the participants to write and answer. and the researcher collects the results himself

Recording both still images and videos during the training.

3.3.5 Data analysis methods

Information obtained from experts. Use the method of collecting qualitative research results by writing method. individual lecture.

For the trainees used quantitative research. collect information from writing to the questionnaire. Use quantitative research by using research statistics, frequency, including percentage (%) in data analysis

CHAPTER 4

RESULTS AND DISCUSSION

Emotional creative product design based on Chinese culture based on user preferences. The research was conducted from literary studies, relevant research and Internet searches as well as from experts. and consumer demand. and information about emotional design From the test results of the knowledge material set used by the researcher The researcher analyzed and summarized the designs and studied the design results. Details are as follows：

4.1 Results of data analysis from the study to create design requirements.

4.2 Experimental design and design modeling.

4.3 The design of product prototypes shows research results and the satisfaction of target consumers.

4.1 Results of data analysis from the study to create design requirements

This chapter mainly analyzes and summarizes, the characteristics of the three representative historical periods of the bucket arch structure and its importance, the importance of emotional product design methods, researchers summarize relevant data research through emotional experience activities, and then combine user demand data to obtain the most critical target group needs, from the survey to get the target group not only requires the product to have a bucket arch structure, but also needs to be applied to the family scene, creative products should have commemorative significance, practical value, can be used in furniture products in the family. Combined with the above characteristics, this chapter finally obtains the evaluation methods and standards of emotional creative product design, and makes sufficient theoretical preparation for the product prototyping stage.

4.1.1 Literature research and research analysis results

From literature research, Internet data, and expert interviews, it is generally believed that the evolution of bucket arche is one of the theories of the evolution of bucket arche, one of which evolved from the intersection of well-dry construction structures. The evolution of Dou Li can be seen as a vital

symbol of the development of traditional Chinese wood frame architecture and an essential foundation for determining the age of traditional Chinese wood frame architecture. Dou Li has played a significant role in developing Chinese wood frame architecture. Therefore, it is crucial to research the bucket arch's structural variations according to significant historical eras.

4.1.1.1 Bucket arch in Tang Dynasty

Bucket arche was a ubiquitous architectural feature in Chinese architecture during the Tang Dynasty, 618-907 AD. It is mainly used as a structural support for the roof, but also plays a decorative role. Similar to the Sui Dynasty before, the structural characteristics of the Bucket Arche of the Tang Dynasty. However, in the Tang Dynasty, bracket use was more skilled and elegantly incorporated into the overall architectural style. The Tang Dynasty Bucket arche is huge, accounting for half of the height of the column, and the Tang Arch is more majestic than later generations. To judge whether a building is Tang Dynasty, its most conspicuous feature is the extremely high proportion of bucket arche layers.

Bucket arches were often utilized in constructions all around China during the Tang Dynasty, including well-known pagodas like the Big Wild Goose Pagoda in Xi'an and the Small Wild Goose Pagoda in Shaanxi. It was also used in many other buildings, including temples, palaces and government buildings. For example, the best-preserved Tang Dynasty Foguangshan Temple East Hall building was built around 857 A.D. It is the only Tang Dynasty official building in China, and there are Tang Dynasty murals, painted sculptures and written records. The materials used for the bucket arch vary depending on the purpose and location of the building, but wood is the most common material.

Compared with Tang Dynasty buildings, the roof is very large, and the building volume is huge. Craftsmen at the time designed larger bucket arches to support the roof. First, the Tang dynasty bucket arch had the role of transmitting weight, and the bucket arch was placed between the pillar and the beam frame, from above to bear the roof weight, downward to the column, and finally the column to transmit the weight to the foundation and the ground. The second Tang dynasty bucket arche had an enlarged eaves, making it more far-reaching. The bucket arch is a cascading structure, and the eaves are gradually picked out. The huge eaves of Foguang Temple are proof of this. Third, the bucket arch layer formed under the eaves, like spring pads, this structure can absorb the longitudinal and

transverse seismic waves caused by earthquakes. Although the earthquake caused the building to shake back and forth, the tenons and tenons in the bucket arche and wooden structure can move in a small range, and the bucket arche has allowed many ancient buildings to be preserved to this day, so the bucket arche is very beneficial to enhance the earthquake resistance of the building.Structural advantages of bucket arches include their ability to distribute weight evenly and resist earthquakes. This is especially important in earthquake-prone regions of China. Researchers have recognized the importance of the bucket arch in Chinese architecture and used 3D modeling techniques to study the structural properties and emotional impact of this unique feature. By creating a 3D model, researchers can better understand how the bucket arch works and how it contributes to the building's overall aesthetic.

Overall, the Tang Dynasty's employment of Bucket archer reflects how sophisticated Chinese building was at the time. It serves both practical and ornamental purposes, and the stability and sturdiness of the structures in which it is utilized depend on its structural qualities.

Internet Browsing According to the data analysis results, it is found from literature and Internet investigations that Obtain key bucket arch, tenon and tenon and tenon structures from classical Chinese architecture.

First, the researchers obtained bucket arch structures in three typical historical periods through 3D printed miniature models from relevant literature on traditional Chinese wooden structures and Internet materials. It can be seen from the analysis that the different positions of the same building have different forms, functions and production methods of bucket arches. As follows:

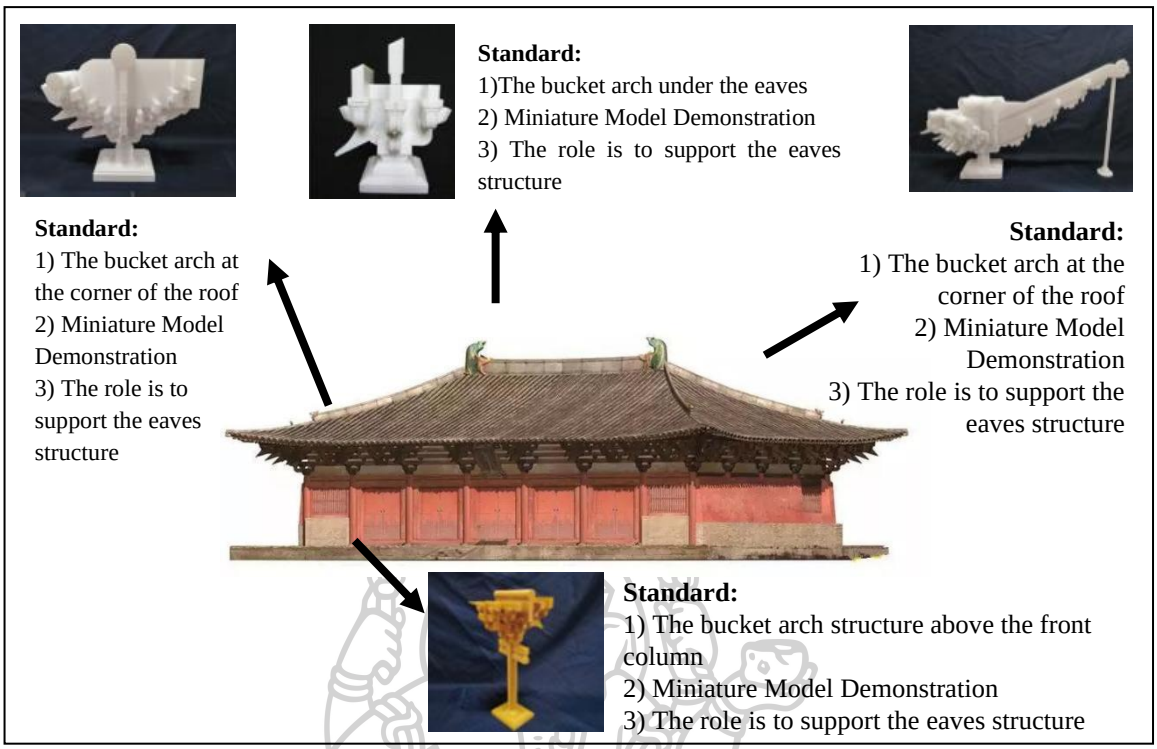


Figure 74 Analysis of Dougong in Foguang Temple in Tang Dynasty

Source: Designed by Guangzhou Li (2020)

4.1.1.2 Bucket arch in the Song Dynasty

During the Song Dynasty, which spanned from 960 to 1279 AD, The country is very rich, more buildings need to be built throughout the country, the demand for wood, craftsmen need is very large. Officials of the Song Dynasty organized and developed "Building French Style," which significantly impacted the evolution of ancient architecture during the Tang and Song Dynasties and on architectural formation, engineering techniques, and construction management after the Song Dynasty. The bucket arche, which has continued to play a significant role in Chinese architecture, is also described in length in the book. However, compared to the Tang Dynasty, there were several noticeable modifications to its structural features and usage. The arch's size was decreased to one-third the height of the column, the volume was decreased, and the structure became more mellow throughout the Song Dynasty.

In the Song Dynasty, Bucket arche was used primarily as a decorative feature rather than a structural support for the roof. The bracket sets became more elaborate and decorative, with

intricate carvings and designs, but they were also smaller in scale compared to previous eras. Additionally, Bucket arche was used to support the extended eaves of the roof, which gave buildings a more elegant and refined appearance.

The materials used for Bucket arche also changed during the Song Dynasty, with brick and stone becoming more commonly used alongside wood. This allowed for more elaborate designs and increased durability.

The importance of Bucket arche in Chinese architecture during the Song Dynasty is reflected in the many famous buildings that incorporated it, such as the Liao Dynasty Imperial Palace in Beijing and the Kaifeng City Tower in Henan province. Bucket arche's ability to withstand earthquakes and distribute weight evenly remained an important factor in its usage during this era.

In terms of research, 3D modeling technology has also been used to study Bucket arche in the Song Dynasty. This has helped researchers to better understand the intricate designs and structural properties of this unique feature and to appreciate its aesthetic and cultural significance in Chinese architecture.

Studying the importance of Bucket arche in the Song Dynasty is important because it provides insight into the architectural styles and techniques of that period. The building codes and standards set forth in the ancient book "Ying Zao Fa Shi" stipulate the design and construction of buildings, including the specifications and dimensions of timber used. By understanding these codes, we can better understand the architectural principles and methods of the Song Dynasty.

Bucket archer's structural characteristics in the Song Dynasty varied somewhat compared to the Tang Dynasty. In the Song Dynasty, the publication of "Ying Zao Fa Shi," an old book that offered instructions for building construction, increased the standardization and regulation of the usage of Bucket arche. The dimensions and specifications for timber usage were specified in detail, and the size and grade of the bucket arches were arranged according to the number of jumps and the number of shops. Each single layer in the Song Dynasty Bucket arche was a jump, and each additional layer was a pavement.

Additionally, the Song Dynasty Bucket arche had more intricate and complex designs compared to those of the Tang Dynasty. The brackets became more decorative and varied in

shape, and the use of multiple layers of bracket sets and interlocking beams became more common. Overall, the structural features of Bucket arche in the Song Dynasty reflect a greater emphasis on standardization and aesthetic complexity.

The use of 3D modeling is also important for the study of Song Dynasty Bucket arche, as it allows for a more detailed and accurate analysis of the structural features and complexity of these buildings. By creating digital models of buildings, researchers can simulate various scenarios and test the structural integrity of designs, gaining a deeper understanding of how the building's individual components are constructed and assembled. This could lead to new insights into the technological and engineering achievements of the Song Dynasty and help inform the prototyping practice of this study's products.

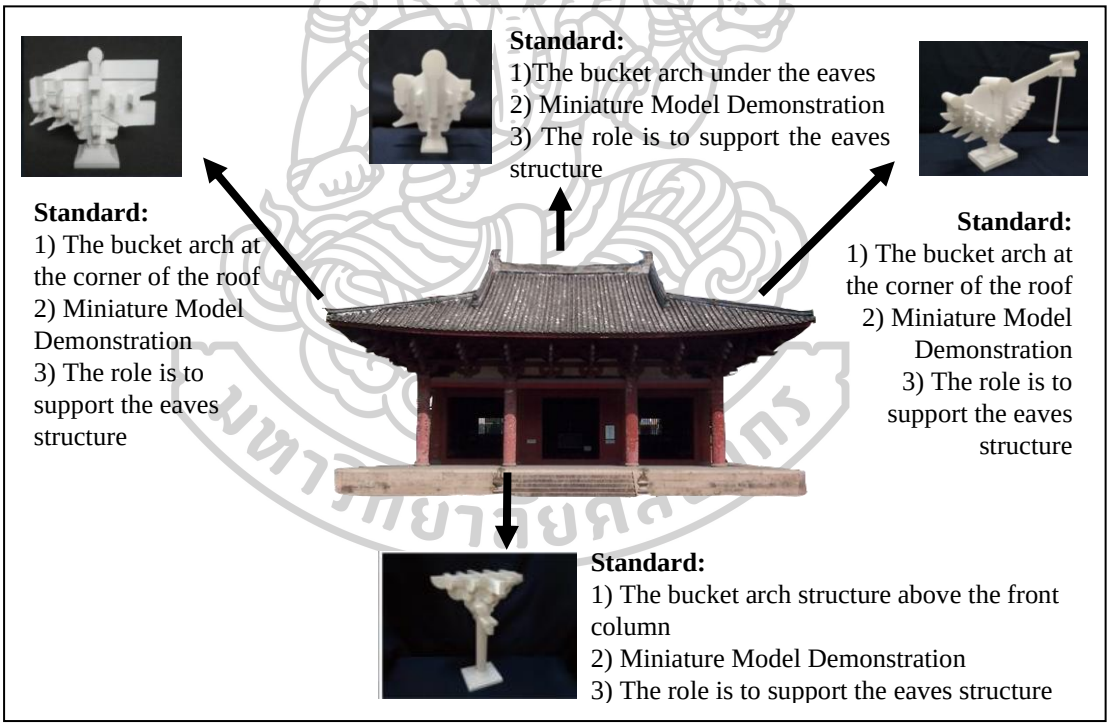


Figure 75 Analysis of Dougong in Hualin Temple in Song Dynasty

Source: Designed by Guangzhou Li (2020).

4.1.1.3 Bucket arch in the Qing Dynasty

The earthen wall of the Qing building has been replaced with a brick wall due to advancements in construction technology. Internal space has also increased, floor height has been raised, and roof volume has decreased. As a result, lighting has improved, and the building is now much more practical and comfortable. The change of wall material in the Qing Dynasty affected the size of the eaves, and the use of the forehead and the beam between the column heads strengthened the integrity of the structure. The disappearance of the rammed earth mound leads to less rainproof "protruding", so the bucket is no longer a stressed component, but a decorative component. In particular, the bucket arch in the algae well, which is only half faced, is pasted on the top and has become a pure ornament.

With specific structural alterations, bucket arche continued to evolve in the Qing Dynasty following the model of the Ming Dynasty. The architecture used in Qing-style buildings was more straightforward, more graceful, and had Bucket archer brackets that were smaller and more abundant. The Bucket Arche was constructed in the Qing Dynasty mostly from the hardwood nanmu, and the brackets were considerably smaller than in the Song Dynasty.

In the architecture of the Ming and Qing dynasties, large eaves were no longer required to protect from rainwater, large wooden frames became straight, and bucket arches were gradually reduced to architectural decoration as brick-making technology advanced and brick walls became more widely used. However, at the same time, old structures have also reached a turning point, their structural purposes have diminished, and the bucket arche will inevitably leave the historical stage.

The Qing Dynasty ruled China from 1644 to 1912 and was the final feudal dynasty. The Qing Dynasty continued to practice traditional Chinese architecture throughout this time while incorporating certain features of Western design. The Qing-style Bucket arche was more integrated into the overall architectural structure, with the beams of the buildings being placed on top of the brackets and directly supporting the eaves, rather than being interspersed in the brackets like the Song-style Bucket arche.

The combat arch of the Qing Dynasty and the Tang Dynasty are pretty different from one other, as can be seen by comparing the bucket arche of the east hall of Foguang Temple with that of the Taihe Hall of the Forbidden City and the volume and proportion of the structure are

considerably smaller.

Researchers have used 3D modeling to study the construction of Qing-style Bucket arche in more detail. By constructing virtual models, researchers can analyze the structural characteristics of Bucket arche more accurately and intuitively, and explore the design principles and construction techniques of traditional Chinese architecture.

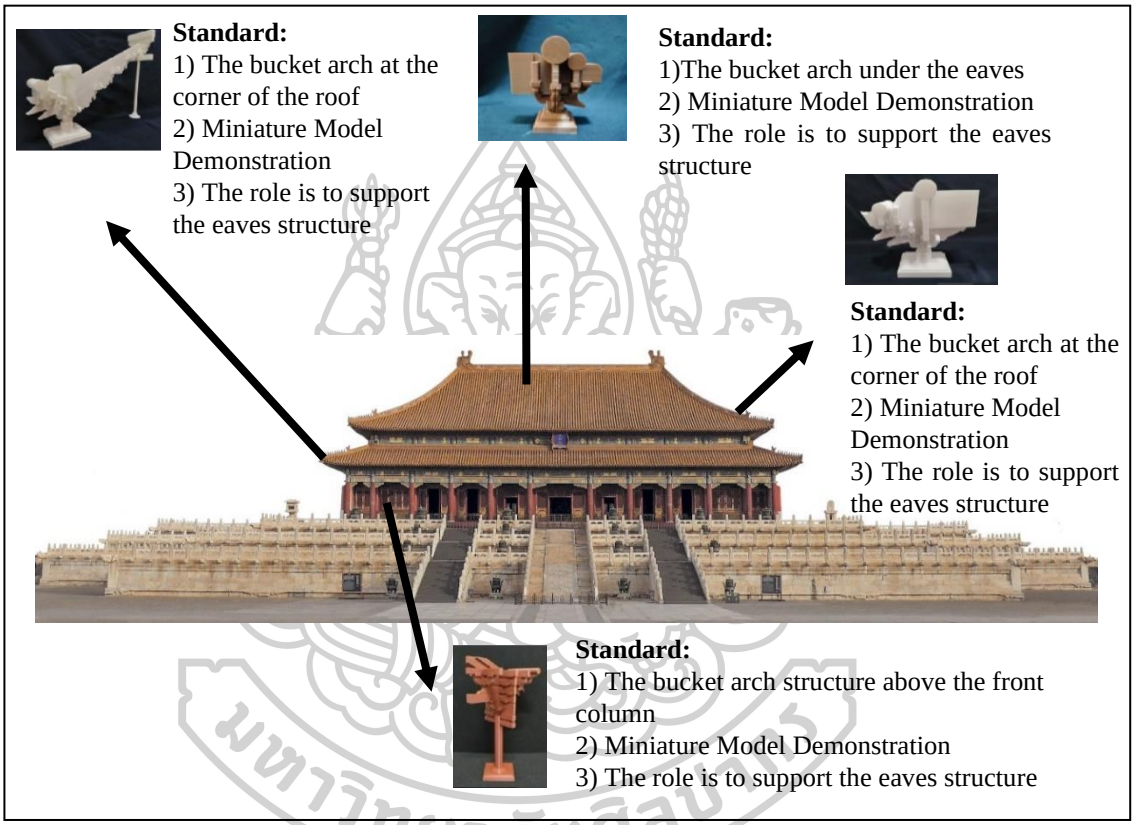


Figure 76 Analysis of Bucket arch in the Forbidden City in Qing Dynasty

Source: Designed by Guangzhou Li (2020).

Results of data analysis from the study: From the analysis of image data and miniature model description data of typical architectural bucket arches in the Tang, Song, and Qing Dynasties, the representative bucket arch structures in the three historical periods have advantages in later product prototype design.), number of parts and function. And compare the differences, as shown in the table below:

Table 6 Comparison of Dougong Features in Three Periods

1.Bucket arch of Tang Dynasty	2.Bucket arch of Song Dynasty	3.Bucket arch of Qing Dynasty
Name: Bucket arch outside the eaves of the East Hall of Foguang Temple	Name: Song Dynasty four-paving Ang Bucket arch	Name: Qing Dynasty Shan'ang three-step column head bucket arch
3D drawings: 	3D drawings: 	3D drawings: 
The number and advantages of 3D printing production components: Number of components: 30 It is helpful for the experiencer to assemble through the miniature Bucket arch model, so as to understand the building components and the connection relationship between the building components.	The number and advantages of 3D printing production components: Number of components: 29 Through disassembly and assembly, you can appreciate the specifications and characteristics of architectural standards in the Song Dynasty.	The number and advantages of 3D printing production components: Number of components: 29 Through disassembly and assembly, you can appreciate the specifications and characteristics of the Qing Dynasty architecture.

Table 6 revealed that the eaves could stretch longer, and the Bucket Arch was enormous during the Tang Dynasty. The gentle roof is stirred up by the bucket arch, which is a crucial component in preserving the stability and structural integrity of the building. A common Tang Dynasty tradition is the remaining Bucket arch of Fo Guang Temple in Wutai Mountain.

" Ying Zao Fa Shi " was compiled and revised in the Northern Song Dynasty, and all parts of the building were standardized. Bucket arch in the Song Dynasty changed the huge simplicity in the Tang Dynasty and the practice that Bucket arch only existed in the stigma. In the song dynasty, Bucket arch used to pick out. It uses the number of floors of Bucket arch to open the ranks of various buildings. The name was changed to "paving".

When the Ming and Qing dynasties changed, During this period, the buildings were built in a smooth and regular way, and Bucket arch was further reduced. Bucket arch was gradually not used as the key structure for supporting the roof, but was made smaller and used only as the external decoration of the building. The name was changed to "Branch".

In summary, Three historical periods are highly representative and have typical significance for studying the development of bucket arche. The biggest difference is in the proportions and scales of the structure. Because of the different times, the difference in building technology is relatively large, and the overall proportion of the bucket arch style and the building is gradually shrinking. So much so that it solely served as an ornament throughout the Ming and Qing dynasties and evolved into a sign of prestige and official architectural status.

4.1.2 Analysis of expert interview results

According to the literature analysis and research in the previous stage, through interviews, let five experts with professional capabilities conduct in-depth discussions and analysis on the issues related to the innovative product design of mortise and tenon and bucket arch structures. The final decision is necessary to carry out this research, which has a profound impact on the dissemination of Chinese traditional culture and ancient architectural structures through innovative product design.

According to the results of interviews and analysis of experts in various fields, experts in the field of furniture and product design suggest that it is necessary to go deep into the field to inspect the same type of products. Cultural and philosophical experts suggest that we should pay attention to the data collection of target consumer groups, and not just imitate classical furniture. Environmental and interior design experts recommend paying close attention to the experience and exchange of wood processing factories, such as going deep into the garden environment to extract and develop typical architectural elements. Environmental and philosophy experts suggest that the needs of modern people

should be combined, the furniture should be simple in shape, economic value should be considered, and sustainable product design concepts should be adopted. Experts in product design and 3D printing suggested to highlight the extraction of elements from the bucket arch structure, combined with modern creative design modeling language, to find a suitable method through scattered and reconstructed experiments.

4.1.2.1 Expert in furniture product design and cultural research.

(1) It is necessary to deeply study the rules of Chinese furniture shape modeling, structural innovation, mass production requirements and material selection, such as the color, texture, texture, smell and origin of wood.

