FROM FORMAL RECOGNITION TO SEMANTIC UNDERSTANDING: RETHINKING FALANGCAI PORCELAIN PATTERN INSTRUCTION IN CERAMIC DESIGN EDUCATION JINGDEZHEN, JIANGXI PROVINCE IN CHINA

DO RECONHECIMENTO FORMAL À COMPREENSÃO SEMÂNTICA: REPENSANDO O ENSINO DOS PADRÕES DE PORCELANA FALANGCAI NA EDUCAÇÃO EM DESIGN CERÂMICO EM JINGDEZHEN, PROVÍNCIA DE JIANGXI, CHINA

DEL RECONOCIMIENTO FORMAL A LA COMPRENSIÓN SEMÁNTICA: REPENSANDO LA ENSEÑANZA DE LOS PATRONES DE PORCELANA FALANGCAI EN LA EDUCACIÓN EN DISEÑO CERÁMICO EN JINGDEZHEN, PROVINCIA DE JIANGXI, CHINA

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ABSTRACT: This study investigates the incorporation of traditional Chinese cultural elements into porcelain tea set design through the framework of morphosemantics, focusing on Falangcai porcelain as a case study. Utilizing archival records from the Imperial Workshop, researchers developed RGB and spectral databases (350–950 nm) specific to Jingdezhen Falangcai porcelain. Aesthetic features were systematically categorized using grounded theory in combination with the KANO-AHP hybrid model. To innovate and restore Falangcai patterns, a generative AI-assisted workflow was implemented, leveraging Stable Diffusion paired with Low-Rank Adaptation (LoRA). Findings reveal that AIGC serves as an effective bridge between traditional craftsmanship and contemporary design practices. Furthermore, the study highlights digital innovation strategies for Falangcai porcelain by incorporating sustainable design principles, providing actionable insights for modernizing this intangible cultural heritage.

KEYWORDS: Falangcai porcelain patterns. Falangcai painted. Artificial intelligence-generated content (AIGC). KANO-AHP hybrid model. Low-rank adaptation (*LoRA*) technology.

RESUMO*: Este estudo investiga a incorporação de elementos culturais tradicionais chineses no design de conjuntos de chá em porcelana por meio do referencial da morfossemântica, tendo como estudo de caso a porcelana Falangcai. Utilizando registros de arquivo da Oficina Imperial, os pesquisadores desenvolveram bancos de dados RGB e espectrais (350–950 nm) específicos para a porcelana Falangcai de Jingdezhen. As características estéticas foram categorizadas de forma sistemática com base na teoria fundamentada, em combinação com o modelo híbrido KANO-AHP. Para inovar e restaurar os padrões Falangcai, foi implementado um fluxo de trabalho assistido por IA generativa, utilizando Stable Diffusion associado à adaptação de baixo ranque (LoRA). Os resultados indicam que o AIGC atua como uma ponte eficaz entre o artesanato tradicional e as práticas contemporâneas de design. Além disso, o estudo destaca estratégias de inovação digital para a porcelana Falangcai ao incorporar princípios de design sustentável, oferecendo subsídios práticos para a modernização desse patrimônio cultural imaterial.*

PALAVRAS-CHAVE*: Padrões de porcelana Falangcai. Pintura Falangcai. Conteúdo gerado por inteligência artificial (AIGC). Modelo híbrido KANO-AHP. Tecnologia de adaptação de baixo ranque (LoRA).*

RESUMEN*: Este estudio investiga la incorporación de elementos culturales tradicionales chinos en el diseño de juegos de té de porcelana mediante el marco de la morfosemántica, tomando como caso de estudio la porcelana Falangcai. Utilizando registros de archivo del Taller Imperial, los investigadores desarrollaron bases de datos RGB y espectrales (350–950 nm) específicas para la porcelana Falangcai de Jingdezhen. Las características estéticas fueron categorizadas de manera sistemática utilizando la teoría fundamentada en combinación con el modelo híbrido KANO-AHP. Para innovar y restaurar los patrones Falangcai, se implementó un flujo de trabajo asistido por IA generativa, empleando Stable Diffusion junto con la adaptación de bajo rango (LoRA). Los resultados revelan que el AIGC actúa como un puente eficaz entre la artesanía tradicional y las prácticas contemporáneas de diseño. Además, el estudio destaca estrategias de innovación digital para la porcelana Falangcai al incorporar principios de diseño sostenible, proporcionando aportes prácticos para la modernización de este patrimonio cultural inmaterial.*

PALABRAS CLAVE: *Patrones de porcelana Falangcai. Pintura Falangcai. Contenido generado por inteligencia artificial (AIGC). Modelo híbrido KANO-AHP. Tecnología de adaptación de bajo rango (LoRA).*

INTRODUCTION

A significant component of traditional Chinese culture is represented by Falangcai porcelain designs, which combine Buddhist, Taoist, and Confucian ideas into a distinctive symbol framework. Traditional Chinese perspectives on nature and philosophy have been reflected in the delicate designs and Falangcai colouring that have characterized ancient Chinese workmanship since the Yuan Dynasty (Wang, 2022). Patterns with historical persons, animals, and plants have deep symbolic connotations.

Numerous porcelains are discovered annually in Jingdedzhen, one of China's primary porcelain-producing regions. The most well-known and valuable of these is the Falangcai porcelains from the Yuan, Ming, and Qing dynasties (Wu et al., 2024). These Falangcai porcelain's are painted using Chinese painting techniques on biscuits (unfired porcelain) using CoO as the pigment. These patterns serve as a crucial foundation for pottery repair as well as a valuable reference for the study of social economy and culture.

The patterns on the mixed porcelain shards are the only way to tell them apart because they typically have similar shapes and textures. Experienced archaeologists often do this duty; in fact, as more and more shards are found, (Zhang & Pollard, 2022), the inefficiency of manual categorization cannot keep up with the demand, necessitating the proposal of an automated categorization approach. Nevertheless, these patterns' integrity is frequently compromised in addition to their intricate architecture. Nevertheless, since the designs are created by hand by employees, who are frequently influenced by drawing methods and other elements, the same kind of patterns might appear very different (Hanzaei et al., 2017). Furthermore, even if a large number of ancient pottery shards have been discovered recently, they are still insufficient for training data. These issues have made the task quite difficult.