(2) In-depth exploration of domestic furniture companies, especially those in Suzhou and Nantong in Jiangsu Province and Shunde and Dongguan in Guangdong Province, have developed their characteristics in recent years. Modern Chinese furniture has a history of more than 20 years.

4.1.2.2 Specialists in culture and philosophy.

(1) From the perspective of research and papers, we should closely focus on user needs, market trends, especially the choice of categories, whether they are young people who meet the current main consumption force and rigid demand.

(2) Formally, we should jump out of the imitation of Ming and Qing furniture styles and start to seek "concepts" and "elements" from China traditional culture.

4.1.2.3 Environmental and interior design experts.

(1) To have in-depth communication with wood processing plants and furniture manufacturing plants, you must go to the factory to understand the technological process.

(2) Taking the Suzhou-style garden architecture as an example, how to extract effective expression techniques and form-shaping features is conducive to the in-depth development of products, such as simplifying and evolving traditional furniture structures, extracting and abstracting some characteristic elements or typical elements.

4.1.2.4 Expert in environmental design and philosophy

(1) From the perspective of environmental protection and social responsibility, not only wood is used for product design. Compared with modern decoration environment and lifestyle, furniture with simple shapes and natural and bright colors is more popular with consumers.

(2) The use of renewable resources and degradable materials has also been generally valued. It makes a new interpretation of wood structure and wood culture through new materials and new technology.

4.1.2.5 Experts in product design and 3D printing research.

(1) From the perspective of product modeling design, the traditional cultural elements and the prototype system of traditional Chinese furniture are abstracted, and innovative innovation is carried out by combining China aesthetics and craft culture;

(2) Within the set scope of Bucket arch culture, the elements are scattered, reconstructed and integrated into furniture product design.

(3) Be clear about the design style, and whether consumers will choose it. Product design should conform to the background of modern life, not too retro, but let classicism become the source of furniture, and modernity is the purpose.

4.1.3 Analysis results of tenon and tenon and bucket arch

Literature analysis results mainly through the means of 3D printing, quickly transformed the structure of Mortise and Tenon and Bucket arch, the traditional buildings in China, into the form of splicing toys that teenagers can easily accept. It classifies the structural documents of Bucket arch, Mortise and Tenon, and Bucket arch, and makes them into hand-spliced toys. Through the popular science experience activities, the subjects are more likely to be interested in the structural cultural content of Mortise and Tenon and Bucket arch. After experimental analysis, the following conclusions are made:

Through the analysis of design and positioning, the data of previous research are summarized, analyzed and summarized, and a set of creative product design methods of Mortise and Tenon and Bucket arch structures are formed. In the whole design process, market research is carried out, and the market, product carrier and process specification of competitive products are deeply analyzed. From this design process, the author deeply felt the great creation of the ancient Mortise and Tenon and Bucket arch structures. Therefore, it still plays a very important role in today's production and life.

To sum up, Bucket arch, a common folk house in Jiangnan area of China, is simplified into four components: Dou, Sheng, Gong, Ang.

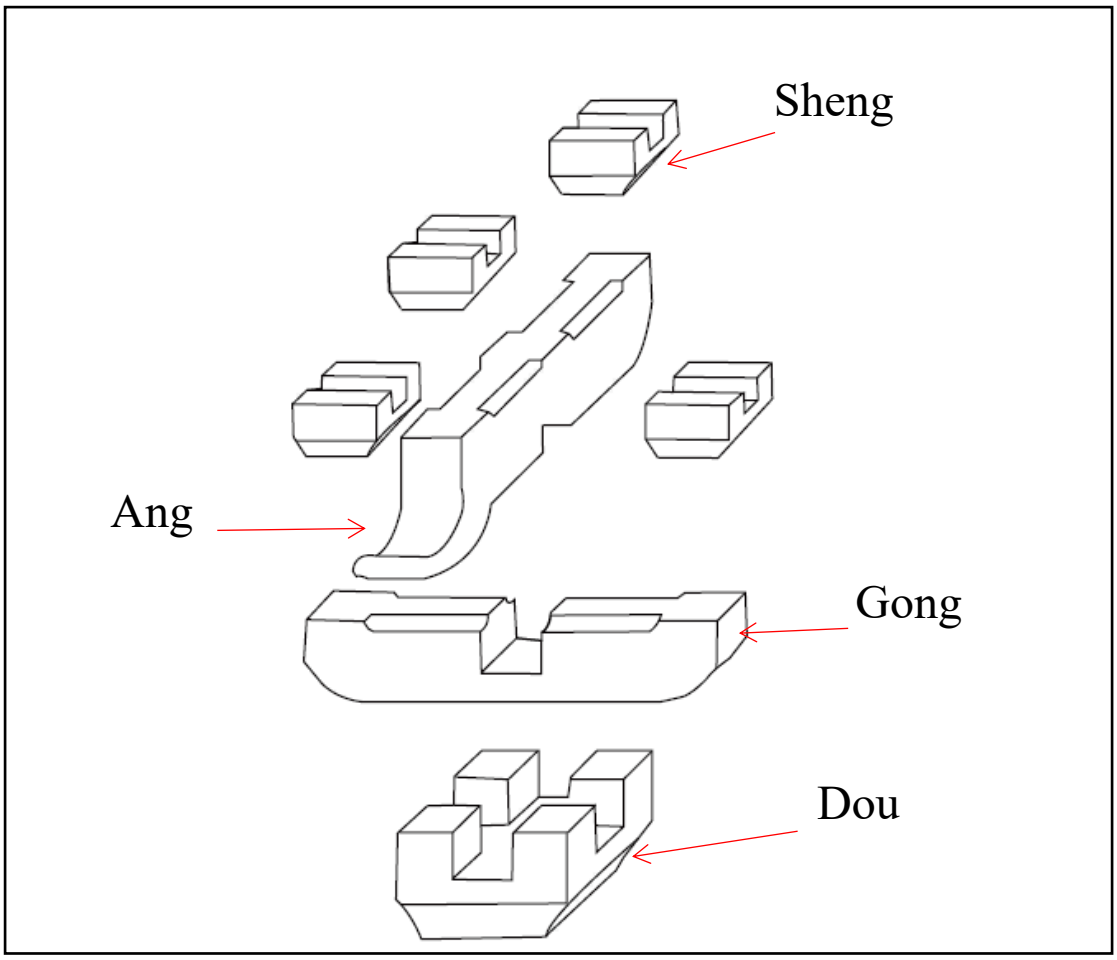


Figure 77 Schematic Diagram of Bucket arch Construction

Source: Designed by Guangzhou Li (2020).

Summary of critical cultural information and design element valuable information for design prototypes:

According to the research on traditional Chinese culture, the most representative architectural styles are Tang, Song and Qing Dynasties. The traditional Chinese wooden structure architecture, which is the most critical to the development of Chinese human history, is the cultural element of emotional product design.

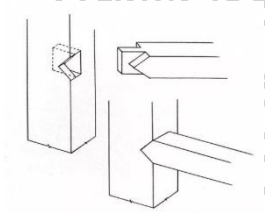
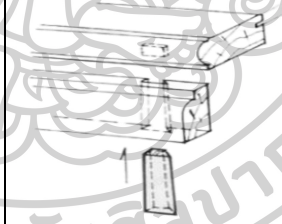
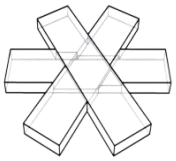
Data analysis reveals that the mortise and tenon structures may be categorized as wood fibre crisscross structures, intermediate connection structures, and piled superposition structures, as per the research on traditional Chinese wooden structures. Prototyping of products will be done using these building techniques. The bucket arch structure is summarized into four structural elements: rising, rising,

arching, and bucket, which will be used as product prototype structural components in the prototype design of emotional innovation products.

According to the wisdom of ancient architectural manufacturing, data analysis shows that modular design thinking is conducive to the study of the sustainability of emotional innovation products and is conducive to the upgrading and optimization of future product prototypes.

Secondly, in traditional Chinese ancient buildings and traditional daily products, the three most basic tenon and tenon structure shapes are obtained:

Table 7 Compare and summarize the types of mortise and tenon structures

Mortise and Tenon structure types	A) structure name: Wood fiber criss-cross structure	B) structure name: Intermediate connection structure	C) structure name: layered overlay structure
Source of structure			
Illustration			
Feature summary	The connection between structure and structure	Intermediate medium, becoming a bridge and link between structures	The superimposed structure is also developed from the ancient building method
Applied range	Wood structure buildings, furniture, farm tools	Wood structure buildings, furniture, farm tools	Wooden structure building doors and windows, furniture, farm tools

From Table 7, it is found that these three sets of tenon and tenon structures will be applied to product prototyping as a way to connect product structures, which are respectively from the wood structure building construction method, and are analyzed and summarized from the following three perspectives:

A) structure. This draws lessons from the principle of woven design, which evolved according to the characteristics of wood. It uses the vertical and horizontal interpenetration of wood fibres to ensure the firmness and stability of wooden utensils and realize various functional requirements.

B) structure The most basic structure in Mortise and Tenon structure, a tenon plus a mortise, can form a complete plug-in system. The practice of flat connection is often regarded as simple work by craftsmen. The practice of "exquisite" is "grid angle insertion" or "grid shoulder insertion".

C) structure that The wood is slotted and blocked and the layers are stacked together. The scientific name is "well dry structure" (cross process).

In terms of the description of the function of mortise and tenon, the three structures are different, and the A structure mainly undertakes the connection between the two objects, and the two structures can be smoothly connected together by performing mortise and tenon treatment at the end. Structure B should be connected by a medium, similar to the role of a wooden nail, and a groove should be opened between the two object pieces to allow the medium to connect. The C structure is mainly a structure that connects the three directions at the central position. There is a function to increase stability.

In the mortise and tenon application method, three structures need to be coordinated, originally acting on wood buildings, doors, house structures, etc.

In summary, the resulting tenon and tenon structure will be used as an important element combination method by researchers to prototype products.

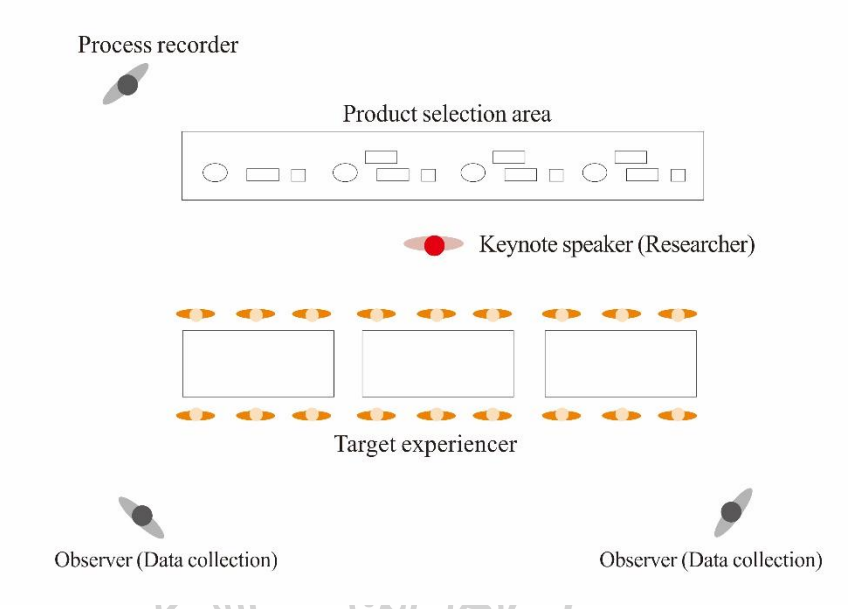
4.1.4 Researchers carry out innovative product design

4.1.4.1 Overview of emotional experience activities

Using the Chinese ancient architectural culture communication education toolkit, nearly 310 people participated in the emotional design research experience through 16 popular science education activities. 269 pieces of effective feedback were obtained through consumer feedback, expert interviews, and questionnaire surveys.

Table 8 Experience activity steps, diagrams, and data collection methods

Schematic diagram of the event site, Designed by Guangzhou Li (2020)



Step	Main content of the activity	Data collection method
Step 1:	Researchers will share and analyze the connotation of Chinese traditional culture, appreciation of ancient buildings, fighting arches, and tenon and tenon structure learning materials	Let the experiencer build a cultural knowledge memory
Step 2:	Tell the target experiencer to start the experience, and the target experimenter will go to the product selection area and choose different product experience kits according to their preferences	Collect data on the instinctive level of emotional design (unconscious observation)
Step 3:	1. In a certain period of time, let the experiencer independently complete the assembly and disassembly of mortise and arch structure science products.	1. Collect data at the level of emotional design behavior (unconscious observation)
	2. According to the needs of users, the researcher provides support for assembly behavior	2. The observer records the frequency provided and compares it
Step 4:	After the experience, the participants are interviewed and a questionnaire is filled. Feedback product suggestions, from practical value, economic value, cultural value, emotional reflection, etc	Collect data for data analysis and product prototyping

From Table 8, it was found that It can be seen from the above table, the proportion of men and women participating in this questionnaire is equal, with the main age being 36-45 years old,

and the education is mainly junior college and undergraduate. Their income is mostly between 5000-10000 yuan. It can be seen that grasping the needs of such users is the key target group for the design of Mortise and Tenon and Bucket arch structural emotional creative products.

From the steps of emotional experience activities and related data collection in the above table, the following four aspects are specifically elaborated, including the content investigated at each step of emotional experience activities, and the results of the analysis are summarized:

(1) The first step of research and analysis of emotional experience activities

In the emotional experience activity, the researchers placed pre-production, detachable popular science products directly converted from the historical data of traditional buildings, and placed them in the on-site product selection area. After the researchers have described the relevant learning information, the target experiencers are allowed to choose their own products. The observer (research assistant) begins to make unconscious observations and records the process of the experiencer's selection, recording relevant indicators such as color, structural complexity, structural difference products, etc.

(2) The second step of the emotional experience activity research and analysis process

As a knowledge learning explainer, the researcher also acts as the host of the event, issuing instructions to start the product experience stage, and the experiencer can carry out product experience behavior according to the knowledge of ancient buildings, tenon and tenon and arch structures previously learned, or according to their own understanding. Observers (research assistants) record data in groups of experiencers on the time of product experience and whether it can be completed within the specified time, which helps to further improve the product. After observing research and feedback after activities, it is concluded that popular science products at this stage are more difficult than ordinary people who experience for the first time, which will reduce the sense of experience and affect the consumption of products by experiencers. Based on the summary of several activities, the researchers designed an exploded view of the bucket arch structure product to remind the experiencers of the product construction steps.As shown in the figure below The name of each ingredient of Bucket arch and the initial description of how to use the product.

(3) The third step of the research and analysis process of emotional experience activities

Figure 78 Bucket arch 3D model and its explosion diagram

Source: Designed by Guangzhou Li,(2020).

Based on the third phase of the emotional experience activity, add information about Mortise and Tenon and Bucket Arch structural learning progression to the product. The design uses the Mortise and Tenon and Bucket arch structural components seen in traditional Chinese architecture:

A Consumers' feedback on the use data of ancient architecture Mortise and Tenon and Bucket arch structure science education products shows that it is necessary to design a product that combines daily life, which is more conducive to the embodiment of cultural values.

B Study the needs of consumers, including materials to be used and production methods.

C It adds the information to promote learning to the original toy product, and tries to create a modular product with Mortise and Tenon and Bucket arch structure by combining the modular design idea.

D Improve product appearance, material, and process performance to help consumers improve their experience.

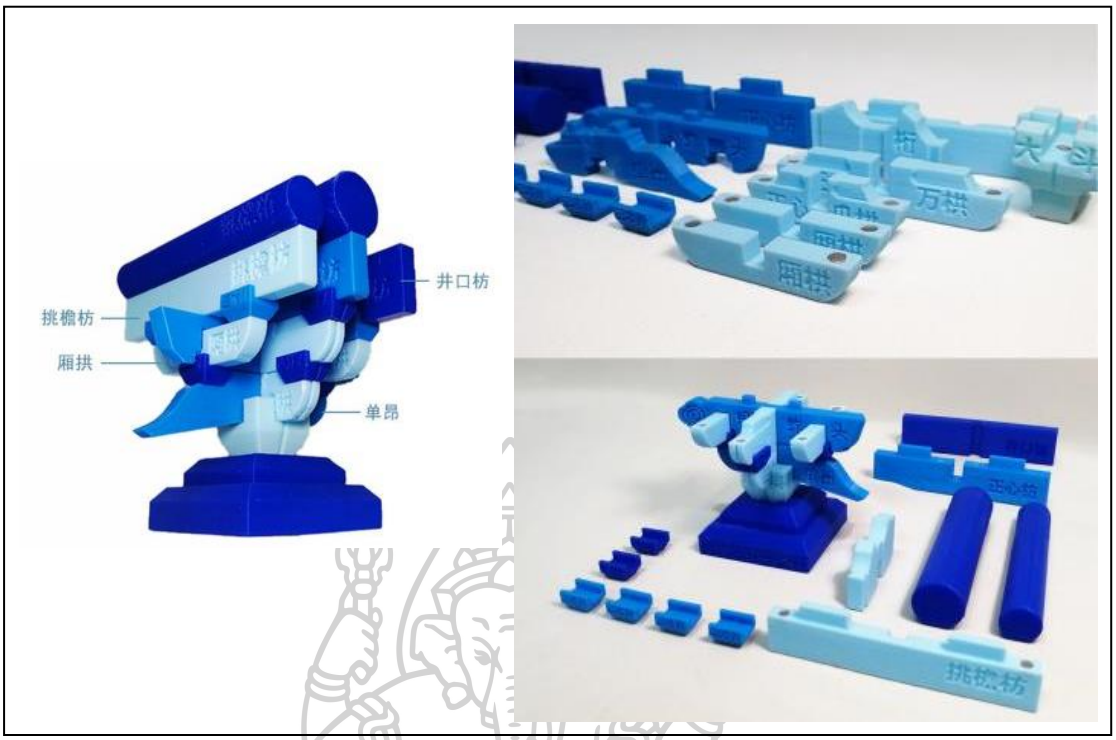


Figure 79 The Bucket arch knowledge science popularization product

Source: Designed by Guangzhou Li (2020)

(4) The fourth step of emotional experience activity research and data analysis process

Data analysis findings demonstrate that the emotional three-level theory is applied to product development and research by studying emotional design. The user needs corresponding to the three levels of emotional design are summarized, which can be summarized into three emotional elements: instinct level-appearance, behavior level-product use behavior and reflection level-psychology or thought. The three are interrelated and simultaneously act in product innovation design, as shown in the following Figure.:

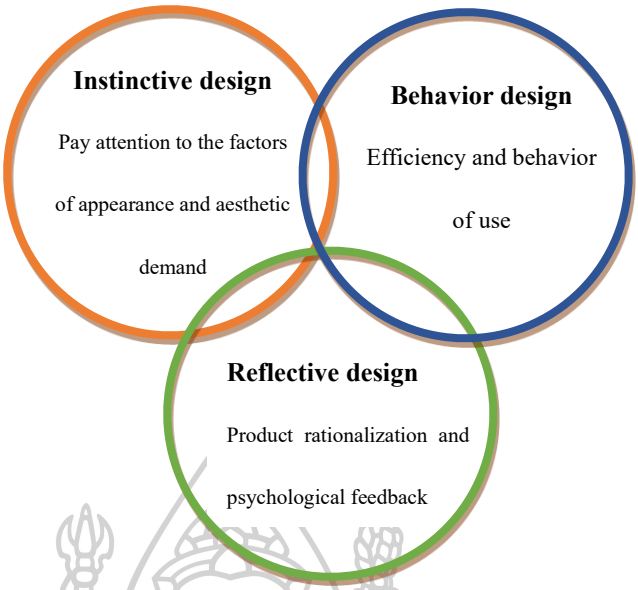


Figure 80 Three-level theoretical relationship of emotional

Source: Designed by Guangzhou Li (2020).

The data analysis outcomes demonstrate that one of the essential design thinking techniques for product innovation designers is emotional design thinking. The instinctive, behavioural, and reflective layers are interrelated and work together in product prototype design, constituting one of the evaluation indicators.

The researchers investigated the user needs and emotional design mapping data of Chinese mortise and tenon structure cultural and creative products. This survey is mainly based on the three-layer theory of emotional design, researching specific design factors, design constraints, product types and emotional elements, analyzing the results, and completing experiments and design prototypes to design future emotional and creative products.

Obtain feedback from emotional experience activities, data collection and analysis process, and design structure factors and product decomposition diagrams that have critical guiding significance for product model design obtained at each stage, pointing to product carriers (home products, furniture products), emotional consumer needs and other aspects. The whole emotional experience activity is also an important part of the product prototyping specification, focusing on explaining the key issue of this study, "how to use emotional design theory" to innovate product design with mortise and arch.

4.1.4.2 Get emotional experience activity data and data analysis

Using user research, compile and evaluate the emotional design data of cultural and creative items using bucket-arch and mortise and tenon structures to get the analysis findings given in the picture below:

(1) Findings from data analysis on emotional designUsers' basic demographic information for goods with Mortise and Tenon and Bucket arch structures.

Mortise, tenon, and bucket arch structural culture creative goods are examples in this study to examine the emotional design of traditional Chinese cultural products for user demands. The results are as follows:

There are 269 valid data on mapping data of user needs and emotional design of Mortise and Tenon and Bucket arch structured cultural creative products. See the appendix for the specific contents of the questionnaire.

Table 9 Analysis Results of User Basic Information

Name	Option	Frequency	Percentage (%)
Gender	Male	134	49.81
	Female	135	50.19
Age	25 years old and under	5	1.86
	26~35 years old	49	18.22
	36~45 years old	157	58.36
	45 years old and above	58	21.56
Academic Degree	High school and below	36	13.38
	Universities and colleges	108	40.15
	Undergraduate course	95	35.32
	Master degree or above	30	11.15
Income	3000 yuan and below	17	6.32
	3,000-5,000 yuan	80	29.74
	5000-10000 yuan	135	50.19
	10,000 yuan and above	37	13.76
Total		269	100.00

According to Table 9, the percentage of men and women who participated in the survey was equal, with the majority of respondents being between the ages of 36 and 45 and having a junior college or undergraduate degree. They often make between 5000 and 10,000 yuan per year. The second category, which makes up the majority of users, is those with a bachelor's degree or higher.

In summary, users' demands are the primary target audiences for the design of emotionally creative goods with mortise and arch structures, namely those aged 36-45, with an income of 5,000–10,000 yuan and a bachelor's degree or above.

(2)Results of data research on emotional design：Analysis results of users' demand for Mortise and Tenon and Bucket arch structural cultural and creative products. There were 296 participants as shown in Table 10 as follows.

Table 10 Maslow's five categories of needs

	Average value	**Standard deviation**
Physiological drives	3.85	0.971
Security requirements	3.71	1.168
Social needs	3.62	1.119
Respect	3.72	0.833
Self - realization	3.59	0.813

The average and standard deviation are typically utilized in descriptive statistical analysis to determine the index level of each variable, according to Table 10. The average level of the sample to this indicator is higher the higher the average value. The discrete trend describes the degree of data dispersion in the data distribution. The standard deviation, for instance, shows how several samples of the same indication deviate from one another. The Likert five-level scale is used mainly in this questionnaire's dimension observation, and the greater the score, the higher the degree.

The above table illustrates that the subjects are more acknowledged, as evidenced by the higher scores for physiological needs, safety needs, and respect for user experience. The significantly low self-realization score shows the individuals' poor consent.

In summary, it is concluded that the proportion of users' emotional design

physiological needs, security needs, and respect needs is high, and it is necessary to start from these aspects, which is also the data basis for the user needs research in this study. It will be applied to product design theory.

(3)Results of data research on emotional design：Analysis results of emotional design instinct of Mortise and Tenon and Bucket arch structural cultural creative products.

Specific to the emotional design instinct level, the survey results are shown in the following table. There were 296 participants as shown in Table 6 as follows.

Table 11 Analysis and summary of key data at the instinct level

Questionable items	Average value	Standard deviation
The appearance (size and shape, lines) of Mortise and Tenon, Bucket arch structural culture and creative products?	3.33	0.960
The material of the Mortise and Tenon, Bucket arch structural culture and creative products?	3.51	1.042
Mortise and Tenon, Bucket arch structural culture and creative products to be touch-sensitive and interactive?	3.66	0.860

From Table 11, it was found that As can be seen from the above table, Mortise and Tenon, Bucket arch structural culture and creative products to be touch-sensitive and interactive? This option has the highest score The material of the Mortise and Tenon, Bucket arch structural culture and creative products? This option is the second highest The appearance (size and shape, lines) of Mortise and Tenon, Bucket arch structural culture and creative products? This option is third.

In summary, at the instinctive level of product emotional design, the content that target users are most concerned about is that the product can have interactivity, then the combined structure of mortise and tenon and bucket arch can meet this requirement, and secondly, the product must have the traditional culture, obvious lines and dimensions of mortise and tenon and bucket arch structure.

(4) Results of data research on emotional design：The analysis results of emotional design behavior of Mortise and Tenon and Bucket arch structural cultural creative products.

On the aspect of emotional design behavior, our conclusions are shown in the following table. There were 296 participants as shown in Table 7 as follows.

Table 12 Summary of key data analysis at the behavioral level

Questionable items	Average value	Standard deviation
Mortise and Tenon and Bucket arch structural cultural and creative products to be practical?	3. 46	1. 163
Mortise and Tenon, Bucket arch structural culture and creative products to be small "tools" that can be used?	3. 36	0. 860
Cultural and creative products with mortise and tenon structure to be large and used in daily life (such as furniture, lamps, space decorations)	3. 32	1. 205
Mortise and Tenon, Bucket arch structural culture and creative products to be used in social events?	3. 42	0. 888

From Table 12, it was found that the score of Mortise and Tenon and Bucket arch structural cultural and creative products to be practical? have a high practical score, which shows that the subjects are more recognized. To be employed in cultural and educational activities, what is the score of Mortise and Tenon, Bucket arch structural, and creative products? It must be higher, indicating that the individuals' consent was not vital.

In conclusion, the study on the behaviour level of emotional product design reveals that the product must satisfy consumers' social and practical demands and be appropriate for usage in social situations. In other words, the creative products of mortise and arch structures not only have practical functions, but also can generate social topics. Secondly, the focus is on the application of furniture products, large-size furniture, small-size household items, etc. on product carriers.

(5) Results of data research on emotional design：The analysis results of emotional design reflection of Mortise and Tenon and Bucket arch's structural cultural creative product design.

On the reflection level of specific emotional design, the research results obtained in this paper are shown in the following table. There were 296 participants as shown in Table 8 as follows.

Table 13 Summary of key data analysis at the reflection level

Questionable items	Average value	Standard deviation
Mortise and Tenon, Bucket arch structural culture creative products to help you get out of the negative state?	3.51	1.021
Mortise and Tenon, Bucket arch structural culture creative products to make you remember and associate with a certain culture?	3.57	0.824
Mortise and Tenon, Bucket arch structural cultural creative products to enhance your social recognition?	3.45	0.774

From Table 13, it was found that Mortise and Tenon, Bucket arch structural culture creative products to make you remember and associate with a certain culture? have a high practical score, which shows that the subjects are more recognized. The score of Mortise and Tenon, Bucket arch structural cultural and creative products to be used in cultural and educational activities? is relatively low, which shows that the consent of the subjects is weak.As can be seen from the above table, Mortise and Tenon, Bucket arch structural culture creative products to make you remember and associate with a certain culture? with a high recognition score, which shows that the subjects are more recognized.

In conclusion, product prototype design places a greater emphasis on emotional design expression, allowing users to connect emotionally with traditional ancient architectural culture and reflect on emotional memory through the product. This allows users to have cultural memory, but also allows those who own products to improve their own cultural taste recognition and social status.

4.1.5 The demand for mortise and tenon products from the target group

Before designing the experiment, after the tool demonstration of the expert group, a field survey of user needs was carried out:

The user demand for traditional Chinese creative items was examined using the KANO model. The investigation at this stage is mainly to study the demand types and demand weights of target consumer groups according to the contents of literature research. Investigate the results to study and create design specifications and design experiments.

4.1.5.1 Analysis and summary of user needs of cultural and creative products

This article describes the gender, age and occupation of the 310 respondents and analyzes the demographic characteristics of the respondent groups, as shown in the figure below:.

Table 14 Basic information of samples

Project		Number	Column N %
Gender	Male	161	51.9%
	Female	149	48.1%
Age	0-18 years old	6	1.9%
	19-26 years old	89	28.7%
	27-35 years old	127	41.0%
	Over 36 years old	88	28.4%
Occupation	school students	118	38.1%
	office worker	117	37.7%
	people waiting for employment	54	17.4%
	other	21	6.8%

From Table 14, the percentage of males in this poll is 51.9%, which is somewhat greater than the percentage of women, according to Table 14. The proportion of women is 48.1%. The age distribution is concentrated over 19 years old, that is, all the people surveyed are basically adults and have the ability to think independently. Among them, 28.7% are 19-26 years old, 41% are 27-35 years old, and 28.4% are over 36 years old. In addition, most of the people surveyed are school students and office workers, of whom 38.1% are school students and 37.7% are office workers.

In summary, This survey of user needs is an undifferentiated survey conducted in tourist attractions and product markets, and the data reflected represents universal significance. The high proportion of concentrated students and office staff also reflects that the demand comes from young people. They have great interest in traditional Chinese cultural and creative products and value recognition.

Table 15 Cultural and creative product demand classification

Questionnaires	Excitement demand (A)	Essential demand (M)	Indifferent demand (I)	Reverse demand (R)	Suspicious demand (Q)	Category
Traditional cultural and creative products need practical use functions?	5.81%	**33.87%**	30.00%	0.97%	0.32%	M
Is there a traditional cultural style in traditional cultural creative products?	3.87%	**50.32%**	29.68%	2.26%	3.87%	M
Traditional cultural and creative products need to have traditional characteristics?	5.81%	**42.58%**	35.81%	5.16%	2.90%	M
Traditional cultural creative products need to have cultural stories?	**47.74%**	0.97%	**35.16%**	11.29%	3.23%	A
Creative expression in traditional cultural and creative products?	**44.84%**	1.61%	29.35%	19.68%	3.23%	A
Is there symbolic significance in traditional cultural creative products?	**43.23%**	6.45%	33.55%	3.23%	1%	A
Is it necessary to move emotions and heal the soul in traditional cultural creative products?	**48.06%**	0.65%	39.03%	5.48%	4.52%	A

From Table 15, it was found that summary of users' demand for traditional cultural and creative products:

(1) Products need to have cultural stories, be creative, have symbolic meaning, and need to impress emotions and heal the soul, which account for the largest proportion, accounting for 47.74%, 44.84%, 43.23% and 48.06% respectively, and are classified as excitement needs (A).

(2) The actual use function, essential requirements with traditional cultural style and traditional characteristics of product. Account for the largest proportion, accounting for 50.32%, 42.58% and 33.87%。respectively, and are classified as essential requirements (M).

(3)Has a reverse demand (R). Seven indicators are classified as indifference demand (I). It is not regarded as an important indicator of design factors.

In conclusion, the study on the market for cultural and creative goods discovered that projects categorized as exciting needs and required requirements need to be supported by important user data for product prototype. Requiring products that can impress consumers at the level of emotional needs can be achieved by emphasizing commemorative products, such as garden lamps. Let the product create an emotional connection and heal the mind.

4.1.5.2 Conclusion of user demand data analysis

In the design of cultural and creative products based on Bucket arch, Mortise and Tenon, the proportion of data to meet users' emotional needs is the highest. Therefore, the development of functional creative products with popular science education and creativity enhancement should focus on emotional design.

(1) Based on KANO model analysis method combined with emotional, intuition, behavior and three-level reflection design. As proposed by Donald A Norman, to expand the relationship between user needs and product characteristics of Chinese traditional culture and creativity. Product style level requirements of the emotional design of Chinese traditional cultural and creative products.

(2) Design with emotion The shape should match the traits of the mortise and tenon structure, according to instinctive design. and prominently visible on auxiliary or structural components. Numerous factors must be taken into account when deciding if the product's texture is firm or not.

(3) Important information at the emotional design behavior level Product prototypes should be practical. Most of them are household items, lamps, furniture, hangers, storage shelves, etc., which can highlight the product structure of mortise and tenon brackets. meanwhile It should have a specific social value and spark discussions about the innovative application of mortise and tenon structures in life situations.

(4) Important information on the emotional design reflection level: New items with mortise and tenon joints have a connection to and memory of old Chinese architecture as well as ancient knowledge. Users of the product are kept engaged, and social identity is strengthened.

4.1.5.3 Summarize the conclusions of expert discussion and data analysis, and draw data conclusions that are helpful for the research stage of product model design

(1) Recruit groups interested in experiments through popular science education activities and network promotion. After feedback analysis, the group indicated that the design project was "worthy of attention and cultural heritage value".

(2) Because there are many varieties, it is necessary to focus on several representative products and increase the sense of experience through the product manual. In particular, the guidance support of the product exploded view increases the sense of experience.

(3) According to the survey of product user needs, the creative products of mortise and tenon and bucket arch should have cultural stories and symbolic significance, be able to move users' emotions and heal the soul, and be summarized as "the level of product emotional design reflection needs to be higher".

(4) From the perspective of innovative design research, the products in the experience activity stage have traditional cultural elements, but this product is not new, so it needs to reflect certain practical and functional value. Users hope to expand the use of scenarios, not only in the museum to experience, can apply the mortise and tenon and arch structure to furniture design. It has both practicality, cultural value, and emotional value.

4.1.5.4 Summary of emotional design information useful for design prototypes

According to the user's research data on mortise and tenon structure emotional design products and the data discussed by experts, through comparative analysis, the key favorable information of product emotional design corresponding to the demand level is summarized.

As can be seen from the figure below, with emotional design as the center, the relationship between the demand levels of the three target consumer groups and product design elements is constructed, the physiological needs correspond to the emotional instinctive level corresponding to the product appearance, color, style and other factors, the use behavior needs correspond to the emotional

design behavior level corresponding to the factors of product technology, portability, and use experience, and the ideological level needs correspond to the emotional design reflection level corresponding to the product cultural characteristics, region, inheritance, story, emotion, commemoration and other factors.

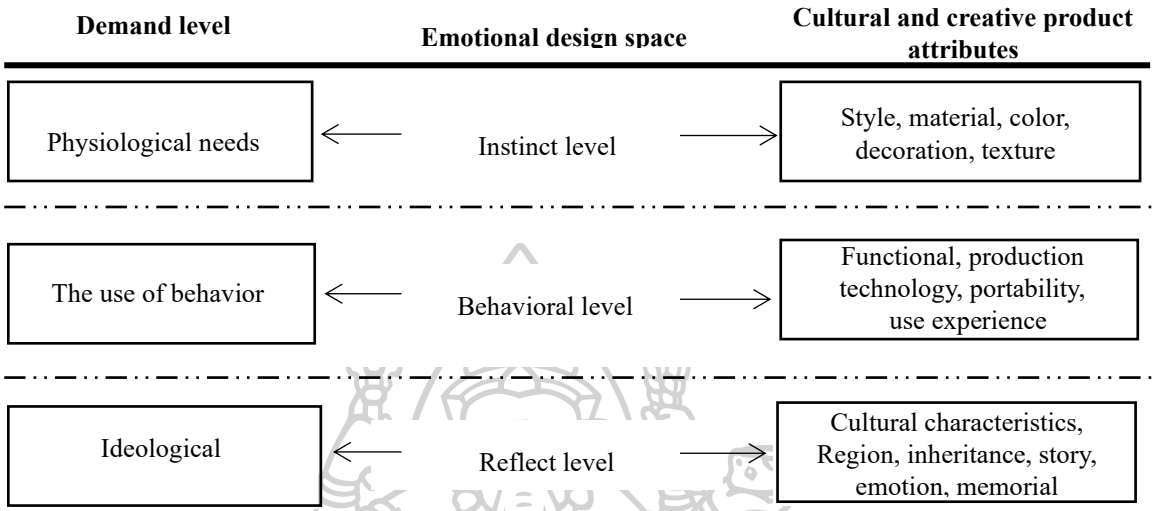


Figure 81 Product emotional design-demand hierarchy framework.

Source: Designed by Guangzhou Li (2020).

4.1.6 Analyze learning information and create design specifications

Summarize the data analysis findings from the study in order to establish the standards for emotional design.It highlights the emotional design standards of traditional cultural creative items from China through the first-stage product prototype design and user-led field research on Mortise and Tenon and Bucket arch structural products.

4.1.6.1 Emotional design specification of Chinese cultural and creative products

After field investigation by target users, experts demonstrated the experimental tools and methods. The emotional design of China traditional cultural creative products is to combine users' emotional needs in household products with Mortise and Tenon and Bucket arch structures, and express users' emotional information in the prototype design stage. Therefore, we should pay attention to the collection and analysis of users' emotional information and the integration of emotional design in the whole process of using and evaluating the design model.

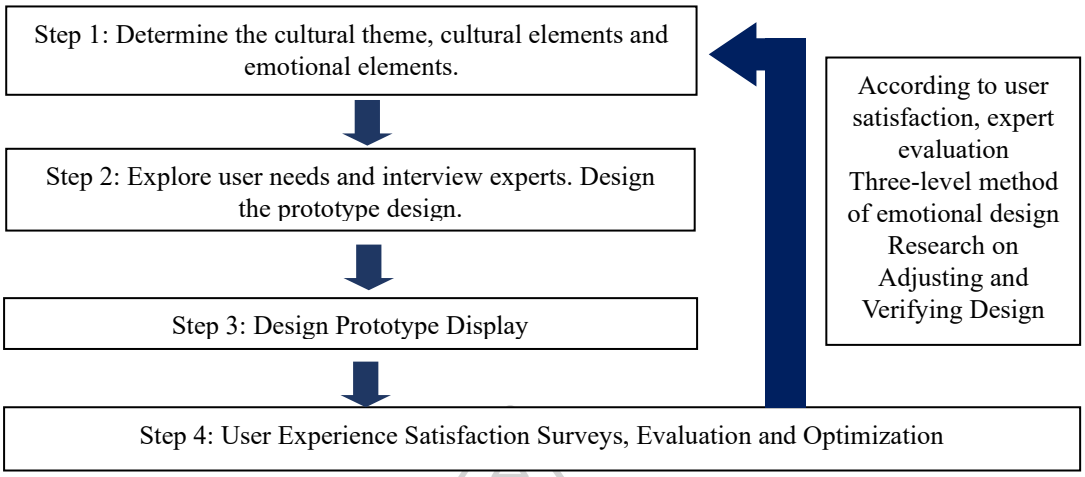


Figure 82 Emotional design process for cultural and creative products

Source: Designed by Guangzhou Li (2020).

As shown in the above Fig., the emotional design process of lamps based on China traditional culture is divided into four stages: determining cultural theme, user experience investigation, scheme design, evaluation and optimization. Choosing a perspective from traditional culture to conduct in-depth theoretical research makes the ideas conveyed by it conform to the aesthetic orientation and values of modern people. After determining the design theme, it conducts research and interviews with the target users to understand their inner functional and emotional needs for China traditional cultural and emotional creative products. Through brainstorming and a large number of sketches, this experiment carries out innovative design of emotional creative products. It starts with the modeling, function, cultural connotation, emotional factors, etc., and designs an emotional creative product that is both interesting and cultural connotation, bringing users a brand-new emotional interaction experience and arousing their sense of identity with China traditional culture. In addition, in order to bring users a better experience and make the product more perfect, after the initial scheme is completed, this design still chooses initial interviews to evaluate the target users and the product experience. According to the evaluation results, the places with poor user experience are further improved and perfected.

4.1.6.2 Principles of expressive design of cultural and creative products in China

A. Rational Principle; B. Creative Principle;C. Cultural Principle; D. Economic Principle

4.1.6.3 Mortise and tenon structure creative product emotional design evaluation criteria

The evaluation criteria for the inspirational product design of mortise and arch structures are summarized, as detailed in the following table.

Table 16 Constructing innovative product design evaluation criteria

Evaluation code	Evaluation item	Evaluation standard
A	Cultural connotation	1) Retains the Bucket arch identity, characterized by vertical assembly of mortise and tenon components. The concept is derived from emotional, creative media from Chinese cultural architecture combining science and art. 2)By science, there will be a body of scientific knowledge in engineering regarding the complex load of the load, including balance.
B	Appearance aesthetics	The design must maintain the characteristics of Bucket arch's Chinese culture in terms of naturalness (material) and solid and elegant appearance. Method using straight lines. Blend with curves in the corners. With the use of square corners in the art composition principle
C	Economicaspect	There must be value for the investment to obtain an appropriate return. 1) Must produce the design in a small industry system. To be a guideline for creating new entrepreneurs. 2) The design must share parts. To modify designs in the same product type or use in conjunction with other products. 3) The design must demonstrate sustainability. It does not cause any impact on the ecosystem
D	Emotional experience	Emotional experience requirements of products from Chinese culture through the researcher's KANO training 1) Traditional Chinese must be preserved. For this work, it should be the assembly structure of Bucket arch, including 2) Simplicity of assembly and use. 3) Product prototypes should be practical in the design of home appliances such as lamps—lights, furniture, hangers, storage shelves, etc., in daily life. 4) Expression of enthusiasm = Personality that shows enthusiasm for design. It uses line expressions to create animated shapes from the complex arrangement of individual parts.

From Table 16, it was found that from the above emotional design evaluation form, it can be concluded that in the product prototyping stage, the evaluation criteria and specific project descriptions can be derived respectively:

Evaluation code D: From the emotional experience perspective, To let the experiencer understand the principle and steps of the product portfolio through the structural assembly drawing to meet the physiological needs and safety needs of the user's emotional experience, the product prototype should reflect the practical value of lamps, furniture, shelves, hangers, etc., to meet the needs of the target user to apply the bucket arch, tenon and tenon structure to practical products. Through the expression of appearance and lines, it expresses the cultural and emotional connection of the product and experiences the ancient architectural culture from the complex structure.

Evaluation code A: From the perspective of traditional Chinese cultural elements, the cultural characteristics of mortise and arch structures are investigated through literature, Internet materials and expert interviews.

Evaluation code B: From the perspective of appearance structure, it must include the appearance line characteristics and composite structural characteristics of mortise and arch in traditional Chinese architecture. There are also materials and product structure teardown diagrams used to show structural features.

Evaluation code C: From an economic point of view, it is necessary to consider whether it can be put into production and serve as a production guide, and to reflect the design idea that parts can be shared with other products, shows sustainability, and do not affect the ecosystem.

In conclusion, researchers have developed evaluation standards for creative product design of tenon and tenon and arch structure furniture, and data from user research, user demand for products, and product emotional experience activities demonstrate that the emotional design method of traditional Chinese cultural creative products is the most critical content in the new eval standards. It is also utilized as a fundamental design theory foundation throughout the design experiment stage, allowing the complete article research to be innovative and groundbreaking compared to earlier research findings.

4.2 Design experimental results

According to the previous user demand survey of China traditional cultural and creative products, it is concluded that it guides the first-stage design research from the perspectives of emotional design, user demand for practical and functional products. Researchers divide the design into different product parts according to the needs of users. There was a period of furniture and various items in the early stage as follows:

4.2.1 Design results of the first stage

From the above topics, 12 early design guidelines can be created.

4.2.1.1 Square table with bucket arch structure

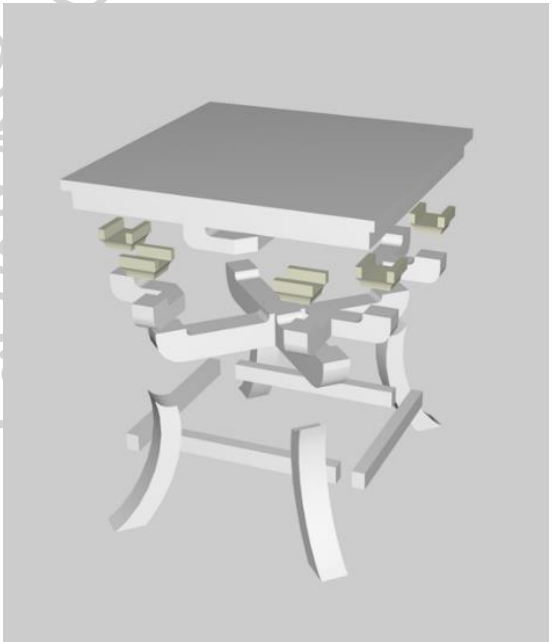
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture. B: The product reflects the design elements of the bucket arch structure. The material plan is wood. Make modular components and paint the surface. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 83 Square table with bucket arch structure

Source: Designed by Guangzhou Li (2021).