Generally speaking, there are two types of ornamental designs seen in Qianlong's porcelain with Falangcai painted enamels. One is the "Convergence of Tints" displays, which feature artworks with written poems and patterns with deep meanings. The other is the portrayal of paintings that thrive on celestial compositions. The creative patterns that are unique to the Qianlong reign are suggested in this section. First, people are drawn to the portraits of the literati, men, eighteen Lohans, the "Mother and Child" theme from the East and West, and the Western woman because of their distinct profiles and striking facial expressions. Figure1 Bowl decorated with panels of landscape on a red ground in Falangcai painted enamel. The third are those with elaborate and sophisticated designs in polychrome colouring, using painting, chisel-

carving, and appliqué embellishment techniques, and highlighted by a variety of flowers to provide the impression of adding shine to the perfection (Ma, 2022).

Figure 1.
Bowl decorated with panels of landscape on a red ground in Falangcai painted enamels

Note. Ma (2022).

It's quite hard to imagine that, the emperor in the 18th century would inspect each piece of porcelain sent in the court from Jingdezhen. In 1737, the emperor was presented with a group of new porcelains in archaic or innovated styles. The exhibited square vase has yellow glaze as the base, covered fully in flowers and intertwining vines and branches, additionally, with flowers distinct from the previous reigns then it would be regarded as "Yangcai Yanghua" Figure 2. The repeated request from the emperor to produce "Yangcai Yanghua", thus entitled this type of decorations to be praised as the classics of artworks in Yangcai painted enamels.

Figure 2.
Square vase with Western flower on a yellow and blue ground in Yangcai painted enamels Qianlong reign (1736-1795), Qing dynasty

Note. Wang and Luo (2021).

"Chine de commanded" refers to all of these items. About 120 pieces of significant services were created and are still in different levels of conservation (Wang & Luo, 2021). This enables for samples for (micro) destructive analyses, such as the stratigraphy of the enamelled layers and the inspection of the sections. The superposition of layers of coloured enamels (also known as overglaze) to create a complex, realistic decoration that allows for the creation of an oil painting-like decoration on various supports (glass, metal, or ceramic) is, in fact, one of the fundamental contributions of European enamelling techniques to Japanese and Chinese craftsmen. Strongly coloured enamels (thus heavily loaded with one or more coloring agents) that are fired at decreasing temperatures (usually between 1000 and ~600 °C) and that can be "painted" on a smooth, dense support that has already been fired, such as porcelain glaze, are required for this technique, which was first developed by enamellers on metals. Ceramic enamelling is more delicate because the firing processes must be slow and long, even though the realization of a complex decoration on metal is made possible by the very short firing cycles (a few minutes plus a final annealing) and the very good mechanical resistance of the support to thermal cycles. Numerous "enamel" firing cycles are required, and the "overglazes" compositions must be modified for each cycle. The ceramics known as Famille Rose, which date back to Kangxi's reign, were the first to employ the overglaze method extensively.

When these items show up at art market auctions, connoisseurs greatly value them. When these porcelains are ordered for weddings or other significant occasions, the delivery or order is sometimes recorded. In addition to the studies conducted on masterpieces to comprehend the application of recipes, even the ingredients imported from Europe for the production of enamelled objects in the workshops of the Imperial Palace (Pan et al., 2024), Jingdezhen, or Canton for the Court and the Chinese market, the examination of items ordered by European clients should enable greater comprehension of the transfer of technological advances.

Additionally, data augmentation is an essential and crucial task since the convolutional neural network requires training a large number of parameters, making it challenging to achieve the desired impact when the amount of training data is limited. Currently, the primary techniques for data augmentation are as follows. picture augmentation techniques include single-sample (represented by CutOut) and multi-sample (represented by MixUp) techniques based on fundamental picture alteration. Moreover, CycleGAN represents an image augmentation technique based on picture creation. However, because of the model's great complexity, the real impact of this approach has not yet been verified.

A valuable perspective for examining the durability of cultural symbols, which include signifiers, signified meanings, and interpretations, is provided by semiotics. For example, the color scheme of Falangcai porcelain embodies the Confucian ideal of "harmony and balance," while motifs such as bamboo (Shaobin et al., 2010), chrysanthemums, orchids, and plum blossoms symbolize Confucian qualities. Buddhism also had a big impact on patterns, most notably the lotus, which stands for nirvana and purity. Semiotic analysis clarifies the connotative relationships through cultural interpretation as well as the denotative relationships between symbols and their meanings. Dragon and phoenix images, for instance, represent strength and nobility in Chinese culture but may have various meanings in other situations, indicating changes in symbolic significance across contexts of culture. Thus, cultural symbols are essential to ensuring cultural sustainability in addition to encapsulating collective identities, social ideals, and historical memory. Maintaining influence and creating new cultural meanings are two aspects of sustainable symbolic activities. Cultural symbols, which go beyond visual representation to include cultural communication in contemporary, globalized situations, may maintain cultural transmission and improve social cohesiveness via intentional design and innovation.

A basic framework for comprehending how Falangcai porcelain patterns serve as cultural symbols is provided by semiotic theory (Edwards, 2021). Semiotics allows for a methodical investigation of how visual motifs communicate both explicit denotations and culturally imbedded connotations. It is based on the classical tripartite framework of signifier, signified, and meaning, which was devised by Saussure and later refined by Barthes. Visual shapes like the lotus, dragon, or phoenix in the setting of Falangcai porcelain express deeply ingrained social norms, religious convictions, and philosophical philosophies in addition to aesthetic or decorative virtues.

A key component of traditional Chinese culture, ceramic ornamental art represents millennia of creative skill and deep cultural importance (Shih, 2007). It makes a substantial contribution to the improvement of decorative appeal, practicality, and spatial aesthetics. A wide variety of ornamental components are used in the field of ceramic decorative pattern design, each exhibiting own expressive ways. Additionally, there are notable variations in the stylistic traits that various ornamental patterns display. For instance, ornamental techniques like the use of Falangcai porcelain's show vivid colors and smooth patterns that resemble the freehand manner of traditional Chinese painting. The traditional ceramic decoration pattern design process frequently requires designers to devote a significant amount of time to style

development and examples, which results in low efficiency (Zhou, 2008), rigid style adoption, and insufficient innovation, making it difficult to meet the specific needs of consumers.

When dealing with particular needs for ceramic ornamental patterns, existing style transfer algorithms sometimes suffer from problems including loss of texture information, low color fidelity, and inadequate capture of style elements. The primary cause of this is the pervasive disregard for semantic limitations specific to ceramic art. For non-stationary textures and intricate structural connections, transfer of style techniques based on conventional convolutional neural networks have limited simulation capabilities. Similarly, conditional generative adversarial networks' generalization capacity and applicability are limited in real-world cross-domain design transferring situations (Shih, 2012). Thus, the goal of the project is to develop a specific framework for style transfer automated generation for ceramic ornamental patterns with intricate textures and distinctive visual elements. The main objective is to address the prevalent issues of texture information decrease, color distortion, and inadequate style expression in the application of current techniques in this field, guaranteeing the efficient and high-quality creation of ceramic decorative patterns that accurately capture the target artistic style while maintaining content framework and offering useful tools for electronic design.

Additionally, this study employs a stable diffusion model to optimize the semantic control of the improved CycleGAN algorithm, taking into account its poor fine-grained control ability. This ensures that the model's generated patterns have better texture detail information and satisfy decorative design requirements. The work is unusual because it addresses the scientific problem of "distant stroke echo" in ceramic patterns by combining the attention mechanism and VGG16 previous knowledge into CycleGAN (Xu, 2015).

Ceramic tea sets are the subject of this research, which presents the theoretical underpinnings of morphosemantics. It offers creative ideas for the design of ceramic tea sets and investigates the use of traditional Chinese cultural themes in the creation of contemporary ceramic tea sets. The study is separated into two separate parts. The study is split into two halves. The style and key characteristics of the ceramic tea set are summarized in the first section, which also examines the cultural significance of the design aspects. The design approach for incorporating traditional Chinese cultural components is examined in the second part.

The evolution of Falangcai porcelain dates back to the Yuan to Xuantong periods at the end of the Qing Dynasty, and there are countless heirlooms and excavations from subsequent dynasties. However, the appearance and style of Falangcai porcelain vary depending on the

period, cobalt blue pigment, craftsmanship, and place of origin. One of the most skilled types of Chinese porcelain in Falangcai porcelain which is renowned across the world and represents the height of ancient Chinese porcelain art (Colomban et al., 2017). The study of Falangcai porcelain particularly the categorization of Jingdezhen blue and white porcelain from subsequent dynasties, has great academic and social worth because to its distinctive position and effect. Nowadays, physical measurement tools or experience are the primary means of dating Falangcai porcelain.

Imaging spectroscopy has become more important in several areas of visual data processing in recent years, and it is essential to these areas. A new method for resolving spectral and spatial issues is to combine deep learning with image spectroscopy. A machine learning technique known as “transfer learning” makes it easier to apply distinct but related issues by transferring information from a source domain to a targeted domain (Giannini et al., 2017). Transfer learning has shown promise in the classification of ceramics thanks to improvements in processing power and the availability of large datasets (Colomban et al., 2018). During training, deep learning made it possible to extract higher-dimensional and more abstract characteristics, exhibiting powerful identification skills in the context of cultural asset protection. Deep learning has been effectively used in several research to recognize and categorize porcelain. Hyperspectral methods and procedures mostly depend on the complex spectral properties recorded by imaging spectrographs. Because imaging spectroscopy is quick and non-destructive, it has been acknowledged for its potential in counterfeit detection in addition to being essential for the preservation of specific cultural artifacts.

This study offers an identification model based on transferred learning for imaging spectral data to rapidly and non-destructively determine the chronology of Jingdezhen Falangcai porcelain (Montanari et al., 2018). This model may produce outstanding identification outcomes in the situation of just a few samples. This approach differs from the multimodal investigation integrating various rays on heritage safeguarding, which uses the classification knowledge acquired on massive datasets through transfer learning and modifications the structure of the classical network model to improve the classification efficiency and enhance the quality of classification (Motanari et al., 2019). This approach cannot be better utilized for the classification task of Jingdezhen Falangcai porcelain, such as the visual information of the porcelain’s textures, styles, and patterns as well as the reflecting spectral information.

The term “foreign colors” is Falangcai. Porcelains created at Beijing’s Forbidden City’s imperial workshops are referred to by this title. Part of the enamels were brought in from the West. Production started in 1696, the 35th year of the Kangxi dynasty Manufactured in the imperial palace, its use was strictly restricted to the emperor, empress, and empress dowager. Due to excessive costs, productivity remained restricted.

From 1644 to 1911, Falangcai porcelains were among the most exquisite and unique ceramic goods produced during the Qing period. In the present market, collectors and connoisseurs continue to pursue these artifacts. At auction, top examples might fetch between HK 100 million and HK 200 million (Fu et al., 2025). That comes to around $13 million or $25 million.

Through coated cloisonne ware, Falangcai initially appeared in Chinese porcelain. Fa lan is the general term for enamel in China. Enamel was applied by artisans to a vase with a metal body. The ancient practice of enamelled cloisonne gave rise to Falangcai porcelain.

Most of the imperial items of the Qing dynasty were manufactured at Jiangxi province’s Jingdezhen kilns. Falangcai chose a different path (Wu & Kyungsun, 2024). The process of production was more complicated. Court painters created the Falangcai porcelain. Officials selected white pottery from the greatest Jingdezhen manufacturing. Workers then carried the blanks to the royal workshop inside Beijing’s Forbidden City. Painting, decorating, colouring, and firing took place in the court. The artisans used Falangcai enamels brought from the West. The semi-opaque vitreous structure of these enamels added depth to the designs. The surface of Falangcai porcelains exhibits several layers of paint and bright colors.

Many of the imperial items of the Qing dynasty were manufactured in the Jingdezhen kilns in Jiangxi province. Falangcai followed a different path. Manufacturing was a more complex process. Court painters created the designs on the Falangcai porcelain (Fanni et al., 2022). Officials selected Jingdezhen’s best white ceramics. Workers then carried the blanks to Beijing’s Forbidden City, where the royal workshop was situated. The court was used for burning, painting, decorating, and colouring. The artisans employed Falangcai enamels brought from the West. The semi-opaque vitreous nature of these enamels added depth to the designs. The surface of Falangcai porcelains has rich colors that show several layers of painting.

Artificial Intelligence-Generated Content (AIGC) has shown a significant influence on the domains of creativity and design with the quick development of AI technology. Utilizing textual descriptions, AIGC may produce a variety of artistic output, (Liu & Zhang, 2023), including photos, sounds, films, and 3D models. It can also mimic human aesthetic and creative

processes, offering new sources of inspiration for design techniques. Deeper investigations of cultural heritage and value creation have steadily replaced the technical viability of AIGC as the primary focus of design study in recent years (Bao et al., 2015). More focus is being placed on how AIGC technology may successfully support the innovation and preservation of traditional culture within contemporary design.