4.2.1.2 Bucket arch structure small table lamp

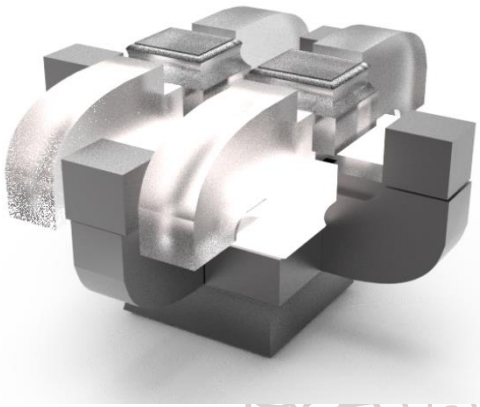
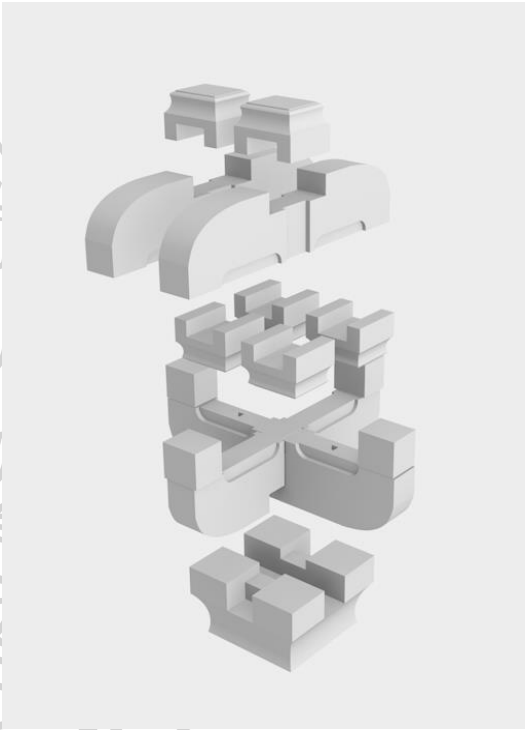
<table>
<tr><td>Complete prototype rendering of the product</td><td>Product decomposition diagram</td></tr>
<tr><td>  </td><td rowspan="3">  </td></tr>
<tr><td>Design guideline</td></tr>
<tr><td>A: Bucket arch elements are used to reflect the connotation of traditional culture
B: The lamps are mainly composed of bucket arch structure elements, which can be used as bedside night lights. The material is transparent resin, which can make the light refract out without appearing dazzling.
C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation
D: It has a specific economic value, and the components can be reused with a sustainable design concept.</td></tr>
</table>

Figure 84 Prototype design of resin desk lamp with Bucket arch structure.

Source: Designed by Guangzhou Li (2021).

4.2.1.3 Product design of Bucket arch incense burner (version 1.0)

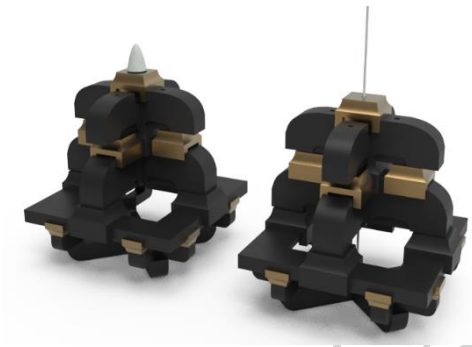
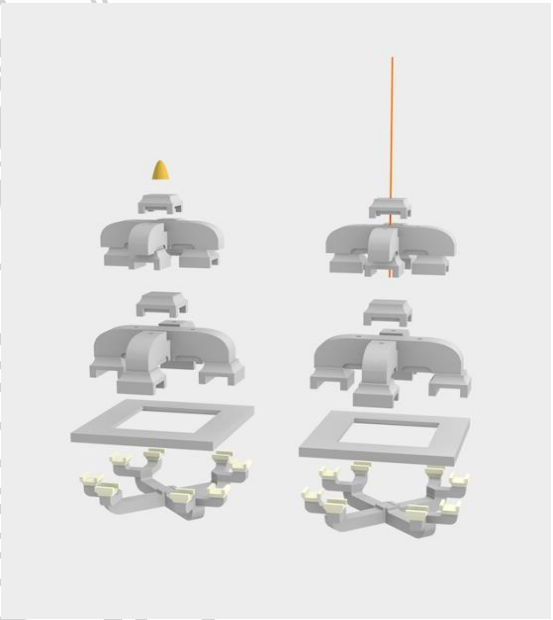
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture B: The se burner is mainly composed of arch structure elements. From the perspective of modeling, it combines the appearance of the pagoda, which is determined by the use scene of the incense burner and the emotional needs of consumers related to Buddhism. The gold part is made of metal from the material, which is in sharp contrast to the black PLA material. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 85 The design prototype of Bucket arch incense burner

Source: Designed by Guangzhou Li (2021).

4.2.1.4 Bucket arch incense burner (version 2.0)

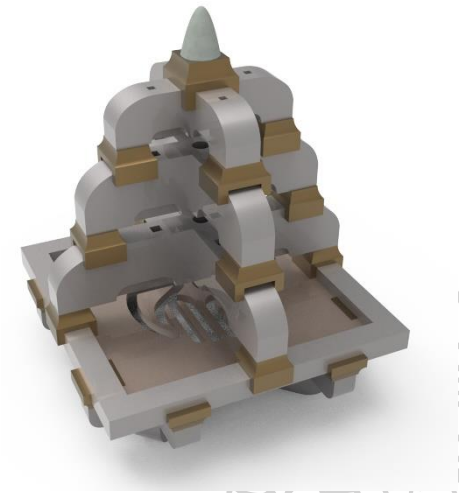
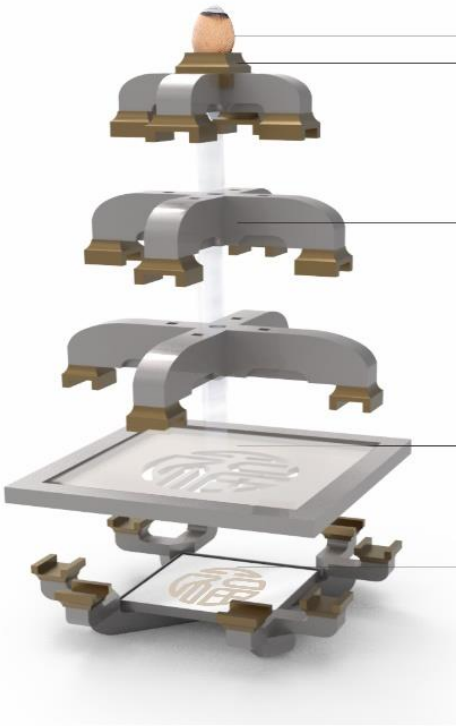
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture B: The incense burner is mainly composed of bucket arch structural elements. From the functional point of view, the incense smoke can return along the central air hole and stay to the incense plate. Through the hollow plate of the tray, a light color pattern can be formed on the sticky paper below the tray. Compared with the previous generation of products, the number of layers is increased and the expression of bucket arch structure is enhanced. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 86 Design prototype of Bucket arch incense burner (version 2.0).

Source: Designed by Guangzhou Li (2021)

4.2.1.5 Bucket arch structure outdoor rocking chair

Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture B: The courtyard chair is mainly composed of the arch structural elements, which is supported by the stability of mortise and tenon and brackets structures to ensure a good product experience. From the appearance and modeling, highlight the internal design idea of mortise and tenon and bucket arch structure, with clear characteristics. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 87 Bucket arch structure outdoor rocking chair

Source: Designed by Guangzhou Li (2021)

4.2.1.6 Bucket arch structural elements combination stool

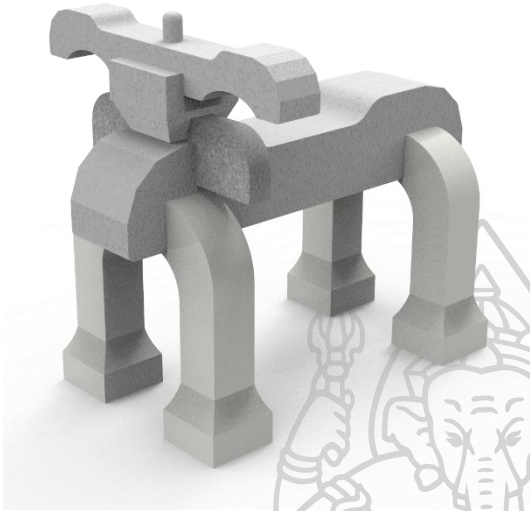
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture B From the use of the low bench, the use of mortise and tenon, bucket arch structure stability support, can be disassembled and combined at will, to ensure a good product experience.From the appearance and modeling, the use of tenon and brackets structure external form, C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 88 Bucket arch structural elements combination stool

Source: Designed by Guangzhou Li (2021).

4.2.1.7 Bucket arch element shelf product design

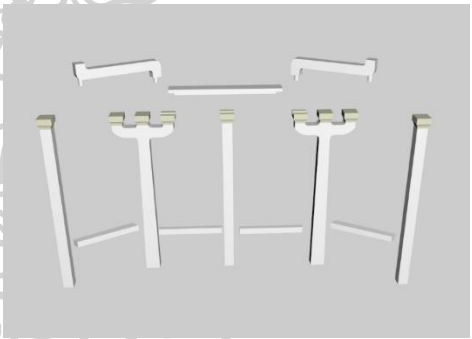
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture B From the use of the object frame, the use of mortise and tenon, bucket arch structure stability support, the direction can be adjusted at will, or the width of the structure can be increased, to ensure a good product experience. From the appearance and modeling, highlighting the use of design ideas in the internal structure of tenon, brackets structure, clear features. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 89 The prototype of Bucket arch element shelf

Source: Designed by Guangzhou Li (2021).

4.2.1.8 Bucket arch structure shelf

Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture B From the use of the flower rack, the use of mortise and tenon, bucket arch structure stability support, to ensure a good product experience. From the appearance and shape, the curve is applied to the design of the object frame, highlighting the mortise and tenon and bucket arch structure, with clear features. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 90 Bucket arch structure shelf

Source: Designed by Guangzhou Li (2021).

4.2.1.9 Bucket arch element low stool

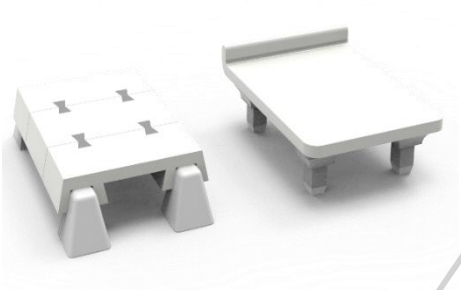
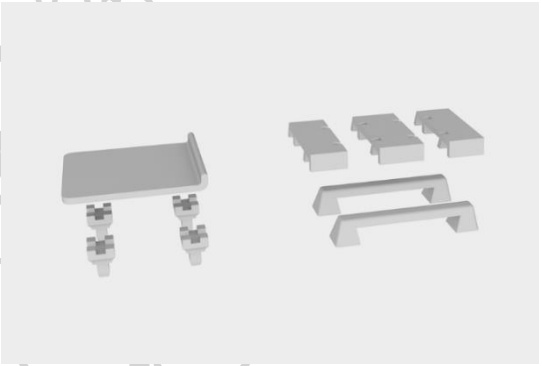
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture B From the use of the low stool, the use of mortise and tenon, bucket arch structure stability support, can be combined at will, according to the demand for the combination, increase the width, to ensure a good product experience. From the appearance and modeling, highlighting the use of design ideas in the internal structure of mortise and tenon, clear features. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 91 Prototype of low stoo

Source: Designed by Guangzhou Li (2021)

4.2.1.10 Bucket arch element coat rack

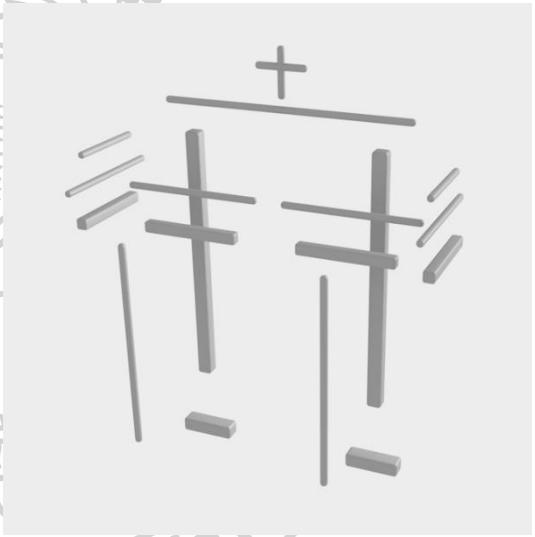
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A: Bucket arch elements are used to reflect the connotation of traditional culture. B From the use of the coat hanger, with the stability support of mortise and tenon and bucket arch structure, the combination mode can be changed at will to ensure a good product experience. From the appearance and modeling, the wood structure frame structure, mortise and tenon, bucket arch structure form are abstractively expressed to meet the needs of simple and modern style. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation. D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 92 Bucket arch outdoor rocking chair prototype

Source: Designed by Guangzhou Li (2021).

4.2.1.11 Mortise and bucket arch structure interior lamp design 1

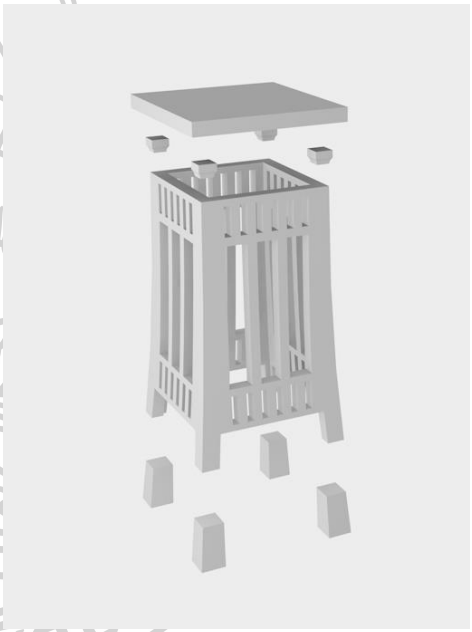
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A:Bucket arch elements are used to reflect the connotation of traditional culture. B: The design of the garden light incorporates the features of a bucket arch and a mortise and tenon framework, and it reflects the structural aspects through shape. It exemplifies the formal elegance of Chinese design. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation. D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 93 Bucket arch coat rack prototype.

Source: Designed by Guangzhou Li (2021).

4.2.1.12 Mortise and bucket arch structure interior lamp design 2

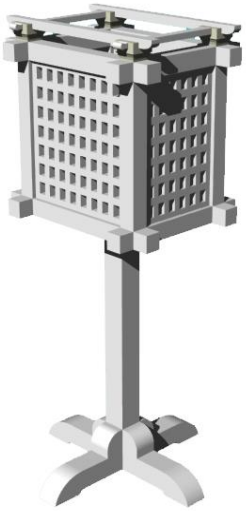
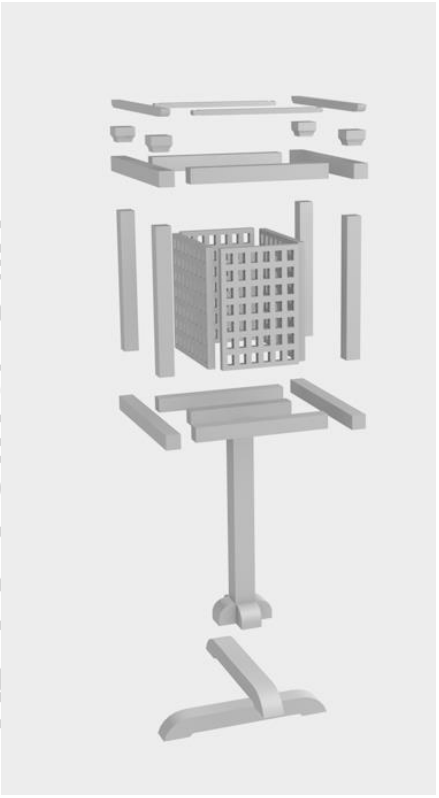
Complete prototype rendering of the product	Product decomposition diagram
	
Design guideline	
A:Bucket arch elements are used to reflect the connotation of traditional culture. B: The design of the garden light incorporates the features of a bucket arch and a mortise and tenon framework, and it reflects the structural aspects through shape. It exemplifies the formal elegance of Chinese design. C: In the process of combining products, consumers can fully feel the connection of mortise and tenon and bucket arch structure. Products can cause social topics and improve consumers' social evaluation. D: It has a specific economic value, and the components can be reused with a sustainable design concept.	

Figure 94 Chair and low stool,

Source: Designed by Guangzhou Li (2021).

4.2.1.13 Summary of the Phase 1 product prototyping evaluation

Seven paper experts analyze the results of product selectivity through an online conference platform; according to the letters and visits of experts, the results are as follows:

(1)Reflection from the perspective of users' needs

According to the survey of users' feedback, it is necessary to thoroughly analyze users' needs and apply them to design research combined with deep emotional needs.

It defines the design and research of furniture products, and has a wider range of user groups and product consumption needs.

Based on furniture products, which are the carrier of a wide range of consumers, this paper designs and studies three style factors (classic style, minimalist style, modern style), material factors, product factors and consumer emotional demand factors in combination with the traditional architecture of China.

In the report, some experts pointed out that products can be based on consumers' evaluation, but not entirely on the point of view of consumption. It is also necessary to pursue the aesthetic feeling of formal design, which is to return to the use of emotional design methods for in-depth research.

The expert committee and tutor guide the direction, hoping to carry out research on the design of creative products with Mortise and Tenon and Bucket arch structures from the carrier of furniture, which is a cultural creative product with certain emotional commemorative significance, and carry out design thinking and design practice from the emotional design angles of feeling, touch and vision.

(2) Reflection on product design

Product design is not a system, but defines product categories according to factors such as site demand, materials, style and culture.

Starting from the category of lamps in furniture design, based on the previous design practice of small desktop lamps with Mortise and Tenon and Bucket arch structure, this paper thinks about the practical products that can be used in consumers' lives. At the same time, it needs to be further studied from the structural elements of ancient architecture Mortise and Tenon, Bucket arch,

consumers' emotional needs and investigation practice.

(3) The next stage of design experiment is carried out

The evaluation of 12 innovative products for the inspirational design of mortise and arch structures in the first phase of investigation by seven experts was investigated, and a product series was selected to enter the second stage of optimization design. The expert evaluation results were as follows:

Table 17 Summary of evaluation results for 12 products in the first phase

Product serial number	Unqualified（-1）	Generally（0）	Qualified（1）
Product 1	0	5	2
Product 2	0	6	1
Product 3	0	5	2
Product 4	1	4	2
Product 5	0	4	3
Product 6	0	5	2
Product 7	0	5	2
Product 8	0	5	2
Product 9	2	4	1
Product 10	0	6	1
Product 11	0	2	5
Product 12	0	1	6

From Table 17, The information in the table above revealed that the scores for products 11 and 12 are pretty high. We will thus continue to optimize the emotive product design direction of the mortise and tenon bucket arch structure garden lights in the second stage and conduct more research.

4.2.2 Design results of the second stage

After getting information from experts, you can get information from them. The researchers put forward a conclusion, namely:

(1)Professor Pu Anguo, a famous furniture scholar in Ming and Qing Dynasties, said that it is necessary to study deeply the rules of Chinese furniture shape modeling, structural innovation, mass production demand, material selection, wood color, texture, smell, origin and so on. According to the thinking and orientation of modern furniture product design, the emotional innovative design of courtyard lamps with architectural roof elements is applied.

(2) Professor Mo Junhua, the tutor of master students, said that through the product, the typical materials and concepts of China traditional architectural culture were excavated, explored and selected, which made the product highlight the cultural connotation of ancient buildings. In the process of design practice, it is necessary to strengthen strong emotional factors and practical consumption of innovative products, which can not only be considered from the product form.

(3) Dr. Feng Xianwei said, "If you want to have in-depth communication with wood processing plants and furniture manufacturing plants, you must go to the factories to understand the technological process, so as to better integrate and innovate. To prepare for the next stage, the design of Mortise and Tenon and Bucket arch structural lamps needs to be deeply explored, and the related research work of consumer evaluation and product exhibition should be completed.

(4)It will be clearer through the following three methods.

4.2.2.1 Courtyard Lighting (with Roof Element) No.1 Product Design

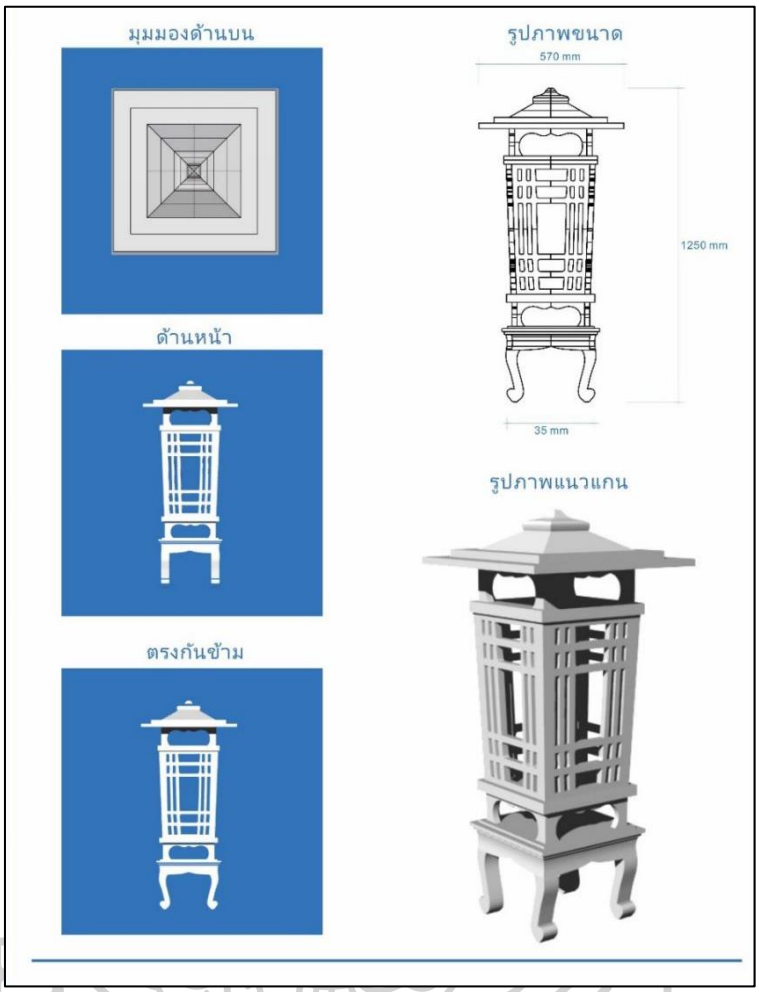


Figure 95 Prototype 1 of courtyard lamps (with roof elements)

Source: Designed by Guangzhou Li (2022)

Design criteria:

A: The product prototype incorporates mortise and tenon bucket arch elements, reflecting traditional cultural connotations.

B: The combination of appearance and architectural style has a certain aesthetic feeling.

C: In terms of behavior, the mortise and tenon structure combines practicality. Emotional reflection has a cultural connection with ancient Chinese architectural culture.

D: It has a specific economic value, the parts can be reused, and it has a sustainable design concept.