Currently, the design community must balance satisfying the needs of contemporary society for sustainability and innovation with maintaining cultural identity and legacy in architecture. On the one hand, it is challenging to precisely duplicate and maintain its beautiful processes in contemporary large-scale manufacturing because to the detailed artistry, high-temperature fire, and use of cobalt blue pigments in the manufacture of Falangcai porcelain. The transfer of Falangcai porcelain workmanship has encountered several difficulties throughout the years (Li et al, 2024). However, in the framework of sustainable development, modern design prioritizes sustainability and how manufacturing procedures affect the environment. Additionally, designers must include cutting-edge technology like 3D printing and artificial intelligence into the creative process of Falangcai porcelain in order to transcend the constraints of conventional porcelain production and investigate novel design approaches and avenues. What contemporary technologies, especially AIGC (Aras et al., 2017), can be used in the new era to bridge the gap between tradition and modernity, as well as aesthetics and ecological sustainability, has become a topic worthy of in-depth investigation in order to overcome the limitations of traditional porcelain creation and explore novel artistic techniques and pathways.

In addition to preserving and passing down the aesthetic qualities of Chinese Falangcai porcelain, this project uses AIGC technologies to investigate creative and sustainable design strategies for cultural heritage.

LITERATURE REVIEW

Jing and Ismail (2023) Uses reconstructive cultural theory and interpretative anthropology as theoretical frameworks to examine the lasting influence of traditional Chinese porcelain art. In order to investigate current preservation strategies among traditional ceramic masters, the KUDAN handmade ceramics industry, and Jingdezhen Ceramic University, the study uses a qualitative research approach and rigorous participant observation. The results show three different contemporary inheritance models that preserve porcelain legacy through

various forms of cultural transmission, such as industrial skills, artisanal practice, and institutional education. This study emphasizes the dynamic relationship between heritage conservation and current creative adaptation by showing how ancient ceramic knowledge is actively recreated within modern social and cultural settings rather than only maintained.

According to Shih (2021), the name "Falang" is specifically mentioned in a painting instruction from the Qing era that was made for export. The manual shows the process of creating porcelain and labels "Falang" in the top right-hand corner of the drawing. Falang mainly refers to two main techniques in Chinese artistic terminology: pinched-wire Falang, also known as cloisonüge, and colored Falang, which is equivalent to painted enamel. Shih (2021) notes that although certain Chinese texts mention a third method called champleños, there is still no historical and tangible proof of its widespread use in China. Chinese artists developed unique stylistic and technical traditions that set Chinese Falang apart from their Western and Middle Eastern counterparts, despite the non-indigenous origins of both painted enamel and cloisonné.

Yan (2024) highlights the Qianlong Emperor's political legacy and historical significance, highlighting his unmatched reign and contribution to the Qing Dynasty's prosperity. The Qianlong Emperor was the longest-reigning and longest-living monarch in Chinese imperial history. He ascended to the throne at the age of 25 and ruled for 60 years before continuing to exercise power as Taishang Huang (Emperor Emeritus) for more than three more years (Yan, 2024). The study demonstrates how, because to robust state finances and efficient governance, the Qing Empire saw geographical growth, ongoing peace, and economic stability during his reign. Yan further emphasizes the symbolic significance of the emperor's several titles, including as Emperor Chun, Emperor Gaozong of Qing, and Qianlong, as representations of his lasting historical grandeur and political legitimacy. In general, the literature presents the Qianlong era as the pinnacle of Qing Dynasty history in terms of both cultural consolidation and imperial power.

Fu (2020) investigates the profound cultural, philosophical, and metaphorical connections between porcelain and important aspects of Chinese culture, such as rice, jade, the Yi (Book of Change), and artistic tradition. The author contends that the agrarian underpinnings of Chinese civilization, notably rice cultivation, are inextricably linked to the development of porcelain from a narrative and cultural standpoint. Both the domestication of plants and the manufacturing of ceramics are described as simultaneous processes that require tolerance, care, and balance with natural cycles. According to Fu, the development of the ceramic industry in a

society that was mostly based on agriculture was culturally inevitable rather than accidental. Additionally, the idea of porcelain's "rice nature" is highlighted to draw attention to its innate softness and unctuousness, which symbolically link it to living, organic aspects rather than just material worth. Because of this connection, porcelain's value surpasses that of costly materials like gold and jade. Additionally, the research places ceramic processing within the philosophical framework of Yi-ology, specifically focusing on the Five Elements, cyclical vertical and circular movements, and yin-yang concepts. By using this perspective, Fu presents porcelain as a material representation of Chinese cosmology and cultural identity in addition to a useful or artistic product.

According to Huang (2008), Jingdezhen is a strategically important city situated in the mineral-rich alluvial plains of Jiangxi Province, some 300 miles southwest of Shanghai. Rough topography, granite formations, and the river systems of the Xinjiang and Raohe basins, which traditionally supported both agricultural output and ceramic manufacture, are characteristics of the area. In the past, Jingdezhen was regarded as a portion of the lower Yangtze River valley, a region renowned for its commercial importance and fertile terrain. Through the Cheng River, which connected it to Poyang Lake and the Yangtze River commerce network, the city maintained a crucial connection to Jiujiang. Jiujiang served as a significant customs station under the Qing period (1644–1911), and after British military intervention in 1861, it became a treaty port. Jingdezhen ever functioned as an administrative capital, despite its economic significance as a significant market town and hub for porcelain manufacture. Rather, county-level administration was carried out at Fuliang, which is situated along the Cheng River north of Jingdezhen, while prefectural authorities were headquartered in Raozhou (Huang, 2008).

Ke (2024) investigated the historical and archaeological relevance of pottery remnants found in and around Ayutthaya after it collapsed in 1767. Large amounts of pottery fragments have been found in urban areas and adjacent canals, including Falangcai porcelain's, coarse household ceramics, and polychrome types like Bencharong, which are uniquely connected with Thailand. These artifacts, which are kept in both private and museum collections, are essential sources of information for comprehending the Ayutthaya period's material culture. Ke (2024) provides insights regarding the Chinese presence in Siam, trading patterns, ceramic manufacturing technology, and the wider political and economic ties between China and Siam before Ayutthaya fell by tracking the provenance of these ceramics. The research is divided into three primary sections, the first of which focuses on the growth of China's ceramic industry in the early Qing dynasty. The Manchu-led Qing Dynasty took power when the Ming Dynasty fell

in 1644, bringing with it political and economic unrest that first hampered commerce and pottery manufacture between China and Siam. However, Ke (2024) points out that the ceramics industry's quick rebound and subsequent growth, strengthening its position in regional and worldwide trade networks, were made possible by the personal patronage and backing of three early Qing emperors as well as strong international demand.