4.2.2.2 Courtyard Lighting (with Roof Element) No.2 Product Design

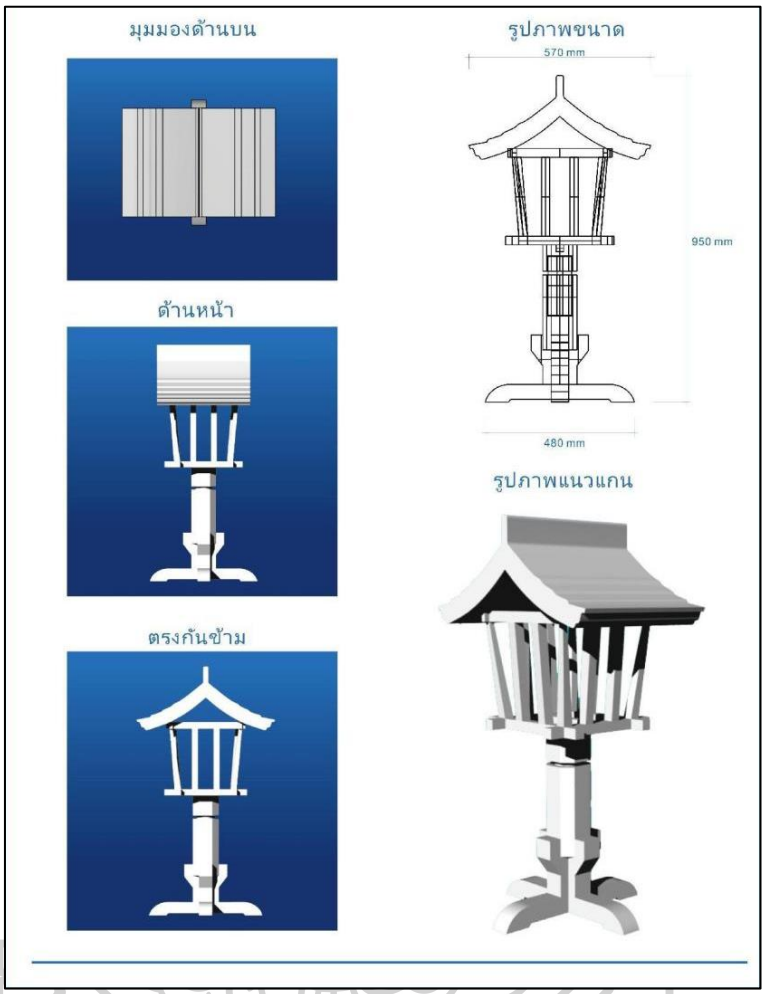


Figure 96 Courtyard lighting (with roof elements) prototype 2

Source: Designed by Guangzhou Li (2022).

Design criteria:

A: The product prototype incorporates mortise and tenon bucket arch elements, reflecting traditional cultural connotations.

B: The combination of appearance and architectural style has a certain aesthetic feeling.

C: In terms of behavior, the mortise and tenon structure combines practicality. Emotional reflection has a cultural connection with ancient Chinese architectural culture.

D: It has a specific economic value, the parts can be reused, and it has a sustainable design concept.

4.2.2.3 Courtyard Lamps (with Roof Elements) No.3 Product Design

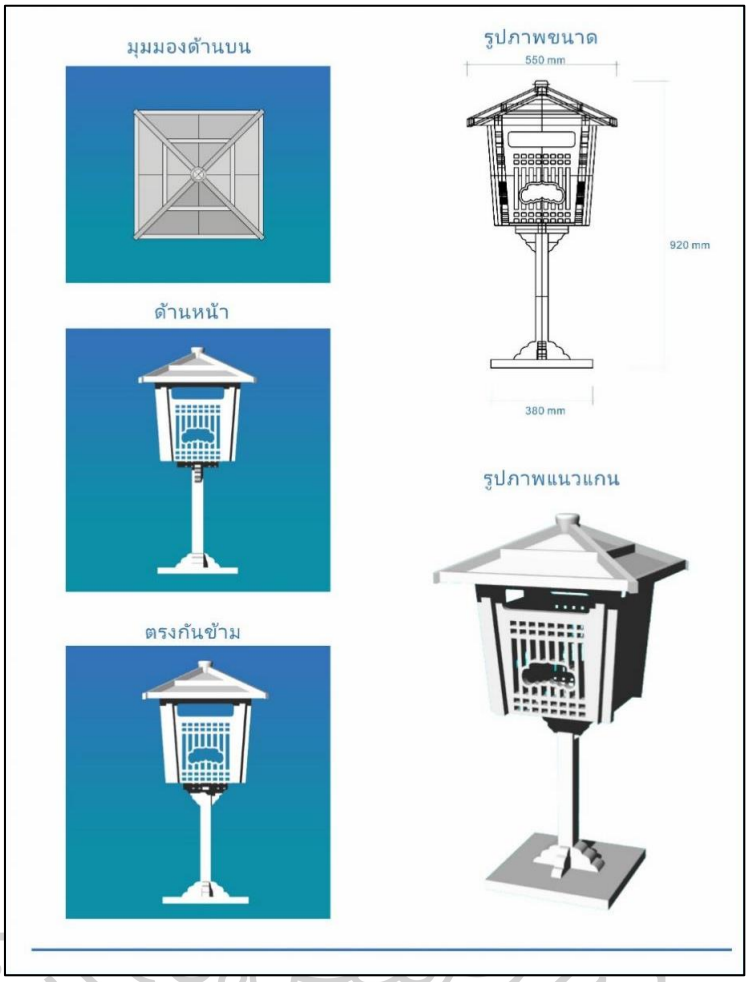


Figure 97 Prototype 3 of courtyard lamps (with roof elements)

Source: Designed by Guangzhou Li (2022)

Design criteria:

A: The product prototype incorporates mortise and tenon bucket arch elements, reflecting traditional cultural connotations.

B: The combination of appearance and architectural style has a certain aesthetic feeling.

C: In terms of behavior, the mortise and tenon structure combines practicality. Emotional reflection has a cultural connection with ancient Chinese architectural culture.

D: It has a specific economic value, the parts can be reused, and it has a sustainable design concept.

The analysis and design results of the prototype design pictures of the above products by seven experts show that:

Table 18 Summary of evaluation results of three garden lighting products

Product serial number	**Unqualified** （-1）	**Generally** （0）	**Qualified** （1）
Garden Lighting Products 1	1	4	2
Garden Lighting Products 2	**0**	**1**	**6**
Garden Lighting Products 3	1	5	1

From Table 18, it was found that from the above expert evaluation data and interview conclusions, it is shown that:

(1) Visually, there is the structure of the roof of an ancient building, and the design of the lampshade is too simple, which does not conform to the aesthetics of China culture. It is necessary to add some structures to fully reflect the ingenious connection of Mortise and Tenon and Bucket arch structures.

(2) Pattern is not the most important thing in outdoor lighting design for courtyard scenes, and structural design needs to be paid attention to.

(3) Finally, product No.2 with roof style is selected as the deepening product, as shown in Figure 97, which is selected by the red box. The combination styles are diverse to meet different needs. Based on this, combined with the advice of experts, we should pay attention to the practicality of the design.

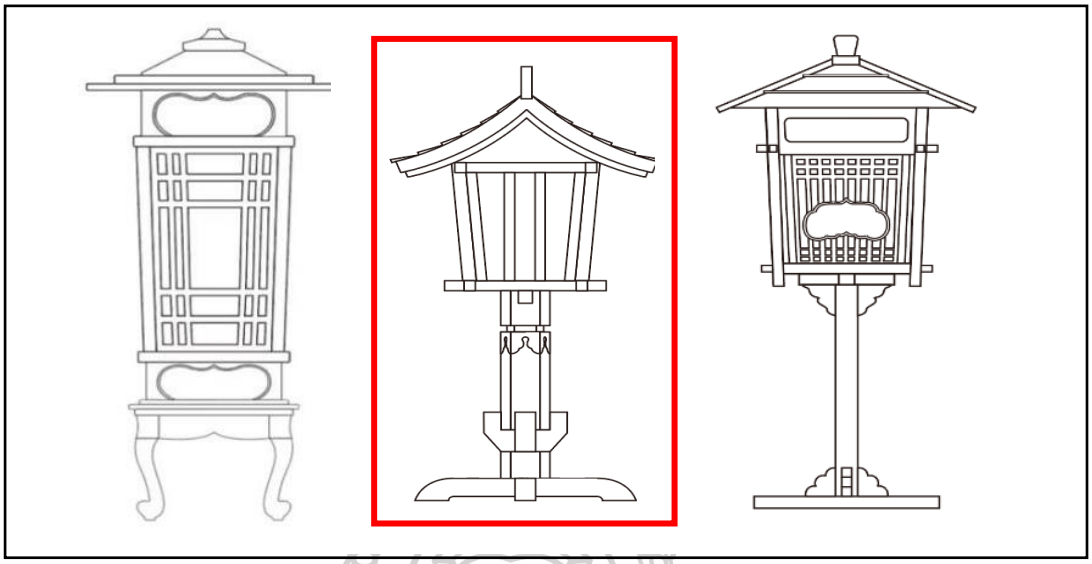


Figure 98 Sketch of traditional building structure element courtyard lamp

Source: Designed by Guangzhou Li (2022).

4.2.3 Prototype development process

After summarizing and describing the experts, the final product is designed in depth, and the specific process is as follows:

Figure 99 3D prototype design of the final courtyard lighting design

Source: Designed by Guangzhou Li (2022).

4.2.3.1 Three views of Mortise and Tenon, Bucket arch structural patio luminaire products

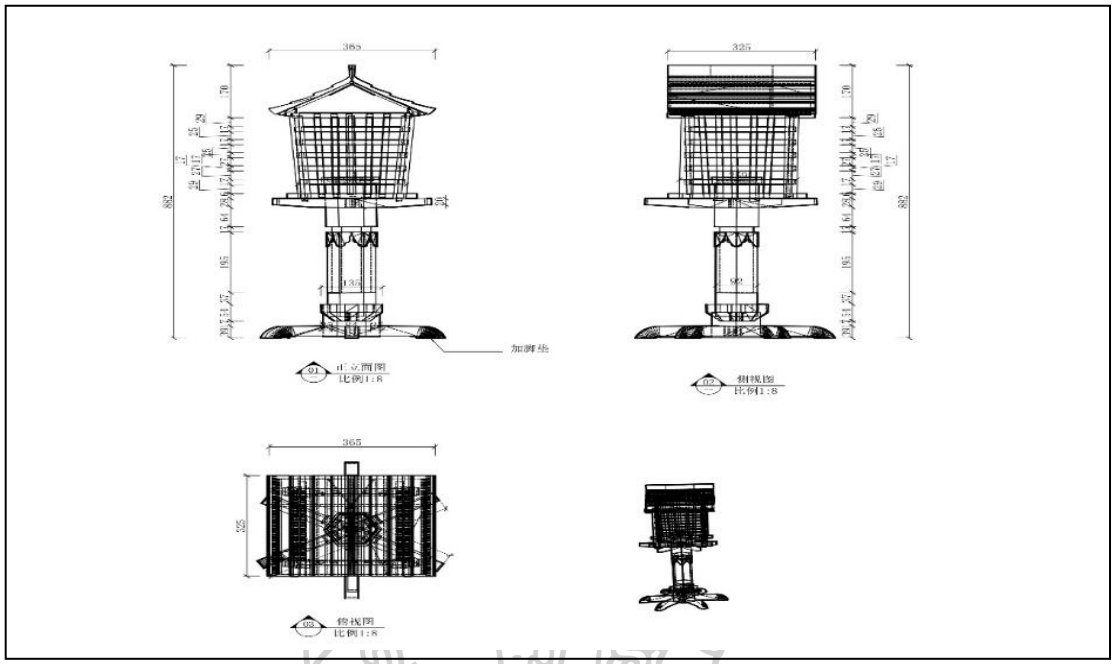


Figure 100 Three views of courtyard lighting products

Source: Designed by Guangzhou Li (2022)

4.2.3.2 Mortise and Tenon, Bucket arch structure courtyard lamps product structure decomposition diagram

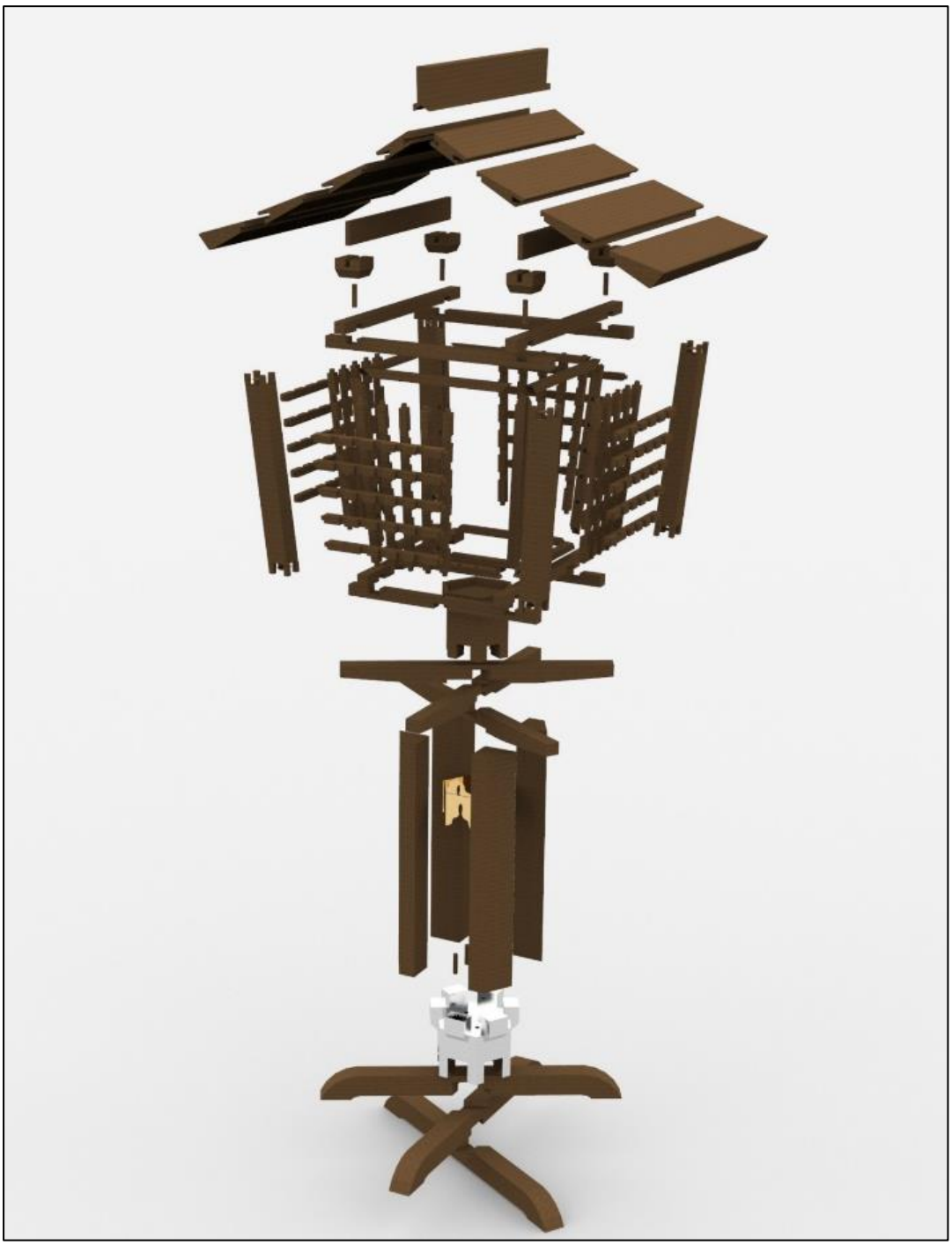


Figure 101 Explosion diagram of courtyard lighting product structure

Source: Designed by Guangzhou Li (2022)

4.2.3.3 Overall perspective view of courtyard lamps with mortise and tenon and Bucket arch structures

Figure 102 Renderings of courtyard lamps

Source: Designed by Guangzhou Li (2022)

4.2.3.4 Structural dimension drawing of Mortise and Tenon and Bucket arch structural courtyard lamps

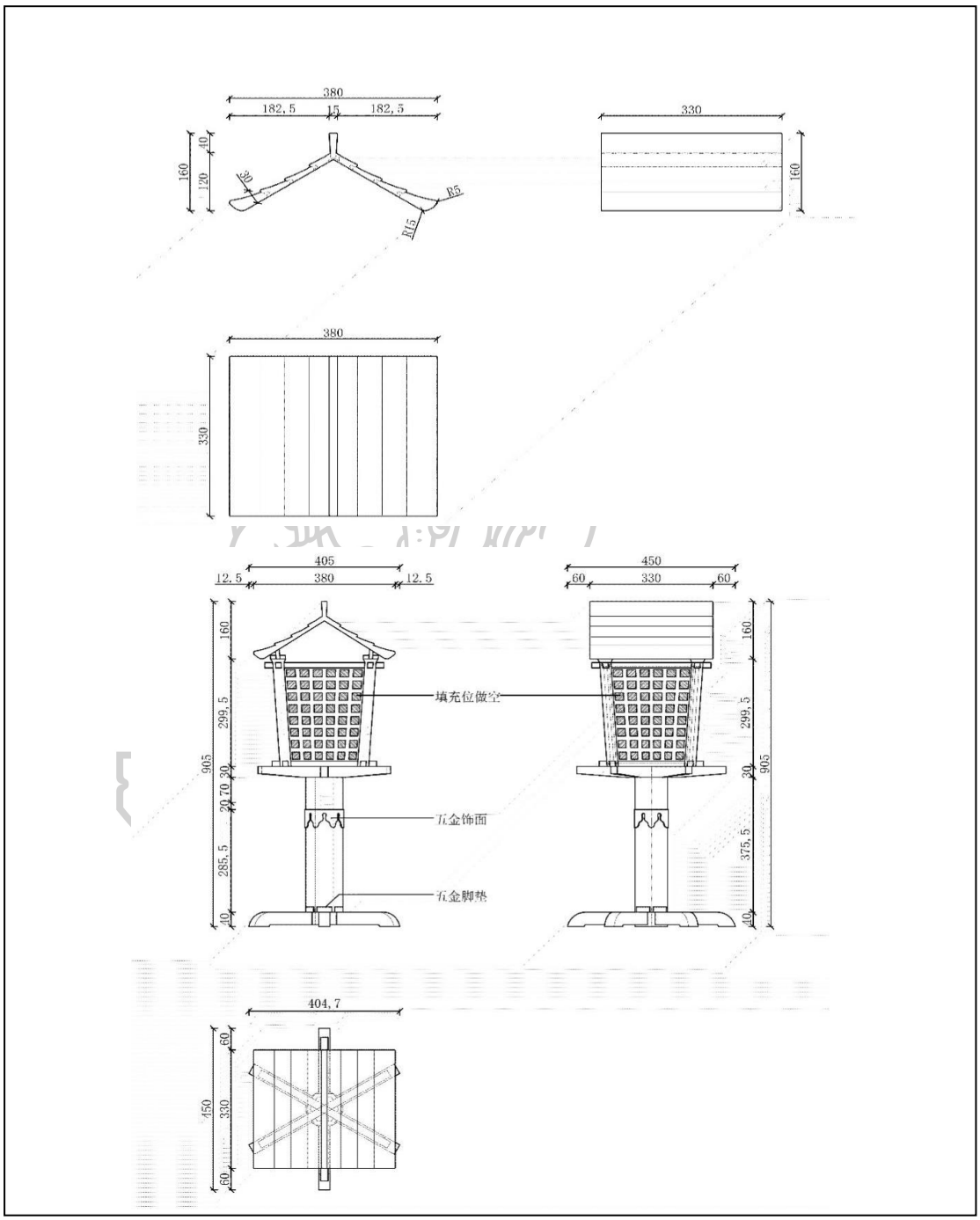


Figure 103 The structural dimension diagram of the courtyard lamp product

Source: Designed by Guangzhou Li (2022)

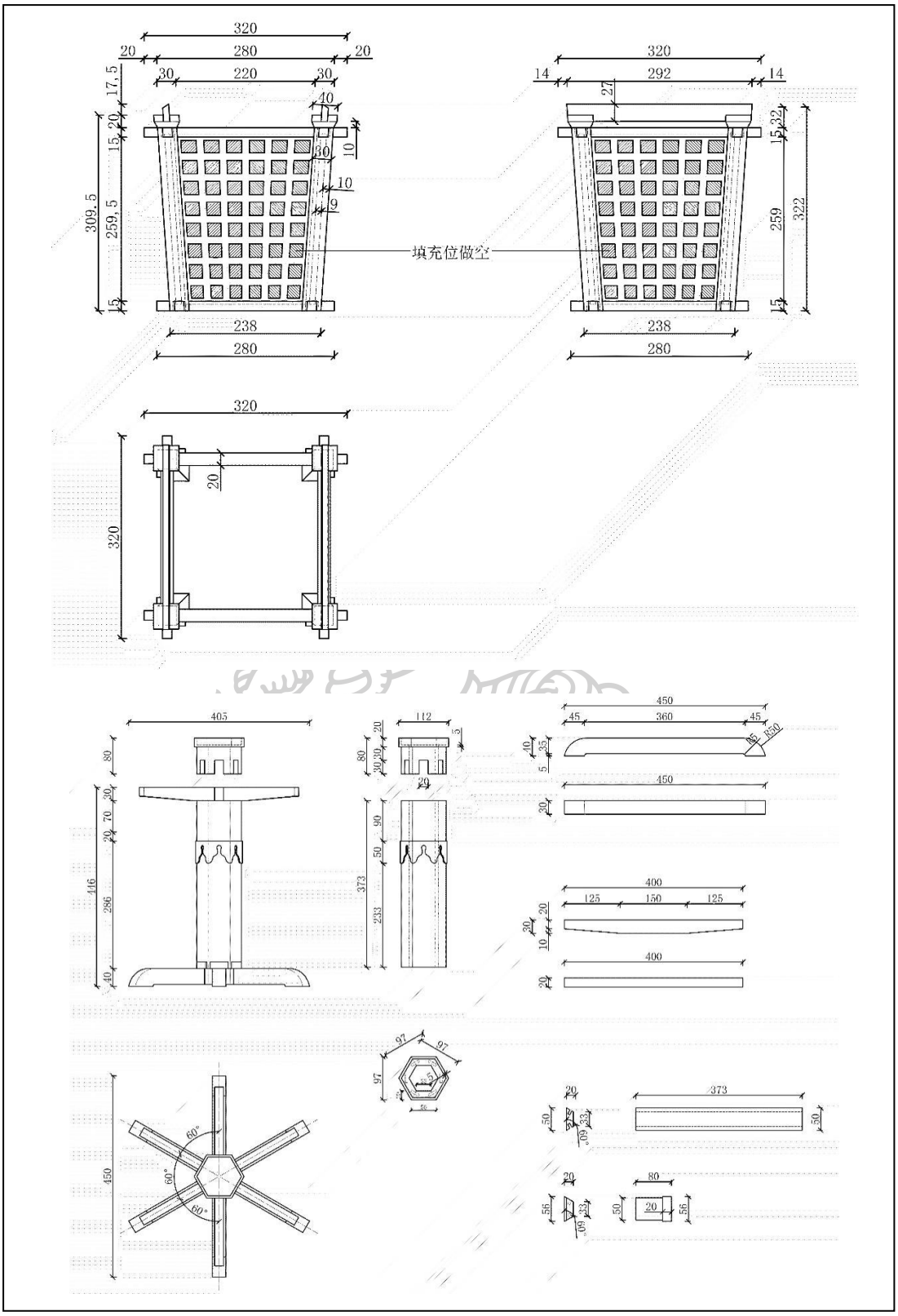


Figure 104 The structural dimension diagram of the courtyard lamp product

Source: Designed by Guangzhou Li (2022)