In the 1720s, enamelled porcelain emerged as a major technological and cultural advancement in Chinese ceramic manufacture, according to Tang (2017). The study demonstrates how the development of new enamel materials and painting methods revolutionized the production of porcelain and increased its market share both domestically and abroad. Tang fills a crucial gap by examining how enamelled porcelain affects production processes, consumption trends, and export networks, whereas prior research has mostly concentrated on the artistic and imperial value of the material. The study shows that both local manufacturers and the Qing court actively participated in technical innovation through a historical examination of eighteenth-century manufacturing practices. While local producers modified these developments to satisfy expanding market needs, the court was crucial in promoting the transfer of technological information. By demonstrating that enamelled porcelain was extensively used by a variety of socioeconomic strata inside the home market, Tang further refutes the generally held belief that it was mostly used for imperial purposes. Overall, the study advances our knowledge of how technological advancements in ceramic manufacturing affected consumer accessibility, market structures, and the interaction between small businesses and governmental institutions in Qing-era China.

After Ayutthaya collapsed in 1767, Bisalputra (2017) investigated the vast ceramic and pottery fragments found around the city and its surrounding river systems. The research highlights a variety of ceramic varieties, such as coarse utilitarian tableware, elegant Falangcai porcelain's porcelain, and Thailand's characteristic polychrome Bencharong ware. The author claims that these archaeological artifacts are essential evidence for comprehending historical trade networks, pottery manufacturing methods, and the character of China-Siam interactions during the Ayutthaya period. Furthermore, the existence of fine ceramics in museums and private collections highlights the importance of the Chinese population in influencing the city's trade and cultural contacts and demonstrates Ayutthaya's economic success before its collapse. The research positions ceramics as a valuable material source for reconstructing the socio-economic and international trade dynamics of pre-collapse Siam

By examining seven bowls and two adorned dishes from the Kangxi, Yongzheng, Qianlong, and Daoguang dynasties, d'Abrigeon (2022) carried out a thorough scientific examination of the materials and techniques employed in Qing Dynasty royal porcelains. The composition of glazes, enamels, and coloring agents employed in both ornamental motifs and background fields was effectively determined by the research using a combination of non-invasive portable analytical techniques, Raman microscopy, and X-ray fluorescence spectroscopy. The results showed that although red and blue enamels were made using either gold or copper nanoparticles implanted in lead-based silicate matrices, the distinctive honey-colored backgrounds were caused by gold nanoparticles mixed with lead- and arsenic-based fluxes. Furthermore, tin and arsenic were often found in enamel layers, with lead-calcium/potassium arsenates being the most prevalent opacifying substances. Notably, purposeful material variation in pigment formulation was shown by the obvious detection of cassiterite (SnO_2) in several yellow enamels and in one ornamented plate. This work emphasizes the complexity of historical enamel engineering and makes a substantial technological contribution to the knowledge of Qing imperial porcelain manufacture.

Previous investigation on enamelled ceramics from the Qing dynasty has mostly focused on the aesthetic preferences of the Qing emperors as well as the technological and stylistic advancements of materials like porcelain, enamels, and glass (Shih, 2005). Instead of portraying painted enamels as a cohesive artistic trend, these studies typically position them as a reflection of imperial taste and technological advancement. But by analyzing a single collection of painted enamels at the Qing court as a purposeful and ambitious creative endeavor, Shih (2005) presents a unique analytical viewpoint. According to the research, Emperors Kangxi, Yongzheng, and Qianlong aimed to create a new Qing art form that would compete with and even outperform Ming overglaze-enamel porcelains and European painted enamels. By expanding the analytical framework beyond conventional stylistic and technological narratives, this interpretation is bolstered by an interdisciplinary examination of imperial glass and enamel workshops, genuine Qing court inventories, European missionary records, and recently published imperial archival materials.

Yan (2024) addresses the longest reign in Chinese imperial history, that of the Kangxi Emperor (1654–1722), who took the Qing throne at the age of eight and ruled for 61 years. The author highlights that the imperial porcelains made during this time are renowned for their grandeur and grace, representing not just technical skill but also the wider cultural and ideological tendencies of the time. Yan claims that Kangxi's fervent support of Confucian

principles, cultural sophistication, and political stability created an atmosphere where creative creation—especially porcelain craftsmanship—was elevated to a symbol of imperial power and cultural legitimacy. The Kangxi-era porcelain's artistic sophistication was a result of the imperial kilns at Jingdezhen's long-term state support, access to talented craftspeople, and advancements in glaze and ornamental methods. The emperor's concept of harmony between government and artistic quality was reinforced by this cultural orientation, economic success, and administrative consolidation, which positioned porcelain manufacture as both a diplomatic tool and a symbol of Qing cultural identity.

By examining its formal, symbolic, and cultural characteristics during the Ming and Qing Dynasties, Shin (2022) investigates the uniqueness of gourd-patterned porcelain as a category of European export ware. According to the study, gourd-patterned porcelain usually features a primary design inspired by classical iconography or antique bronzeware, complemented by complementing motifs like Gilxiang (auspicious symbols), Wenfang Qingjing (scholarly elegance), and the Eight Treasures. The aesthetic ideals and intellectual interests of the Chinese literati are reflected in these features, especially in the mid-to-late seventeenth century, when academic elites became increasingly interested in antiquity and bronzeware. Shin (2022) contends that as the commodity economy grew and artistic objects became more widely available, this enjoyment of culture spread beyond the literati class throughout the Qing Dynasty. Gourd-patterned China thus gained popularity among all social classes, including the imperial court. The study also highlights how the expansion of East-West trade networks throughout the seventeenth and eighteenth centuries made it easier to export these goods on a big scale to Europe. Gourd-patterned porcelain developed a unique character as a type of European export porcelain through this transcontinental movement, fusing Chinese symbolic customs with needs from overseas markets.