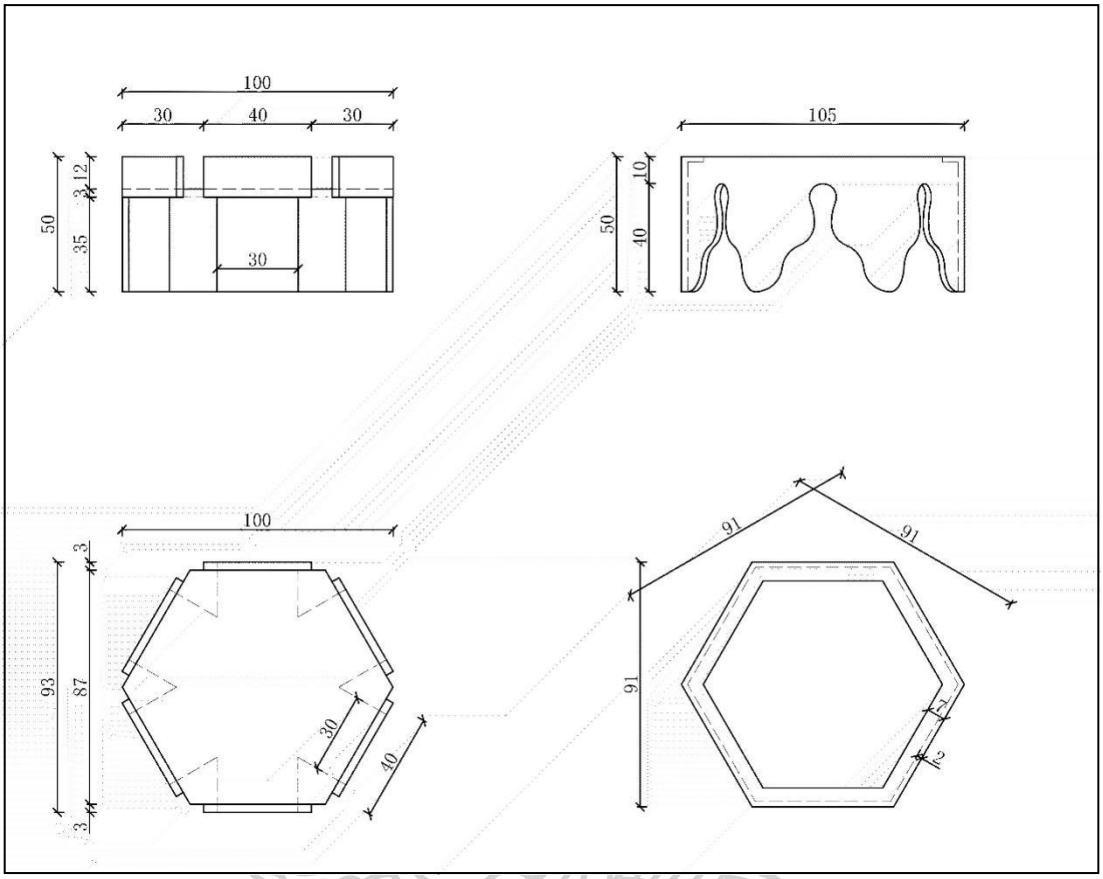


Figure 105 The structural dimension diagram of the courtyard lamp product

Source: Designed by Guangzhou Li in (2022)

Summary of product design of Mortise and Tenon and Bucket arch structural courtyard lamps:

(1) At this stage, we should pay attention to the connotation of product design. The Mortise, Tenon and Bucket arch structures of traditional Chinese architecture show a simple modern beauty. The dismantling of the Mortise and Tenon and Bucket arch structure fully reflects the design concept and the summary of the study of literature related to Mortise and Tenon and Bucket arch structure.

(2) The product reflects the concise and connotative design advocated by China, and uses sophisticated internal structure to support the minimalist external shape, so that users can have the best experience.

(3) The product also needs to carry out consumer satisfaction survey and work exhibition.

4.3 Product prototype design exhibition and target consumer satisfaction research results

In the final step the researcher has brought it to the exhibition as well as collected satisfaction results from interested target groups of consumers. The results can be classified as follows.

4.3.1 Product model exhibition situation and results

From January 10th to 15th, 2023, the product exhibition was held in Suzhou, Jiangsu Province, China. The theme of the exhibition is "Making the Past Serve the Present: Exhibition of Design Achievements of Traditional Cultural Creative Products". It conducted a questionnaire survey on 223 effective users' satisfaction with courtyard lamps with Bucket arch, Mortise and Tenon structures.

Figure 106 Consumer Satisfaction Survey Display of Final Works

Source: Photo by Guangzhou Li (2022)

Figure 107 Posters on the exhibition site

Source: Photo by Guangzhou Li (2022)

4.3.2 Summary of user satisfaction survey, evaluation and analysis

In the product satisfaction survey questionnaire of bucket arch tenon structure garden lights, respondents can scan the QR code of the questionnaire with their mobile phones, fill in the questionnaire online, and collect questionnaire data. For details of the questionnaire, see app According to the five-level Likert scale, the impact of five consumers' gender, age, education background, occupation and income level on product instinct level, behavior level, reflection level and marketing satisfaction level is analyzed.

Figure 108 Consumer survey on product satisfaction

Source: Photo by Guangzhou Li (2022)

The results of the user satisfaction survey and evaluation analysis are as follows The general information of all 223 respondents can be classified as follows.

Table 19 Results of the target user information analysis

Apellation	0ption	Frequency	Percentage	Cumulative percentage
Gender	male	138	61.88	61.88
	female	85	38.12	100.00
Age	Age 20 and below	58	26.01	26.01
	20-29 Years old	47	21.08	47.09
	30-40 Years old	63	28.25	75.34
	Age 40 and over	55	24.66	100.00
Educational background	High school degree or below	44	19.73	19.73
	junior college	53	23.77	43.50
	undergraduate course	71	31.84	75.34
	Graduate student or above	55	24.66	100.00
Occupation	Enterprise personnel	38	17.04	17.04
	Career, civil servants and other public officials	31	13.90	30.94
	student	43	19.28	50.22
	liberal professions	50	22.42	72.65
	Retired people	61	27.35	100.00
Monthly income	RMB 3,000 yuan and less	42	18.83	18.83
	RMB 3000-5000 yuan	58	26.01	44.84
	RMB 5,000-10,000 yuan	70	31.39	76.23
	RMB 10,000 yuan and above	53	23.77	100.00
summation		223	100.0	100.0

From Table 19, it was found that it can be seen from the above table: From the perspective of gender distribution, most of the samples are "male", with a total of 138.0, accounting for 61.88%. The additional proportion of the female sample was 38.12%. The proportion of "30-40 years old" is 28.25%. In terms of academic qualifications, the proportion of "undergraduate" is the highest, at 31.84%. In terms of occupation, "retirees" accounted for the highest proportion, 27.35%. From the perspective of monthly

income distribution, most of the samples are "5000-10000 yuan", accounting for 31.39%.

Table 20 Target user satisfaction analysis results

Questionnaire questions	option	frequency	percentage	Cumulative percentage
1. (Instinct level) The lamps use interactive induction light sources	Very dissatisfied	13	5.83	5.83
	Discontent	49	21.97	27.80
	Commonly	35	15.70	43.50
	Satisfaction	37	16.59	60.09
	Very satisfied	89	39.91	100.00
2. (instinctive level) the color collocation is reasonable, the main material is walnut material	Very dissatisfied	9	4.04	4.04
	Discontent	36	16.14	20.18
	Commonly	47	21.08	41.26
	Satisfaction	67	30.04	71.30
	Very satisfied	64	28.70	100.00
3. (instinctive level) using the lotus pattern, decorated with metal material	Very dissatisfied	9	4.04	4.04
	Discontent	35	15.70	19.73
	Commonly	53	23.77	43.50
	Satisfaction	70	31.39	74.89
	Very satisfied	56	25.11	100.00
4. (Behavior level) The product is easy to assemble and use	Very dissatisfied	2	0.90	0.90
	Discontent	56	25.11	26.01
	Commonly	44	19.73	45.74
	Satisfaction	44	19.73	65.47
	Very satisfied	77	34.53	100.00
5. (Behavior level) The product is very practical and can be used in the courtyard design	Very dissatisfied	10	4.48	4.48
	Discontent	34	15.25	19.73
	Commonly	53	23.77	43.50
	Satisfaction	76	34.08	77.58
	Very satisfied	50	22.42	100.00
6. (Behavioral level) The product can be a good social topic	Very dissatisfied	9	4.04	4.04
	Discontent	33	14.80	18.83
	Commonly	57	25.56	44.39
	Satisfaction	78	34.98	79.37
	Very satisfied	46	20.63	100.00
7. (Reflection level) This product can enhance the society's recognition of itself	Very dissatisfied	4	1.79	1.79
	Discontent	54	24.22	26.01
	Commonly	40	17.94	43.95
	Satisfaction	46	20.63	64.57
	Very satisfied	79	35.43	100.00

Table 20 Target user satisfaction analysis results (continued)

8. (Reflection level) The product can help you get out of a negative state and have a certain sense of pleasure	Very dissatisfied	12	5.38	5.38
	Discontent	31	13.90	19.28
	Commonly	51	22.87	42.15
	Satisfaction	72	32.29	74.44
	Very satisfied	57	25.56	100.00
9. (Reflection level) This product can enable you to remember and associate with traditional Chinese culture	Very dissatisfied	11	4.93	4.93
	Discontent	23	10.31	15.25
	Commonly	69	30.94	46.19
	Satisfaction	78	34.98	81.17
	Very satisfied	42	18.83	100.00
10. (Marketing) The market price of this product is 2000 yuan per piece	Very dissatisfied	5	2.24	2.24
	Discontent	65	29.15	31.39
	Commonly	27	12.11	43.50
	Satisfaction	46	20.63	64.13
	Very satisfied	80	35.87	100.00
11. (Marketing) This product structure components can be used as common accessories for second-generation products	Very dissatisfied	8	3.59	3.59
	Discontent	30	13.45	17.04
	Commonly	60	26.91	43.95
	Satisfaction	73	32.74	76.68
	Very satisfied	52	23.32	100.00
summation		223	100.0	100.0

From Table 20, it was found that based on the satisfaction survey data of the prototype design of mortise and gong structure of the above target population, the conclusion is as follows:

(1) Judging from the data of each group, the satisfaction of the tested users is high, and the "satisfaction" index reaches more than 64.13%.

(2) Among them, the emotional design reflection level satisfaction item that reminds you of Chinese traditional culture has reached more than 81.17%, which proves that the research method and product model design process have reached the expected goal and completed the satisfaction test.

(3) In addition, according to the data, it is also found that different genders, ages, educational backgrounds, occupations, and income levels attach different importance to the instinct, behavior, and reflection of emotional products with a tenon-tenon structure. From a marketing and sales standpoint. Some data will provide support for future directions of this research.

CHAPTER 5

SUMMARY OF RESEARCH FINDINGS

DISCUSSION AND SUGGESTIONS

Derived from research on the development of culturally innovative goods based on conventional Chinese architectural wooden dowel joints. The researchers conducted an in-depth study of ancient Chinese architectural structures from three eras and the wonders that have existed for hundreds of years to the present day. To be the starting point for designing new furniture that meets the needs of today's consumers by dividing the objectives of the event into 3 parts as follows review on emotional design of innovative products with mortise and tenon and bucket arch structures.

1) Research on Chinese architectural structural components (mortise and tenon, bucket arch structure), including analysis of user test results of emotional products and creation of design requirements.

2) Design of furniture products for the household goods group. including prototyping.

3) Study the satisfaction results of the target group through the exhibition.

5.1 Summary of research results

In summarizing the research results The researcher divided the work into 3 parts: data study to create design specifications Then design, create a prototype, and bring it back to collect the results from the target group again with the following conclusions.

5.1.1 Research on Chinese architectural structural components (mortise and tenon, bucket arch structure), including analysis of user test results of emotional products and creation of design requirements

"Bucket arch" is a traditional Chinese architectural element widely used in three significant historical periods: the Tang, Song, and Qing Dynasties. The word "bucket arch" translates to "cap-and-block" in English, which refers to a unique system of interlocking wooden brackets used to support the weight of the roof in traditional Chinese architecture.

During the Tang Dynasty (618-907), bucket arch was primarily used in palaces and temples, and it was often decorated with intricate carvings and ornate designs. In the Song Dynasty (960-1279), bucket arch became even more popular, and it was used in a wide range of buildings, from large government buildings to tiny houses. The Song Dynasty is also known for its advancements in bucket arch technology, with engineers developing new techniques for creating more intricate and complex bucket arch structures.

In the Qing Dynasty (1644-1912), bucket arch continued to be a prominent feature of Chinese architecture, although it was often simplified and used more functionally. The Qing Dynasty is also known for its use of bucket arch in constructing imperial palaces, such as the Forbidden City in Beijing.

The following results were summarized from the survey data of emotional experience activities:

The analysis of users' needs for Mortise and Tenon and Bucket arch structural cultural and creative products showed that users prioritize physiological needs (3.85±0.971), security needs (3.71±1.168), and respect needs (3.72±0.833). Self-realization needs received a relatively low score, indicating that the subjects' consent in this area was weak.

According to the findings regarding the emotional design instinct of Mortise and Tenon and Bucket arch structural cultural and creative products, users are most concerned with products that can be interactive (3.660.860), followed by the product's material (3.511.042), and finally its appearance (3.330.960).

According to the survey on the behavior level of product emotional design (3.46 1.163), the product must satisfy the consumers' practical demands as well as their social and recreational needs. In other words, the creative products of mortise and arch structures not only have practical functions, but also can generate social topics (3.42±0.888). Secondly, the focus is on the application of furniture products, large-size furniture, small-size household items, etc (3.36±0.860). on product carriers, such as furniture, lamps, space decorations (3.32±1.205).

Product prototype design focuses on expressing more at the level of emotional design reflection, through the product can allow users to make emotional connection with traditional ancient

architectural culture, reflect to emotional memory (3.57±0.824). Through the ancient building arch, mortise and tenon structure productized expression, let users have cultural memory (3.51±0.824). And allow people who own products to enhance their own cultural taste recognition, as well as social recognition (3.45±0.774).

In conclusion, based on answers from 269 valid data acquired from consumers, the study assessed the emotional design data of cultural and creative items with mortise and tenon structure and bucket arch structure. The study found that the key target group for emotional, creative product design is users aged 36-45 years old, with an income of 5,000-10,000 yuan and a bachelor's degree or above.

Regarding users' needs for Mortise and Tenon and Bucket arch structural cultural and creative products, the study found that users prioritize physiological, security, and respect needs. Self-realization needs to be received a relatively low score, indicating that the subjects' agreement in this area was weak.

The study also revealed that users are most concerned about products that can have interactivity, followed by the product's material, and finally, the product's appearance. Additionally, the study found that the product needs to meet the practical needs of users and social needs, generating social topics and that the focus is on the application of furniture products and small-size household items, among others.

Regarding product prototype design, the study found that emotional design reflection is essential and that the product can allow users to connect emotionally with traditional ancient architectural culture and reflect emotional memory. Through the ancient building arch, mortise and tenon structure productized expression, users can have cultural memory, and people who own products can enhance their cultural taste recognition, as well as social recognition.

The conclusions drawn from expert discussion and data analysis are as follows:

Recruitment of interested groups for experiments through popular science education activities and network promotion was successful, and the feedback analysis showed that the design project was deemed "worthy of attention and cultural heritage value."

To increase the sense of experience, the research should focus on several representative products with the help of product manuals and exploded views.

According to the survey of product user needs, mortise and tenon and bucket arch creative products should have cultural stories and symbolic significance, moving users' emotions and healing the soul. This indicates that the emotional design reflection of the product needs to be higher.

From the perspective of innovative design research, mortise and tenon and arch structure products have traditional cultural elements, but they also need to reflect practical and functional value. Users hope to expand the use of these products to include furniture design to increase practicality, cultural value, and emotional value.

These conclusions are essential for the research stage of product model design as they provide valuable insights into the needs and preferences of potential users, helping designers create products that better meet users' expectations and requirements.

It is concluded that the evaluation criteria for emotional product design with mortise and tenon and bucket arch structures are as follows:

Evaluation code Evaluation item Evaluation standard：

A Cultural connotation 1) Retains the Bucket arch identity, characterized by vertical assembly of mortise and tenon components. The concept is derived from emotional, creative media from Chinese cultural architecture combining science and art. 2) By science, there will be a body of scientific knowledge in engineering regarding the complex load of the load, including balance.

B Appearance aesthetics The design must maintain the characteristics of Bucket Arch's Chinese culture in terms of naturalness (material) and solid and elegant appearance method using straight lines. Blend with curves in the corners. With the use of square corners in the art composition principle.

C Economic aspect There must be value for the investment to obtain an appropriate return. 1) Must produce the design in a small industry system. To be a guideline for creating new entrepreneurs. 2) The design must share parts. To modify designs in the same product type or use in conjunction with other products. 3) The design must demonstrate sustainability. It does not cause any impact on the ecosystem.

D Emotional experience Requirements of products from Chinese culture through the researcher's KANO training 1) Traditional Chinese must be preserved. This work should be the assembly structure of the Bucket arch, including 2) Simplicity of assembly and use. 3) Product prototypes should

be practical in the design of home appliances such as lamps lights, furniture, hangers, storage shelves, etc., in daily life. 4) Expression of enthusiasm = Personality that shows enthusiasm for design. It uses line expressions to create animated shapes from the complex arrangement of individual parts.

5.1.2 Design of furniture products for the household goods group including prototyping

There are 8 steps in the design process mentioned in the provided text：

The first phase of design, series product prototype production (12 models)

Comparison of self-assessment and expert assessment data

Conclusion: The method of the 12th product in the first stage can be in-depth, and the data matching degree is the highest.

The second stage of design, according to the design method obtained from the conclusion of the previous stage, according to this method to design the prototype production of garden lighting products (3 models)

Comparison of self-assessment and expert assessment data

Conclusion: The second product in the first stage has the highest matching degree of comparison data, and is determined to be the product that finally meets the design standards

Design the final product: deepen product renderings, three views, and exploded views for readers' reference

Prototype your product

Regarding expert selection, the text mentions two stages of design. In the first stage, 12 product prototypes were produced, and the data from self-assessment and expert assessment were compared. The conclusion was that the design method used for the 12th product had the highest data matching degree and could be further developed. In the second stage, the design method obtained from the conclusion of the first stage was used to design three prototype products, and their self-assessment and expert assessment data were compared. The conclusion was that the second product from the first stage had the highest matching degree of comparison data and was selected as the product that met the design standards.

In summary, the expert selection process involved comparing self-assessment and expert assessment data for multiple product prototypes in two design stages. As a result, the selected product

was based on the highest matching degree of comparison data, and the design method was further developed in the second stage.

5.1.3 Target user satisfaction survey, analysis and summary

Through the exhibition, the created prototypes will be used to study the satisfaction of interested target consumers. From January 10th to 15th, 2023, the product exhibition will be held in Suzhou, Jiangsu Province, China. The theme of the exhibition is "Using the Past for the Present: Exhibition of Design Achievements of Traditional Cultural and Creative Products".

From the analysis of target user satisfaction survey data, a total of 223 valid data were obtained, and the basic information of users is as follows:

Number of visitors: 223

Age range: 20-50 years old

Gender: 53.36% male, 46.64% female

Occupation: 35.4% are office workers, 26.8% are students, 22.9% are freelancers, and 14.8% are others

Income level: 31.4% have an income of less than 5,000 yuan, 27.8% have an income between 5,000-10,000 yuan, 21.5% have an income between 10,000-20,000 yuan, and 19.3% have an income of more than 20,000 yuan

The following is the important target satisfaction evaluation data, summarized and analyzed as follows:

For the instinctive level questions (Questions 1-3), the highest percentage of respondents (39.91%) were "very satisfied" with the interactive induction light sources used in the lamps (Question 1), while the lowest percentage of respondents (4.04%) were "very dissatisfied" with the lotus pattern and metal material used (Question 3).

For the behavioral level questions (Questions 4-6), the highest percentage of respondents (34.53%) were "very satisfied" with the ease of assembly and use of the product (Question 4), while the lowest percentage of respondents (4.48%) were "very dissatisfied" with the product's practicality in courtyard design (Question 5).

For the reflection level questions (Questions 7-9), the highest percentage of respondents (35.43%) were "very satisfied" with the product's ability to enhance society's recognition of itself (Question 7), while the lowest percentage of respondents (4.93%) were "very dissatisfied" with the product's ability to remember and associate with traditional Chinese culture (Question 9).

For the marketing questions (Questions 10-11), the highest percentage of respondents (35.87%) were "very satisfied" with the market price of the product at 2000 yuan per piece (Question 10), while the lowest percentage of respondents (3.59%) were "very dissatisfied" with the product structure components' ability to be used as common accessories for second-generation products (Question 11).

In summary, the product received generally high satisfaction ratings across all levels, with the highest satisfaction ratings given to the product's ability to enhance society's recognition of itself and the market price of the product. The lowest satisfaction ratings were given to the product's practicality in courtyard design and its ability to remember and associate with traditional Chinese culture.

5.2 Research results discussion

5.2.1 Discussion on the design results of creative garden lamps with tenon and tenon and bucket arch structures

This is a garden lighting product design with mortise and tenon, and bucket arch structural elements. The mortise and tenon structure's wisdom and allure may be appreciated by fusing the product's structure with an emotional link to old architectural tradition. Discuss that there should be issues with using schemas in new designs. The bucket arch is reflected in the product as a decomposition structure. Stylistically, the original composition of ancient buildings has changed in terms of structure, material, identity, needs and production.

The design achievements of creative garden lights with mortise and tenon structure make consumers expect and have high satisfaction in terms of its structural and emotional design elements. Mortise and tenon construction is a traditional Chinese woodworking technique used for centuries in architecture and furniture design. Using this technology in garden light design not only highlights the cultural significance of the technology but also adds aesthetic value to the product.

Additionally, bucket arches, a fundamental component of the mortise and tenon construction, have been included into the design of garden lights to forge an emotional bond between the latter and the former. Bucket arch has been a prominent feature of Chinese architecture since ancient times, and its use in garden light design adds emotional and cultural value to the product.

It is crucial to consider using traditional styles in new designs, as they can present benefits and challenges. On the one hand, integrating elements of ancient architectural culture can create a sense of heritage, tradition, and cultural significance in the design. In addition, it can help create an emotional connection with users. This can add depth and meaning to a product and may help it stand out from other designs on the market. On the other hand, there are several potential problems with using legacy patterns in new designs. One is the risk of creating a sense of inauthenticity or cultural appropriation. Therefore, when using elements from another culture, it is imperative to respect their history and context and avoid misrepresenting or belittling them.

In the case of this courtyard lighting product design, it is worth considering the use of mortise and tenon and bucket arch structural elements as the embodiment of the decomposition structure. While these elements may add cultural significance to a design, it must be ensured that they are used in a way that respects its historical context and meaning. Furthermore, the effect of altering the original composition of ancient architectural styles must also be considered, as this may alter its meaning or significance. In addition, changes in structure, material, identity, demand and production may also affect the cultural significance of the design and should be carefully considered.