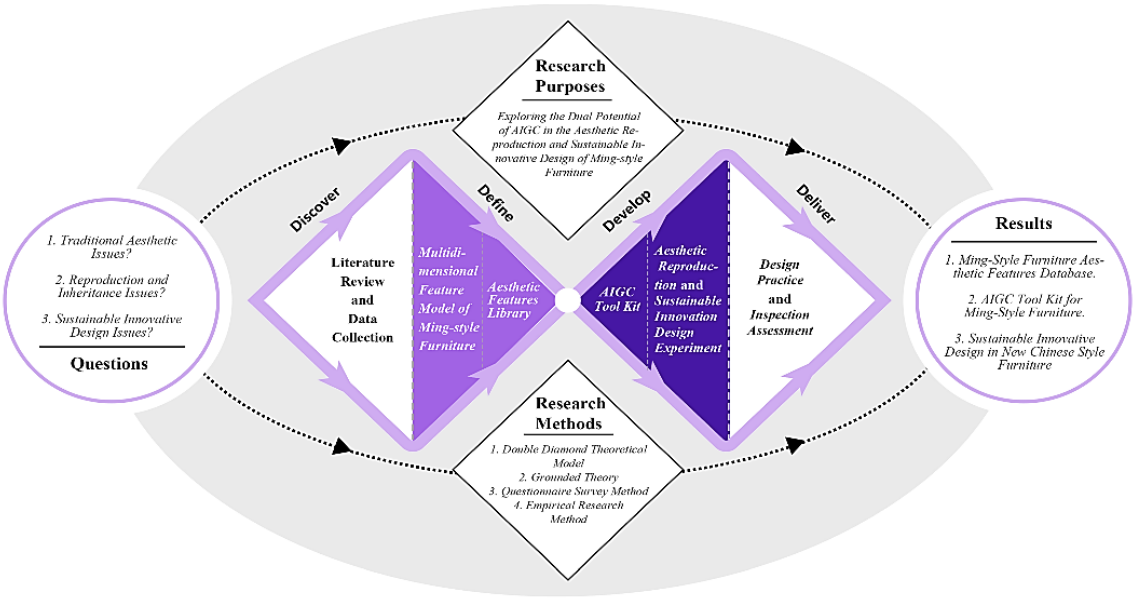
In summary, the use of AIGC technology to support the sustainable design and inheritance of Falangcai porcelain's aesthetic cultural DNA is still in its infancy. Our research is a major step in maintaining the beauty of Falangcai porcelain. We hope to improve design efficiency, simplify the creative process, and solve current technological issues by thoroughly investigating the dual potential of AIGC technology. It is anticipated that this study will offer fresh perspectives on the subject of intangible cultural heritage design's long-term development.

DESIGNED RESEARCH AND METHOD

The combination of methods used in this study, which includes a grounded theory, the KANO model, and the AHP (Analytic Hierarchy Process) method, will be thoroughly clarified in this section along with how these research techniques are applied to both qualitative and quantitative evaluation of the aesthetic characteristics of Falangcai porcelain.

The potential benefits of AIGC technology in the transmission of cultural genes and sustainable, creative design of Falangcai porcelain's was investigated using this model. In order to guarantee the thoroughness and dependability of our research findings, the double diamonds design aids study across the two phases of "Discovery" and "Validation". The double diamond model served as the foundation for the research method structure, as seen in Figure 3 (Park, 2021).

Figure 3.
Develop a framework for research based on the double diamonds model



Note. Iansiti (2020).

Developing a multidimensional aesthetic characteristic library for Falangcai porcelain inside the double diamond model was the focus of the second phase, "Definition." Three-stage coding based on grounded theory was used to examine user interview data, along with Kano model questionnaires that included both positive and negative elements (Iansiti, 2020). After classifying aesthetic qualities into basic, performance, appealing, and indifferent categories using the Better–Worse quadrant coefficient analysis, important factors affecting these aspects were quantitatively examined. The primary aesthetic components of Falangcai porcelain were

then prioritized using the Analytic Hierarchy Process (AHP), creating a multidimensional esthetic feature library.

The grounded theory approach was used in this study to methodically determine and improve the Falangcai porcelain's aesthetic characteristics.

In order to guarantee that the final aesthetic framework had theoretical saturation and explanatory force, the aesthetic qualities of Falangcai porcelain were coded and collected utilizing a dynamic, iterative, and complimentary method.

Professor Noriaki Kano of the Tokyo Institute of Technology created the Kano model in the 1980s as an empirical technique to examine and comprehend the connection between user requirements and satisfaction (Peng, 2024). The Kano model's central idea is to classify user demands according to how they affect user happiness, which offers direction for product creation, quality enhancement, and customer experience improvement.

The use of the Kano model in this study offered a logical foundation for the categorization, weight ranking, and user demand placement of the aesthetic components of Falangcai porcelain, matching the aesthetic qualities of traditional craftsmanship with contemporary user requirements and further elucidating the relative significance of each characteristic.

Experimental Process

Developing a Multidimensional Aesthetics Feature Library for Falangcai Porcelain Utilizing the KANO-AHP Hybrid Modeling and Grounded Theory

A semi-structured interview framework on the aesthetic qualities of Falangcai porcelain patterns was created by an expert panel made up of five university professors with expertise in Falangcai porcelain art study and cultural intangibles inheritors (Mirza, 2020). Specific information is included in Table 1.

Table 1.
Summary of semi-structured interview questions

S/No.	Semi-structure Interview Questions
1	Which aspects of the Falangcai porcelain designs do you believe best capture their aesthetic qualities?
2	In what ways do you think Chinese cultural traditions' aesthetic aspirations are reflected in the Falangcai porcelain patterns?
3	What distinctive characteristics do you believe Falangcai porcelain designs have? What effects do they have on aesthetics?
4	Which guidelines do you believe are often adhered to while creating Falangcai porcelain patterns?
5	Which artisan elements, in your opinion, best encapsulate the visual appeal of Falangcai porcelain designs?
6	How may the aesthetic qualities of Falangcai porcelain designs be innovated and passed down?

Note. Researcher's findings.

In order to get the most recent information on the aesthetic qualities of Falangcai porcelain patterns, interview subjects were screened using particular inclusion criteria, such as:

(a) Possessing a master's degree or higher in fields linked to traditional handicraft or ceramic artistic design;

(b) Focusing on fields like multidisciplinary study, art history, ceramic art, or traditional craftsmanship; and

(c) Professionals with more than three years of experience in ceramic production, research, or craftsmanship, such as Falangcai porcelain makers, academics teaching ceramic art and design at universities, PhD candidates studying Falangcai porcelain, or researchers working on creative entrepreneurship projects or porcelain culture preservation. Refer to Table 2 for comprehensive information about participants information.