A further noteworthy design accomplishment is the dynamic design of outdoor lighting items. Customers' emotional requirements are determined using the KANO model, which is then utilized to develop goods that satisfy those demands. The emotional bond between the customer and the product raises the product's value and improves customer satisfaction.

Finally, using wood structures in garden light design demonstrates the importance of sustainability in the design process. Mortise and tenon structure is a sustainable design technique that has been used for centuries, and its use in garden lighting design adds environmental value to the product.

In summary, while using traditional schemas in new designs can add cultural meaning and emotional depth, it must be approached with emotion and respect for the cultural heritage represented. The design achievements of creative garden lights with mortise and tenon structures are famous for their cultural and emotional design elements. Traditional Chinese woodworking techniques, emotional design and sustainability were used in the design process to make the product aesthetically pleasing and culturally significant.

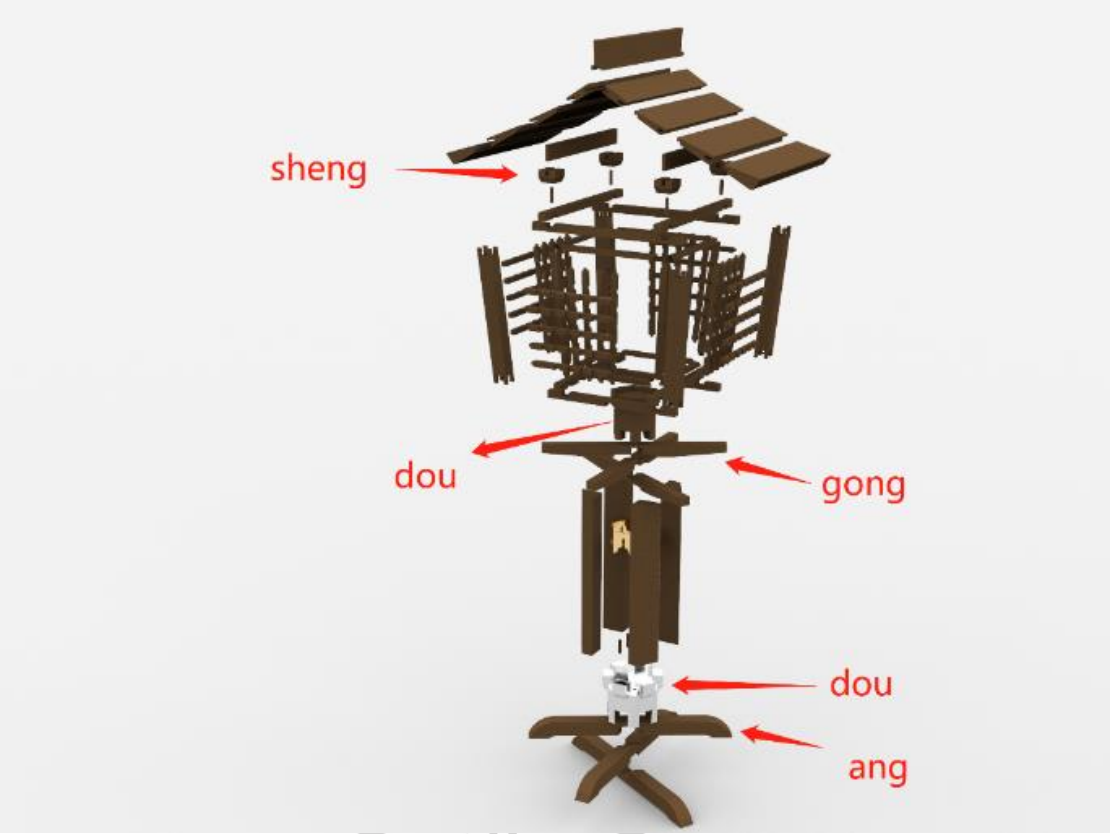


Figure 109 The performance of bucket arch elements in new product design

Designed from Guangzhou Li, 2023

5.2.2 Discusses the significance of using emotional experience principles and standards for developing culturally and creatively inspired products

Important cultural and creative issues for product design include emotional experience methodologies and assessment standards. Emotional design is the deliberate development of goods that cause the user to experience a certain emotion or set of sentiments. When it comes to cultural and creative product design, this might entail giving the design a feeling of tradition, legacy, or cultural relevance.

Emotional experience methods can be used to identify and understand users' emotional

needs and desires. This can involve conducting user research, such as surveys or focus groups, to gain insights into users' emotional associations with specific design elements or cultural artefacts. This information can then inform the design process and create products that resonate with users on an emotional level.

Emotional experience is an essential aspect of product design that considers the emotional connection between a user and a product. It aims to create products that evoke positive emotions and create a lasting impression on the user. This is especially important for cultural and creative product design as these products often have deeper meanings and connections to the user's identity and culture.

One of the critical methods used in emotional design is the KANO model, which categorizes product features into different levels of importance based on their ability to satisfy customer needs. This method helps evaluate emotional design elements in cultural and creative product design as it helps designers prioritize the most important features and create products that are highly desirable to users.

Evaluation criteria are also critical in cultural and creative product design, as they can help ensure that products are culturally appropriate and effective in achieving their intended emotional impact. Evaluation criteria can include cultural authenticity, sensitivity to historical context, and effectiveness in eliciting specific emotional responses. These criteria can be used to assess a design's success and guide future design decisions.

Evaluation criteria for cultural and creative product design include cultural connotation, appearance aesthetics, economic aspects, and emotional design. For example, a product design incorporating traditional Chinese cultural elements like the Mortise and Tenon and Bucket arch structure should retain the identity of these elements while incorporating them visually appealing and elegantly. The design should also be sustainable and economically viable while incorporating emotional design elements that evoke positive emotions and create a connection with the user.

Emotional experience methods and evaluation criteria are essential for creating culturally and creatively significant products that meet the user's functional needs and create a meaningful emotional connection. By considering these elements in the design process, designers can create products that are aesthetically pleasing and functional and have a profound and lasting impact on the user's

emotional well-being.

In summary, emotional design methods and evaluation criteria are essential considerations in cultural and creative product design, as they can help ensure that products effectively create an emotional connection with users and convey cultural significance. By incorporating these considerations into the design process, designers can create culturally appropriate and emotionally impactful products.

5.2.3 Discussion on the application of cultural elements to furniture design

Applying cultural elements to furniture design can add depth and meaning to the design and help create an emotional connection with users. By incorporating cultural elements into designs, designers can create furniture that reflects a particular cultural heritage, tradition or aesthetic.

Cultural elements can take many forms, including patterns, patterns, colours, materials and forms.

When incorporating cultural elements into furniture design, it is important to do it in a way that respects and respects the cultural heritage represented. This may involve conducting research on the cultural significance of particular design elements and ensuring they are used in authentic and appropriate ways.

In addition, designers should also consider the target audience of the furniture and the environment in which it will be used. For example, a designer creating furniture for a restaurant might incorporate cultural elements that reflect the restaurant's cuisine or cultural heritage.

Applying cultural elements to furniture design can add cultural meaning and emotional depth to the design. However, it is important to approach this in a way that is sensitive and respectful of the cultural heritage represented, taking into account the target audience and context in which the furniture will be used.According to the previous literature research on the integration of culture or Chinese style into furniture design, the creative ideas of furniture generated by combining traditional culture, historical relics and Chinese style are discussed and analyzed here. The focus is on the mastery and understanding of culture and style, the combination of innovative furniture absorbing Western furniture characteristics and Chinese style, or deconstructing and reorganizing the unique symbols of ancient Chinese furniture, retaining some traditional cultural visualization elements, handicraft elements, traditional colors, etc., or adapting to relatively low-priced products produced by contemporary

industrialization. These products are focused on cultural and modern products, modern consumer needs, cultural needs, etc. Not only considering whether it has Chinese traditional culture, but ultimately designing furniture in line with "Chinese style" for the purpose, integrating Chinese and Western cultural backgrounds and philosophies, and constantly seeking products for modern life. In the context of cultural competition and value competition in today's world, the challenges facing China's cultural export require many designers to constantly challenge and conduct in-depth research. It is now difficult to define "Chinese-style" furniture.

The researchers developed a new design method—the application of emotional experience techniques for the creation of traditional Chinese cultural creative products—during the process of creating prototypes, researching customer satisfaction, and designing and manufacturing those prototypes. Emotional experience is a method of comprehensively evaluating the emotional needs, cultural elements, economic aspect, and appearance aesthetics of the target consumers. Through a series of methodological studies, the Product name "Chinese Chair" Designed by Wan Wei (2022) and "Heyi," Design: Zuo Siyang by (2022), each incorporating elements of traditional furniture culture. Further studies on the integration of cultural elements into product design, consistent with "The Beard Stool" Design by Wan Wei (2022) and "Unlocked," Designed by Yuan Yuan (2019), incorporate ancient bronze and tenon and tenon structures into product design, as well as carefully consider the use of modern material injection moulding to industrial production to lower product production costs. To develop products, this is the concept of experimenting with cultural and creative goods made of new materials. Things may be utilized to demonstrate how to use emotional design principles to culturally and creatively design things and how producers and customers can embrace products.

In summary, the innovative design of cultural and creative products using emotional design methods should not only resist the outdated concepts in traditional furniture, but also integrate the positive factors of classic Chinese elements such as foreign furniture and economic factors to comprehensively evaluate product design and manufacturing. Culture is integrated into furniture creative product design to meet the needs of contemporary consumer behavior, aesthetics and emotional reflection, and also inherits traditional cultural genes.

5.3 Research Suggestions

5.3.1 Detailed study should be done on the cultural relevance of traditional Chinese design components like bucket arches and mortise and tenon joints. This can entail reading historical documents, touring cultural landmarks, and speaking with subject-matter authorities.

5.3.2 Use Emotional experience methods, such as user research and evaluation criteria, to identify and understand the emotional needs and desires of users. This can involve conducting surveys or focus groups to gain insights into the emotional associations users have with traditional Chinese design elements.

5.3.3 Explore new ways of incorporating traditional Chinese design elements into modern product design. This can involve experimenting with new materials, forms, and color palettes, while still staying true to the cultural significance of the design elements.

Let us delve deep into the past, and uncover the hidden gems that lie within. Only then can we create designs that truly resonate with the emotions of our users. Let us not be discouraged by the challenges that arise. Instead, let us use them as opportunities to learn and grow, and to create even more meaningful and emotionally impactful designs.

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APPENDIX

APPENDIX

Official documents

No. 8606/ ๙๙๙

Graduate School
Silpakorn University
Boromarachachonnani Road,
Taling Chan, Bangkok 10170

15 June , 2022

Subject: Invitation to be an inspector of research tool quality

Dear Associate Professor Feng Xianwei, PhD.

Mr. Guangzhou LI is a graduate student ID 620430052 at Silpakorn University and is studying for Doctor of Philosophy (Design) at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled: Emotional Design of Traditional Chinese Cultural Creative Products Based on User Needs. 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.

Sathit Niratisai

(Asst. Prof. Sathit Niratisai, Ph.D.)
Associate Dean for Administration Acting for
Dean of Graduate School, Silpakorn University

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ปณิธานบัณฑิตวิทยาลัย *"มุ่งส่งเสริม สนับสนุน เพื่อพัฒนาคุณภาพบัณฑิตศึกษา"*

Invitation letter for interior design experts

No. 8606/ 992

Graduate School
Silpakorn University
Boromarachachonnani Road,
Taling Chan, Bangkok 10170

15 June , 2022

Subject: Invitation to be an inspector of research tool quality

Dear Associate Professor Meng Lin, Ph.D.

Mr. Guangzhou LI is a graduate student ID 620430052 at Silpakorn University and is studying for Doctor of Philosophy (Design) at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled: Emotional Design of Traditional Chinese Cultural Creative Products Based on User Needs. 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.

Sathit Niratisai

(Asst. Prof. Sathit Niratisai, Ph.D.)
Associate Dean for Administration Acting for
Dean of Graduate School, Silpakorn University

Meng Lin

The Secretariat of Graduate School, Silpakorn University (Taling Chan)
Tel: 0-2849-7502
Fax: 0-2849-7503

ปณิธานบัณฑิตวิทยาลัย *"มุ่งส่งเสริม สนับสนุน เพื่อพัฒนาคุณภาพบัณฑิตศึกษา"*

Invitation letter for environmental art design experts

No. 8606/ ๑๑๘

Graduate School
Silpakorn University
Boromarachachonnani Road,
Taling Chan, Bangkok 10170

15 June , 2022

Subject: Invitation to be an inspector of research tool quality

Dear Professor Mo Junhua,

Mr. Guangzhou LI is a graduate student ID 620430052 at Silpakorn University and is studying for Doctor of Philosophy (Design) at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled: Emotional Design of Traditional Chinese Cultural Creative Products Based on User Needs. 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.

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(Asst. Prof. Sathit Niratisai, Ph.D.)
Associate Dean for Administration Acting for
Dean of Graduate School, Silpakorn University

Mo Junhua

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ปณิธานบัณฑิตวิทยาลัย *"มุ่งส่งเสริม สนับสนุน เพื่อพัฒนาคุณภาพบัณฑิตศึกษา"*

Invitation Letter for Art Philosophy Experts

No. 8606/ 997

Graduate School
Silpakorn University
Boromarachachonnani Road,
Taling Chan, Bangkok 10170

15 June , 2022

Subject: Invitation to be an inspector of research tool quality

Dear Professor PU Anguo,

Mr. Guangzhou LI is a graduate student ID 620430052 at Silpakorn University and is studying for Doctor of Philosophy (Design) at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled: Emotional Design of Traditional Chinese Cultural Creative Products Based on User Needs. 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.

Sathit Niratisai
(Asst. Prof. Sathit Niratisai, Ph.D.)
Associate Dean for Administration Acting for
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PU Angu

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ปณิธานบัณฑิตวิทยาลัย *"มุ่งส่งเสริม สนับสนุน เพื่อพัฒนาคุณภาพบัณฑิตศึกษา"*

Invitation Letter for Research Experts on Traditional Culture and Classical Furniture

No. 8606/ 1060

Graduate School
Silpakorn University
Boromarachachonnani Road,
Taling Chan, Bangkok 10170

15 June , 2022

Subject: Invitation to be an inspector of research tool quality

Dear Associate Professor Yang Yanshi, Ph.D.

Mr. Guangzhou LI is a graduate student ID 620430052 at Silpakorn University and is studying for Doctor of Philosophy (Design) at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled: Emotional Design of Traditional Chinese Cultural Creative Products Based on User Needs. 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.

Sathit Niratisai

(Asst. Prof. Sathit Niratisai, Ph.D.)
Associate Dean for Administration Acting for
Dean of Graduate School, Silpakorn University

Yang Yanshi

The Secretariat of Graduate School, Silpakorn University (Taling Chan)
Tel: 0-2849-7502
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Product Design Expert Invitation Letter

No. 8606/ 991

Graduate School
Silpakorn University
Boromarachachonnani Road,
Taling Chan, Bangkok 10170

15 June , 2022

Subject: Invitation to be an inspector of research tool quality

Dear Ruan Xianggun,

Mr. Guangzhou LI is a graduate student ID 620430052 at Silpakorn University and is studying for Doctor of Philosophy (Design) at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled: Emotional Design of Traditional Chinese Cultural Creative Products Based on User Needs. 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.

Sathit Niratisai

(Asst. Prof. Sathit Niratisai, Ph.D.)
Associate Dean for Administration Acting for
Dean of Graduate School, Silpakorn University

Ruan Xianggun

The Secretariat of Graduate School, Silpakorn University (Taling Chan)
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3D Printing Expert Invitation Letter

No. 8606/ 993

Graduate School
Silpakorn University
Boromarachachonnani Road,
Taling Chan, Bangkok 10170

15 June , 2022

Subject: Invitation to be an inspector of research tool quality

Dear Pu Qi Min,

Mr. Guangzhou LI is a graduate student ID 620430052 at Silpakorn University and is studying for Doctor of Philosophy (Design) at Graduate School, Silpakorn University. Currently, he is conducting his thesis study entitled: Emotional Design of Traditional Chinese Cultural Creative Products Based on User Needs. 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.

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(Asst. Prof. Sathit Niratisai, Ph.D.)
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Dean of Graduate School, Silpakorn University

Pu Qimin

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Invitation letter for furniture product design experts

FARAA Journal of fine arts research and applied arts
ISSN 2822-003X (Print) ISSN 2822-0048 (Online)
วารสารศิลปกรรมศาสตร์วิชาการ วิจัย และงานสร้างสรรค์
JOURNAL OF FINE ARTS RESEARCH AND APPLIED ARTS

ที่ ว.2565/030 15 ธันวาคม 2565

เรียน *Li Guangzhou* และ รองศาสตราจารย์ ดร.รัฐไท พรเจริญ

ตามที่ท่านได้ส่งบทความทางวิชาการ เรื่อง **การเข้าไม้แบบจีนโบราณสู่หลักการออกแบบ CMF กับผลิตภัณฑ์ในปัจจุบัน** เพื่อขอรับการพิจารณาตีพิมพ์เผยแพร่ ในวารสารศิลปกรรมศาสตร์วิชาการ วิจัย และงานสร้างสรรค์ (Journal of Fine Arts Research and Applied Arts) นั้น

ในการนี้ กองบรรณาธิการวารสารศิลปกรรมศาสตร์วิชาการ วิจัย และงานสร้างสรรค์ ขอเรียนให้ท่านทราบว่า บทความทางวิชาการของท่านได้ผ่านเกณฑ์การประเมินคุณภาพจากผู้ทรงคุณวุฒิ (peer review) จำนวน 3 ท่าน และกองบรรณาธิการเห็นควรตอบรับลงตีพิมพ์และเผยแพร่บทความดังกล่าวในวารสารศิลปกรรมศาสตร์วิชาการ วิจัย และงานสร้างสรรค์ ปีที่ 10 ฉบับที่ 1 (เดือนมกราคม-มิถุนายน 2566) ซึ่งเป็นวารสารที่ได้การยอมรับในฐานข้อมูลของศูนย์อ้างอิงวารสารไทย (TCI) สาขามนุษยศาสตร์และสังคมศาสตร์ กลุ่มที่ 2

จึงเรียนมาเพื่อโปรดทราบ กองบรรณาธิการขอขอบพระคุณที่ท่านให้เกียรตินำผลงานทางวิชาการมาเผยแพร่ข่าวสารที่เป็นประโยชน์ในวารสารศิลปกรรมศาสตร์วิชาการ วิจัย และงานสร้างสรรค์ หวังเป็นอย่างยิ่งว่าทางวารสารจะได้รับโอกาสนี้ต่อไปดังเช่นเคย

ขอแสดงความนับถือ

(ผู้ช่วยศาสตราจารย์ประวิทย์ ฤทธิบูลย์)
บรรณาธิการ
วารสารศิลปกรรมศาสตร์วิชาการ วิจัย และงานสร้างสรรค์

กองบรรณาธิการวารสารศิลปกรรมศาสตร์วิชาการ วิจัย และงานสร้างสรรค์
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JOURNAL OF GRAPHIC ENGINEERING AND DESIGN

Editorial Board of Journal of Graphic Engineering and Design
Novi Sad, July 10, 2023.

To: **Li Guangzhou,**
Faculty of Decorative Arts, Silpakorn University,Bangkok,10200,Thailand

Dear Li Guangzhou,
It is my pleasure to inform you, that your paper

Emotional Design of Traditional Chinese Cultural Creative Products Based on User Demand

authors:
Li Guangzhou, Ratthai Porncharoen

has been accepted and approved for the publication in the Journal of Graphic Engineering and Design (i.e. JGED) as the professional paper.

You are entitled to get a free copy of the printed journal.

Best regards,

Editor
Nemanja Kašiković, University of Novi Sad, Novi Sad, Serbia

UNIVERSITY OF NOVI SAD ▪ FACULTY OF TECHNICAL SCIENCES ▪ DEPARTMENT OF GRAPHIC ENGINEERING AND DESIGN
TRG DOSITEJA OBRADOVIĆA 6, 21000 NOVI SAD, SERBIA ▪ TEL. +381 21 485 2628 / 485 2620 ▪ WWW.GRID.UNS.AC.RS

Article published in Journal of Graphic Engineering and Design

APPENDIX

Research tool

Index of Item Objective Congruence (IOC)

For Questionnaire

Consideration, Evaluation, Suggestions

Research topic:

Emotional design of traditional Chinese cultural creative products based on user Demand

Researchers:

Mr. Guangzhou Li（Ph. D student of Silpakorn University）

Phone:+86 15895556255，

E-mail：liguangzhou2023@gmail.com

Associate Professor Ratthai Porncharoen

Phone :0961016590，

E-mail：ratthai6654@gmail.com

Research objectives:

1.Study data to create design requirements.

2.Stage of design Product development and prototyping.

3. Study the satisfaction results of the target group through the exhibition.

This research tool is used to answer the following research Questions:

(1) Population groups are general consumers. who are interested in bringing identity from Chinese culture into product design.

(2) The sample group is those who are interested in training skills from the Emotional Learning Test Set (Ton Gong) from Chinese architecture structures. Number of 269 people.

(3) Phase I included 12 new designs based on the data obtained from the study data.

(4) Phase 2 has been developed and improved, leaving 3 approaches.

(5) Phase 3 finalization and prototyping

Clarification:

Consultation with a research advisor at every stage since the design prototyping improvement and putting it to the real test Including tools to record observations and interviews by measuring and evaluating the effectiveness of the tools. (IOC): A research on the method of emotional design of Chinese cultural creative products based on user needs. It is appropriate to use it as a research data collection tool by determining accuracy criteria.

+1=ensure the problem is correct

0=Not sure whether the problem is appropriate.

-1=ensure that the problem is inappropriate

Tick(✓)in your comment box and write down suggestions for further improvement.

Part 1: General information issues

Questions in the questionnaire	Expert Options			Suggestions
	Appropriate (1)	Uncertain (0)	Inappropriate (-1)	
1. Gender (1) Male (2) Female (3) Non-binary				
2. Generation (1) 0-18 years old (2) 19~26 years old (3) 27~35 years old (4) Over 36 years old				
3. Occupational situation: (1) School students (2) Office workers (3) To do your work (4) Others				

Part 2: " User demand survey of cultural and creative products " issues

Questions in the questionnaire	Expert Options			Suggestions
	Appropriate (1)	Uncertain (0)	Inappropriate (-1)	
5. The actual use function required in traditional pattern cultural and creative products (1) Very dissatisfied (2) Dissatisfied (3) Neither dissatisfied or satisfied (4) Satisfied (5) Very satisfied				
6.Traditional tattoo cultural and creative products need to be conducive to carrying Internet (1) Very dissatisfied (2) Dissatisfied (3) Neither dissatisfied or satisfied (4) Satisfied (5) Very satisfied				
7. For durability in. traditional pattern cultural and creative products (1) Very dissatisfied (2) Dissatisfied (3) Neither dissatisfied or satisfied (4) Satisfied (5) Very satisfied				

8. Traditional pattern cultural and creative products can be decorated (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
9. The price is low in traditional pattern cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
10. Traditional pattern cultural and creative products are exquisitely packaged and high-end appearance (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
11. Traditional pattern cultural and creative products have a good texture (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				

12. Traditional pattern cultural and creative products have a fashion sense (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
13. There are traditional pattern characteristics in traditional pattern cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
15. Cultural stories are needed in traditional tattoo cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
16. Creativity is needed in traditional pattern cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				

17. Symbolic in traditional pattern cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
18. Interesting and humorous in traditional pattern cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
19.Traditional tattoo cultural and creative products need to move emotion and heal the mind (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				

Part 3: " Emotional design, mortise and tenon arch structure creative products " issues

Questions in the questionnaire	Expert Options			Suggestions
	Appropriate (1)	Uncertain (0)	Inappropriate (-1)	
20. You pay attention to the appearance of mortise and tenon cultural creative products (size, shape and line) (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
21. You pay attention to the color collocation of mortise and tenon, bucket arch cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
22. You pay attention to the diversity of mortise and tenon, bucket arch cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				

Questions in the questionnaire	Expert Options			Suggestions
	Appropriate (1)	Uncertain (0)	Inappropriate (-1)	
23. You pay attention to the traditional cultural patterns of mortise and tenon joints and bucket arch cultural and creative products (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
24. You hope that different tenon, bucket arch cultural creative products can produce different sound effects (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
25.You hope that mortise and tenon, bucket arch cultural and creative products are silent (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
26. You hope that mortise and tenon, bucket arch cultural and creative products are silent (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
27. You pay attention to the touch (texture) of cultural and creative products				

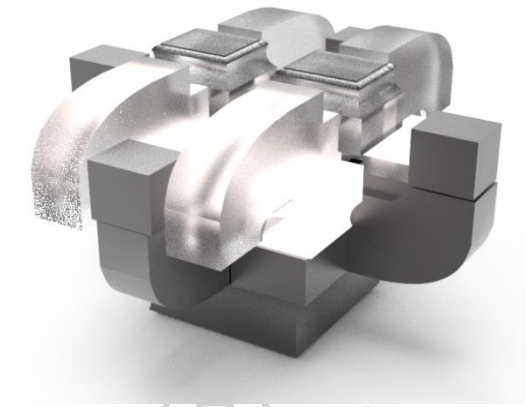
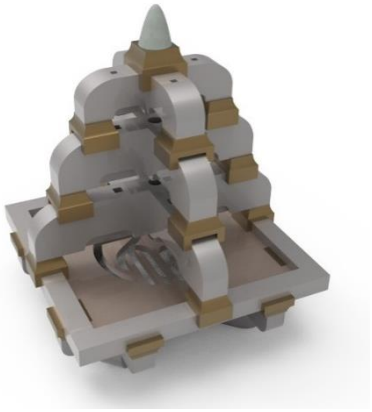
Questions in the questionnaire	Expert Options			Suggestions
	Appropriate (1)	Uncertain (0)	Inappropriate (-1)	
(1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
28. You follow the material of the product (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
29. You hope that the cultural creative products of mortise and tenon joints are ornamental (such as sculpture, sketch, hanging ornaments, seals, etc.) (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
30. You hope that mortise and bucket arch cultural creative products will be large and used in daily life (such as furniture, lamps, space accessories) (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
31. You hope that mortise and bucket arch cultural creative products are small "tools" that can be used (1)Very dissatisfied (2)Dissatisfied				

Questions in the questionnaire	Expert Options			Suggestions
	Appropriate (1)	Uncertain (0)	Inappropriate (-1)	
(3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				
32. You hope that mortise and tenon, bucket arch cultural and creative products can be used in social activities (1)Very dissatisfied (2)Dissatisfied (3)Neither dissatisfied or satisfied (4)Satisfied (5)Very satisfied				

Part 4: Product design stage, design scheme decision

33. Mortise and Tenon, Bucket arch Structural Emotional Product Design Evaluation Criteria				
A. Cultural connotation: 1) Retains the Bucket arch identity, characterized by vertical assembly of mortise and tenon components. The concept is derived from emotional, creative media from Chinese cultural architecture combining science and art. 2)By science, there will be a body of scientific knowledge in engineering regarding the complex load of the load, including balance.				
B. Appearance aesthetics: The design must maintain the characteristics of Bucket arch's Chinese culture in terms of naturalness (material) and solid and elegant appearance. Method using straight lines. Blend with curves in the corners. With the use of square corners in the art composition principle				
C.Economic aspect: There must be value for the investment to obtain an appropriate return. 1) Must produce the design in a small industry system. To be a guideline for creating new entrepreneurs. 2) The design must share parts. To modify designs in the same product type or use in conjunction with other products. 3) The design must demonstrate sustainability. It does not cause any impact on the ecosystem				

33. Mortise and Tenon, Bucket arch Structural Emotional Product Design Evaluation Criteria				
D.Emotional design requirements of products from Chinese culture through the researcher's KANO training 1) Traditional Chinese must be preserved. For this work, it should be the assembly structure of Bucket arch, including 2) Simplicity of assembly and use. 3) Product prototypes should be practical in the design of home appliances such as lamps—lights, furniture, hangers, storage shelves, etc., in daily life. 4) Expression of enthusiasm = Personality that shows enthusiasm for design. It uses line expressions to create animated shapes from the complex arrangement of individual parts.				
E. Use behavior experience： Users must be guided by the product experience, especially using exploded drawings to prompt product combinations and operations				
34.Which product is more in line with the requirements of emotional design standards				
				
Product design of square table with Bucket arch structural elements				

33. Mortise and Tenon, Bucket arch Structural Emotional Product Design Evaluation Criteria				
				
Product design of resin desktop lamps with Bucket arch structure.				
				
Product design of Bucket arch incense burner (version 1.0)				
				

33. Mortise and Tenon, Bucket arch Structural Emotional Product Design Evaluation Criteria				
Bucket arch incense burner (version 2.0)				
				
BUCKET ARCH element outdoor rocking chair product design (classic style)				
				
Mortise and tenon arch structure children's combination stool				
				

33. Mortise and Tenon, Bucket arch Structural Emotional Product Design Evaluation Criteria				
Bucket arch element shelf product design (classic style)				
				
Product design of plant shelves and low stools in Bucket arch, (classic style)				
				
Bucket arch element low stool product design (classic style)				

33. Mortise and Tenon, Bucket arch Structural Emotional Product Design Evaluation Criteria				
				
Mortise and tenon arch structure coat rack				
				
Mortise and tenon and bucket arch structure interior lighting design 1				
				
Mortise and tenon and bucket arch structure interior lighting design 2				

33. Mortise and Tenon, Bucket arch Structural Emotional Product Design Evaluation Criteria				
				
Bucket arch element chair and low stool product design (modern style)				

Thank you very much!

Brief info of the expert

Mo Junhua

Title: Professor

Institute: School of Art, Suzhou University of Science and Technology

Tel: +86 13913172075

E-mail: Mo Junhua @gmail.com

Address: No. 55, Changjiang Road, High-tech Zone, Suzhou City, Jiangsu Province, 215000

Reviewed by: _____

Date: _____

User demand survey of cultural and creative products with traditional patterns based on KANO model

Thank you very much for filling it out. Please understand the basic information of the questionnaire before starting:

In order to improve the quality of the traditional pattern theme cultural and creative design, the questionnaire has 13 questions, and it may take you some time to think carefully.

To confirm the prioritization of product functionality, we need you to combine your own experience and select the emotional level for each feature.

Each problem has "have" this function and "no" this function two problems, please choose one by one.

Please select the emotional level you think is correct based on the functional details before each form.

Emotional Level: Corresponding score:

Surprise —— This feature was unexpected than I thought, I was pleasantly surprised. 5 points

Loved —— this feature I expected to have and I was satisfied. 4

Of course —— this function should be and must have. 3 points

It doesn't care if —— doesn't care, can it OK. 2 points

I don t like —— I m very unhappy with this feature and don t want to have. 1 points

1. Your gender male / female

2. Your age group

0~18; 19~26; 27~35; 36 above

3. Your career

School students Office workers To do your work Others

Whether 4. The actual use function required in traditional pattern cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Value in use				

Like it	This should be so	It does not matter	It arely accept	Not to like it
No use value				

Whether 5. Traditional tattoo cultural and creative products need to be conducive to carrying

Like it	This should be so	It does not matter	It arely accept	Not to like it
Easy to carry				
Not really easy to carry				

Whether 6. For durability in. traditional pattern cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Durability				
No durability				

Whether 7. Traditional pattern cultural and creative products can be decorated

Like it	This should be so	It does not matter	It arely accept	Not to like it
Has the function of decoration and viewing				
It not no decoration of ornamental viewing				

Whether 8.The price is low in traditional pattern cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Cheap price				
The price is not cheap				

Whether 9 There are traditional cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Has a traditional cultural style				
No traditional cultural style				

Whether 10. Traditional pattern cultural and creative products are exquisitely packaged and high-end appearance

Like it	This should be so	It does not matter	It arely accept	Not to like it
Exquisite packaging, high-end appearance				
Do not have a delicate packaging, high-end appearance				

Whether 11. Traditional pattern cultural and creative products have a good texture

Like it	This should be so	It does not matter	It arely accept	Not to like it
Have a good texture				
Not have a good texture				

Whether 12. Traditional pattern cultural and creative products have a fashion sense

Like it	This should be so	It does not matter	It arely accept	Not to like it
Have a fashion sense				
Not having a sense of fashion				

Whether 13. There are traditional pattern characteristics in traditional pattern cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Has the traditional pattern characteristics				
Do not have the traditional pattern characteristics				

Whether 14.Cultural stories are needed in traditional tattoo cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
There are cultural stories				
There is no cultural story				

Whether 15.Creativity is needed in traditional pattern cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Creative nature				
Not being creative				

Whether 16. Symbolic in traditional pattern cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Symbolic significance				
Not symbolic				

Whether 17. Interesting and humorous in traditional pattern cultural and creative products

Like it	This should be so	It does not matter	It arely accept	Not to like it
Have an interesting and humorous connotation				
There is no interesting humor				

Whether 18. Traditional tattoo cultural and creative products need to move emotion and heal the mind

Like it	This should be so	It does not matter	It arely accept	Not to like it
Can move the emotion and heal the heart				
Do not have the function to move the emotion and heal the heart				

Questionnaire on user demand and emotional design of mortise and tenon and bucket arch cultural creative products

Now in a mortise and tenon joint, bucket arch cultural creative product user needs and emotional design of research, want to know based on different demand level you to mortise and tenon joint, bucket arch cultural creative product emotional demand, the following is I do a questionnaire, want to invite you to help fill in the following questionnaire, thank you very much for your help. All the data of this survey are only used for academic research. Please feel free to fill in them. Your answer is very important to us. I would like to express your heartfelt thanks again for taking time out of your busy schedule to fill in this questionnaire.

Part 1 Essential information

The following is about your personal information, please answer according to the actual answer.[single choice]*

1. Your gender: A, male, B, and female
2. Your age: A, 25, years old and below B, 26 to 35 years old C, 36 to 45 years old D, 45, years old and above
3. Your education background: A, high school and below B, junior college C, Bachelor degree D, Master degree or above
4. Your current monthly income: A, 3000 yuan and below B, 3000-5000 yuan C, 5000-10000 yuan D, 10000 yuan and above

Part 2 The mortise and tenon and bucket arch cultural creative products demand level

Follow "1-5" for the following sense of urgency about your needs at different levels (not all-very much).[Matrix Scale Questions] *

	1	2	3	4	5
physiological needs					
Security needs					
social demand					
respect					
self-fulfilment					

Part 3 The emotional design at the sensory level

According to "1-5", you pay attention to the emotional design of the mortise and tenon and bucket arch cultural creative products (no attention-very attention).[Matrix Scale Questions] *

Questions	1	2	3	4	5
You pay attention to the appearance of mortise and tenon cultural creative products (size, shape and line)					
You pay attention to the color collocation of mortise and tenon, bucket arch cultural and creative products					
You pay attention to the diversity of mortise and tenon, bucket arch cultural and creative products					
You pay attention to the traditional cultural patterns of mortise and tenon joints and bucket arch cultural and creative products					
You hope that different tenon, bucket arch cultural creative products can produce different sound effects					
You hope that mortise and tenon, bucket arch cultural and creative products are silent					
You pay attention to the touch (texture) of cultural and creative products					
You follow the material of the product					
You want mortise and tenon cultural creative products to have a soft smell, rather than an annoying garbage or plastic smell					
You hope that mortise and tenon, bucket arch cultural creative products can touch type interactive sensing					

Part 4 Use of levels of emotional design

According to "1-5", it means your recognition of the emotional design of mortise and tenon and bucket arch cultural creative products at the behavioral level (very disagree-very agree).[Matrix Scale Questions] *

Questions	1	2	3	4	5
You hope that mortise and tenon, bucket arch cultural creative products have practical					
You hope that the cultural creative products of mortise and tenon joints are ornamental (such as sculpture, sketch, hanging ornaments, seals, etc.)					
You hope that mortise and bucket arch cultural creative products will be large and used in daily life (such as furniture, lamps, space accessories)					

Questions	1	2	3	4	5
You hope that mortise and bucket arch cultural creative products are small "tools" that can be used					
You hope that mortise and tenon, bucket arch cultural creative products can have commemorative significance					
You hope that mortise and tenon, bucket arch cultural and creative products can be used in social activities					
You hope that mortise and tenon, bucket arch cultural and creative products can be used in cultural and educational activities					
You hope that mortise and tenon, bucket arch cultural and creative products can be used in the work					

Part 5 Emotional design at the reflective level

According to "1-5", it indicates your recognition of the emotional design of mortise and tenon and bucket arch cultural creative products (very disagree-very agree).[Matrix Scale Questions] *

Questions	1	2	3	4	5
You hope that mortise and tenon cultural creative products can increase your thinking and sense of identity to traditional culture					
You hope that mortise and tenon, bucket arch cultural creative products can have a strong traditional cultural emotion					
You hope that mortise and tenon, bucket arch cultural creative products can help you get out of the negative state					
You hope that mortise and tenon, bucket arch cultural creative products can let you have a memory and association of a certain culture					
You hope that mortise and tenon, bucket arch cultural creative products can enhance your sense of self-identity					
You hope that mortise and tenon, bucket arch cultural creative products can enhance the society's recognition of you					
You hope that mortise and tenon, bucket arch cultural creative products can enhance your sense of belonging					

Satisfaction questionnaire of creative products of mortise and tenon structure

Dear Mr. / Madam: This research project explores the consumption satisfaction survey of Chinese traditional cultural creative products with mortise and tenon and bucket arch structure as an example. You are invited to participate in this project voluntarily. The questionnaire is an anonymous questionnaire. Please answer the following questions truthfully according to your own information. Thank you very much for your participation and support!

Part I: Consumer basic information survey

1. Your gender:	
A, man	B, woman
2. Your age:	
A, 20, years old and below	B, those aged from 20 to 29 years old
C, 30 to 40 years old	D, 40, age and above
3. Your education background:	
A, High school and below	B, junior college
C, undergraduate course	D. Graduate student or above
4. Your occupation is:	
A Enterprise personnel	B career, civil servants and other civil servants
C student	D liberal professions
E retiree	
5. Your current monthly income:	
A, RMB 3,000 yuan and less	B, RMB 3000-5000 yuan
C, RMB 5000-10000 yuan	D, RMB 10,000 yuan and above

Part II: According to the survey of mortise and tenon products shown in the exhibition objects

5. (Instinct level) The lamps use interactive induction light sources				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
6. (instinctive level) the color collocation is reasonable, the main material is walnut material				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
7. (instinctive level) using the lotus pattern, decorated with metal material				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
8 (Behavior level) The product is easy to assemble and use				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
9 (Behavior level) The product is very practical and can be used in the courtyard design				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
10 (Behavioral level) The product can be a good social topic				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
11 (Reflection level) This product can enhance the society's recognition of itself				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
12 (Reflection level) The product can help you get out of a negative state and have a certain sense of pleasure				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
13 (Reflection level) This product can enable you to remember and associate with traditional Chinese culture				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
14 (Marketing sales) The market price of this product is 2,000 yuan per piece				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐
15 (Marketing) This product structure components can be used as common accessories for the second generation of products				
Very satisfied ☐	satisfied ☐	same as ☐	discontent ☐	Very dissatisfied ☐

APPENDIX

Pictures of research activities

Researchers carried out science popularization activities in the Suzhou Museum

Researchers are interacting with consumers about product experiences

The researchers and members of the thesis review committee held a discussion online

Researchers discuss the application of mortise and tenon structures in products with experts

Researchers conduct user research

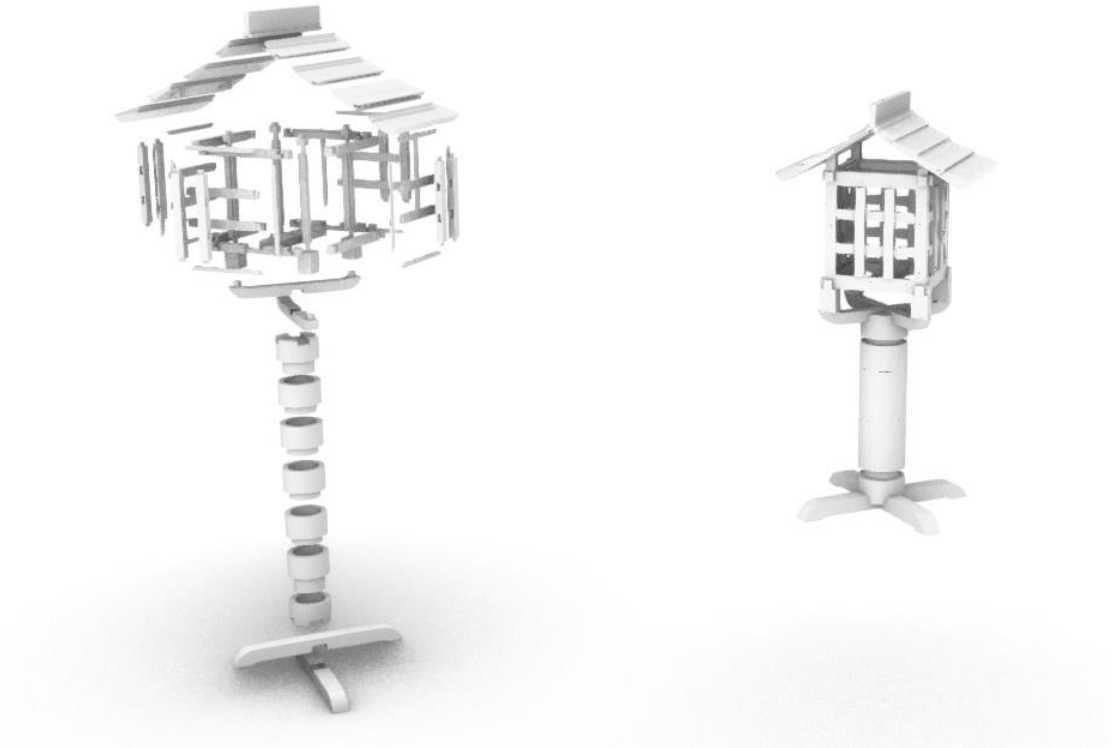
Researchers conduct field research

The seven-member committee will determine the design content of the second phase online

Researchers interview experts and communicate the final product design

APPENDIX

Product Design Extension

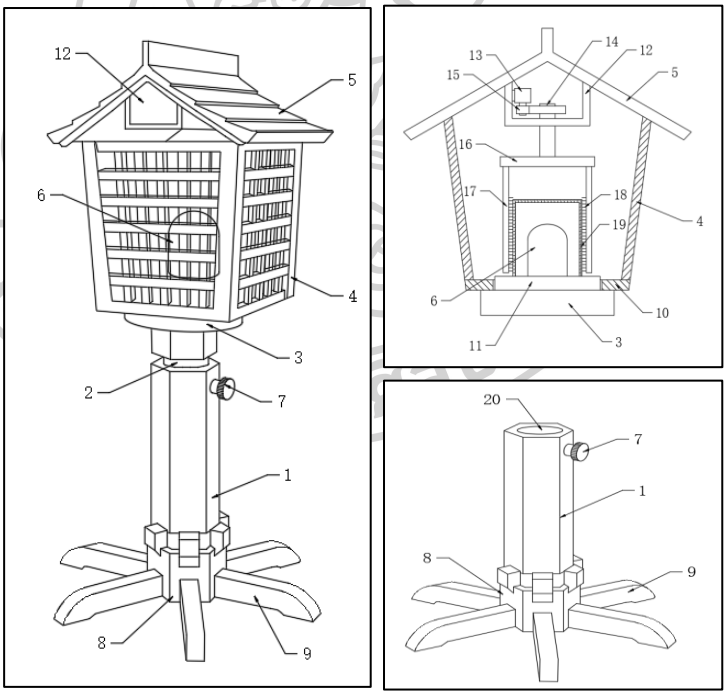


Product features: support column into cylinder, layered assembly, highly variable.

Product features: The style of the lampshade has been adjusted

Product features: The support column is changed to four and placed on the base to increase stability.

Product features: increase the function of the insecticidal table, by installing the insecticidal table outside



the lamp, insecticidal protection can be carried out outside the lamp to prevent insect phototaxis from affecting the lighting effect of the lamp. The ash removal mechanism makes it possible to clean up killed insects outside the insecticidal grill.

VITA

NAME	Guangzhou Li
INSTITUTIONS ATTENDED	Faculty of Decorative Arts,Silpakorn University
PUBLICATION	1.Wood joining traditional chinese style to Principles of CMF design with current products.(Journal of Fine Arts Research and Applied Arts) 2.Emotional Design of Traditional Chinese Cultural Creative Products Based on User Demand.(Journal of Graphic Engineering and Design)
AWARD RECEIVED	In June 2023, the works will be exhibited in the 2022 Changjiang Future International Public Welfare Poster Design Invitational Exhibition. In April 2023, the works will be exhibited at Guangfu Impression Taihu International Poster Design Invitational Exhibition. In September 2022, they won the Excellence Award in the Cultural and Creative Group of the 7th Jiangsu Science Popularization Public Welfare Works Competition; In November 2021, won the Excellence Award in the National Competition of the 7th "Cross-Strait Emerging Design Competition Huacan Award"; In September 2021, won the first prize in the cultural and creative group of the 7th Jiangsu Science Popularization Public Welfare Works Competition; In January 2021, the works will be exhibited at Yangtze River Future 2020 International Charity Poster Design Invitational Exhibition; In November 2021, the third prize in the 2021 "Yushan Award Cultural and Creative Design Competition"; In September 2020, won the first prize in the cultural and creative group of the 6th Jiangsu Science Popularization Public Welfare Works Competition; In December 2020, won the second prize in the graphic vision category of the National Vocational College Art Design Works "Canton Fair" Simultaneous Trading Exhibition Works Competition of the Vocational College Art Design Professional Teaching Committee of the Ministry of Education; In October 2020, won the finalist award of the first Suzhou Cultural Tourism Creative Design Competition; In July 2020, the third prize of the 3rd National College Digital Creative Teaching Skills Competition

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