Table 2.
Demographics of Semi-Structured Interviews (n-15)

Participants	Research Field	Age	Education Level	Workplace	Employment Qualifications	Location
P1	Exploration of Contemporary Ceramic Art and Ceramic Craft Research	30	Master	University Lecture	Five years as a lecturer and more than eight years of expertise in ceramic design	Wuhan, China
P2	Intangible Cultural Heritage's Digital Transformation	25	Ph.D	Research Assistant, Tongji University	One year as a research assistant and more than five years of design experience	Shanghai, China
P3	Research on Falangcai Porcelain Craftsmanship	36	Master	Independent Studio	Falangcai porcelain intangible heritage inheritor	Chaozhou, China
P4	AIGC and Sustainable Design for Intangible Cultural Heritage	24	Master	Doctoral Student, Hanyang University	Three years of experience designing intangible cultural heritage	Seoul, republic of korea
P5	Craftsmanship in Falangcai porcelain's	41	Ph.D	Independent Studio	inheritor of the ethereal Falangcai porcelain legacy	Jigdezhen, China
P6	Research on Ancient Ceramics	40	Master	Intangible Cultural Heritage Research Institute	An heir to the technique of Falangcai porcelain	Bejing, China
P7	Intangible Cultural Assets Innovation Design and AIGC	33	Ph.D	Doctoral Student, Hanyang University	Five years of research experience in ceramic art	Seoul, republic of korea
P8	Ancient Ceramic Art Research	25	Master	Senior Designer of Ceramic Products	inheritor of the ethereal Falangcai porcelain legacy	Jingdezhen, China
P9	Digital Transmission and Preservation of Cultural Heritage	29	Ph.D	Tongji University School of Creativity	Two years of research experience and seven years of design experience	Shanghai, China

P10	Ceamic Art design	28	Master	Doctoral Student, China Academy of Art	More than nine years of ceramic art design experience	Hangzhou, China
P11	Ceamic Art design	26	Ph.D	Chinese Academy of Arts	More than six years of ceramic art design experience	Beijing, China
P12	Research on Digital Cultural Heritage	33	Master	School of Art, Renmin University of China	5 years of teaching experience and 12 years of design experience	Beijing, China
P13	Falangcai porcelain's Art	32	Master	Independent Studio	inheritor of the intangible legacy of Falangcai porcelain's porcelain	Jingdezhen, China
P14	Current Research on Ceramic Creation	30	Ph.D	China Ceramic Art Research Center	More than eight years of ceramic art design experience	Beijing, China
P15	Ceamic Art design	38	Master	Jingdezhen Ceramic University	More than five years of ceramic art design experience	Jingdezhen, China

Note. Researcher's findings.

Participants had to assess each demand element in the particular implementation process from two perspectives: the positive dimension (the degree satisfaction rises when the demand is satisfied) and the negative dimension (the degree of satisfaction falls when the demand is not met). Table 3 provides specific details. In addition to integrating the KANO model's classification outcomes with users' quantitative assessments of elements' importance, the dual scoring approach for the positive and negative dimensions offers a more thorough empirical basis for further AHP analysis and the development of environmentally friendly design approaches.

Table 3.
The structure of Kano questions for gathering the aesthetic qualities of Falangcai porcelain patterns

User needs	Questions	Favourite	Necessary	Indifferent	Reluctant	Disgusting
The primary visual elements of porcelain designs in shades of Falangcai porcelain's	If you possess this attractive quality, how do you feel?	□	□	□	□	□
	Without this visual element, how would you feel?	□	□	□	□	□

Note. Researcher's findings.

Thirdly, using the information gathered from the user survey, reliability and validity assessments were carried out; the comprehensive findings are displayed in Table 4. The dependability of the data was thoroughly evaluated using SPSS 26.0 software following the merger of the online and offline data (Xiong, 2024). First, Cronbach's α coefficient was used to examine the data's reliability and evaluate the scale's stability in general.

Table 4.
Bartlett test and KMO

KMO value	**0.549**	
Barlett's test of sphericity	**Approximate chi-square**	8971.00
	DF value	745.00
	p-Value	0.000

Note. Researcher's findings.

Lastly, each indication in the categorized evaluation index system's proportion of demanding kinds was statistically examined. As shown in Table 5, the final type for each indication was determined to be the demand element that occurred most frequently. Attractive elements (A), must-be elements (M), expected elements (O), indifferent elements (I), and reverse elements (R) all had statistically equal distribution of demand elements. The data's overall dependability is excellent, and the assessment indicators' design makes sense.

Table 5.
Results from the User Demand Survey on the Visual Appeal of Falangcai Porcelain Patterns

Numbers	Percentage (%)					Type	SI	DSI
	(A)	(R)	(M)	(I)	(Q)			
A1. Transparency Patterns	41.52 %	41.52 %	14.59%	15.25 %	0%	I	35.59%	-63.25 %
A2. Contest Patterns	62.69 %	62.53 %	22.26%	26.14 %	0%	I	48.29%	-21.99 %
A3. Layering Patterns	15.89 %	22.56 %	65.25%	25.69 %	0%	I	42.02%	-36.59 %
A4. Hue Patterns	25.61 %	21.59 %	33.15%	22.69 %	0%	M	96.59%	-36.96 %
A5. Religious Patterns	21.59 %	41.25 %	14.52%	14.25 %	0%	M	41.52%	-14.52 %
A6. Text Patterns	26.25 %	63.25 %	62.14%	63.25 %	0%	M	62.12%	-61.59 %
A7. Artifact Patterns	14.65 %	21.56 %	26.25%	36.54 %	0%	M	15.62%	-65.82 %
A8. Landscape Patterns	28.96 %	23.66 %	32.32%	25.52 %	0%	A	21.96%	-29.65 %
A9. Figure Patterns	22.64 %	25.45 %	29.63%	63.25 %	0%	A	64.58%	-25.49 %
A10. Geometric Patterns	41.25 %	59.62 %	25.69%	93.65 %	0%	M	48.96%	-36.59 %
A11. Animal Patterns	25.96 %	25.96 %	33.14%	55.62 %	0%	A	95.62%	-65.59 %
A12. Plant Patterns	15.62 %	65.58 %	65.21%	32.52 %	0%	A	62.89%	52.89 %
A13. Symmetry Patterns	14.52 %	22.54 %	65.25%	54.62 %	0%	A	59.63%	-54.21 %
A14. Balance	11.65 %	21.62 %	31.52%	63.26 %	0%	I	64.89%	-65.95 %
A15. Centralized Layout	19.62 %	33.65 %	63.59%	95.63 %	0%	I	25.96%	-25.96 %
A16. Scattered Layout	52.66 %	25.65 %	65.99%	65.94 %	0%	M	96.32%	-21.63 %
A17. Line Fluidity	25.65 %	32.63 %	65.61%	62.58 %	0%	M	65.59%	-99.59 %
A18. Pattern Simplification	41.25 %	59.62 %	25.69%	93.65 %	0%	M	48.96%	-36.59 %

A19. Structural Features	36.26 %	33.64 %	25.63%	31.58 %	0%	I	25.63%	- 34.56 %
A20. Spatial Perception	21.36 %	96.65 %	48.96%	96.54 %	0%	O	66.54%	- 26.59 %
A21. Handmade Painting	55.62 %	22.69 %	36.54%	25.96 %	0%	O	96.59%	- 49.65 %
A22. Engraving and Filling	36.96 %	36.54 %	96.59%	59.69 %	0%	A	51.26%	- 98.65 %
A23. Underglaze Colouring Techniques	21.69 %	25.64 %	14.52%	12.69 %	0%	I	61.66%	- 54.55 %
A24. Gradient Effects	25.66 %	23.15 %	96.65%	21.52 %	0%	O	41.69%	- 96.48 %
A25.Religion and Philosophy	28.21 %	26.32 %	25.63%	63.26 %	0%	O	99.96%	- 95.63 %
A26. Symbolic Meaning	63.52 %	56.32 %	15.69%	65.69 %	0%	O	65.52%	- 62.65 %
A27. Traditional Auspicious Symbol	26.25 %	25.55 %	41.58%	69.54 %	0%	A	96.55%	- 94.51 %
A28. Historical Culture	32.22 %	99.92 %	94.52%	88.41 %	0%	M	21.58%	- 55.62 %
A29.Nature Themes	96.14 %	54.89 %	89.65%	58.96 %	0%	I	99.54%	- 14.52 %
A30. Mythological Legends	58.96 %	25.69 %	98.54%	32.51 %	0%	O	14.59%	- 65.98 %
A31. Life Senses	98.96 %	64.89 %	28.96%	69.58 %	0%	O	59.89%	- 65.21 %

Note. Researcher's findings.

Ten professionals in manufacturing design (Fang, 2024), porcelain design, and visual design were asked to do pairwise assessments of the main aesthetic features of Falangcai porcelain based on the findings of grounded theory estimate and Kano model evaluation. The structure of judgment matrix A was the following:

$$A = (a_{ij})_{n\times n} \text{ .....1}$$

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} (i, j = 1,2,3 \ldots . . n.) \text{ .....2}$$

$$c_i = \sum_{j=1}^{n} b_{ij} (i, j = 1,2,3, \ldots, n) \text{ .....3}$$

$$\omega_i = \frac{c_i}{\sum_{i=1}^{n} c_i} (i = 1,2,3, \ldots, n) \text{ .....4}$$

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(PW)_i}{nW_i} (i, j = 1,2,3 \ldots . . , n). \text{ .....5}$$

$$a_{ij} > 0, a_{ij} = 1, a_{ij} = \frac{1}{a_{ij}}, (i, j = 1,2,3, \ldots, n) \text{ .....6}$$

$$CI = \frac{\lambda_{max} - n}{n-1} \text{ .....7}$$

$$CR = \frac{CI}{RI} \text{ .....8}$$

The evaluation matrix for the user demand criterion layer of the aesthetic qualities of Falangcai porcelain patterns was initially created using the Analytic Hierarchy Process (AHP), as indicated in Table 6.

Table 6.
Judgment matrix at the criterion levels

Index	Must-Be Needs (M)	Attractive Needs (A)	One-dimensional Needs (O)	Weighted Value	I_{CR}
Attractive Needs (A)	1	3	5	0.5489	0.0189
Must-Be Needs (M)	1/3	1	3	0.2148	
One-dimensional Needs (O)	1/5	1/3	1	0.6598	

Note. Researcher's findings.

Formulas (2)–(4) were used to determine the weight values of each indication. Formula (5) was then used to get the greatest eigenvalue, yielding λmax = 3.0387. The judgment matrix is consistent, as shown by the Consistency Ratio (ICR) (Liu, 2023), which was found to be 0.0372 < 0.1 using Formulas (6) and (7). The weight values of each indication were determined by applying the same method as the sub-criteria layer judgment matrix, as indicated in Table 7

Table 7.
Sub-Index Judgment matrix

Primary Index	Secondary Index	Judgment Matrix							Weight	I_{CR}
The must-be needs (M)	M1. Plant Patterns	1	3	5	1	2			0.6639	0.9767
	M2. Animal Patterns	1/3	1	1/2	1/3	1/3			0.6563	
	M3. Geometric Patterns	1/5	2	1	1/3	1/5	/		0.2549	
	M4. Traditional Auspicious Symbols	1	3	3	1	3			0.3369	
	M5. Symbolic Meanings	1/2	3	5	1/3	1			0.2159	
The one-dimensional needs (O)	O1. Hue	1	1/3	2	1/5	1/2	1/5		0.6350	0.7547
	O2. Layering	3	1	2	1	1/3	2		0.9890	
	O3. Symmetry	1/2	1/2	1	1/3	1/5	1/3		0.6320	
	O4. Line Fluidity	5	1	3	1	1/2	2	/	0.9789	
	O5. Structural Features	2	3	5	2	1	3		0.6359	
	O6. Handmade Painting	5	1/2	3	1/2	1/3	1		0.5489	
The attractive needs (A)	A1. Character pattern	1	1/2	5	2	1/5	1/4	1/3	0.6325	07973
	A2. Landscape Patterns	2	1	3	2	1/3	1/2	1/3	0.9865	
	A3. Contrast	1/5	1/3	1	1/5	1/4	1/5	1/3	0.6489	
	A4. Balance	1/2	1/2	5	1	1/2	1/2	1/2	0.6359	
	A5. Gradient Effects	5	3	4	2	1	3	3	0.5489	
	A6. Historical Culture	4	2	5	2	1/3	1	2	0.6325	
	A7. Nature Themes	1	1/2	5	2	1/5	1/4	1/3	0.9862	

Note. Researcher's findings.

As shown in Figure 4, they also worked with the China Pattern Online Museum to compile 375 high-resolution images of Falangcai porcelain patterns. In addition to covering the variety of Falangcai porcelain aesthetic qualities, these data resources offer a solid foundation for innovative design and long-term cultural heritage preservation.

Figure 4

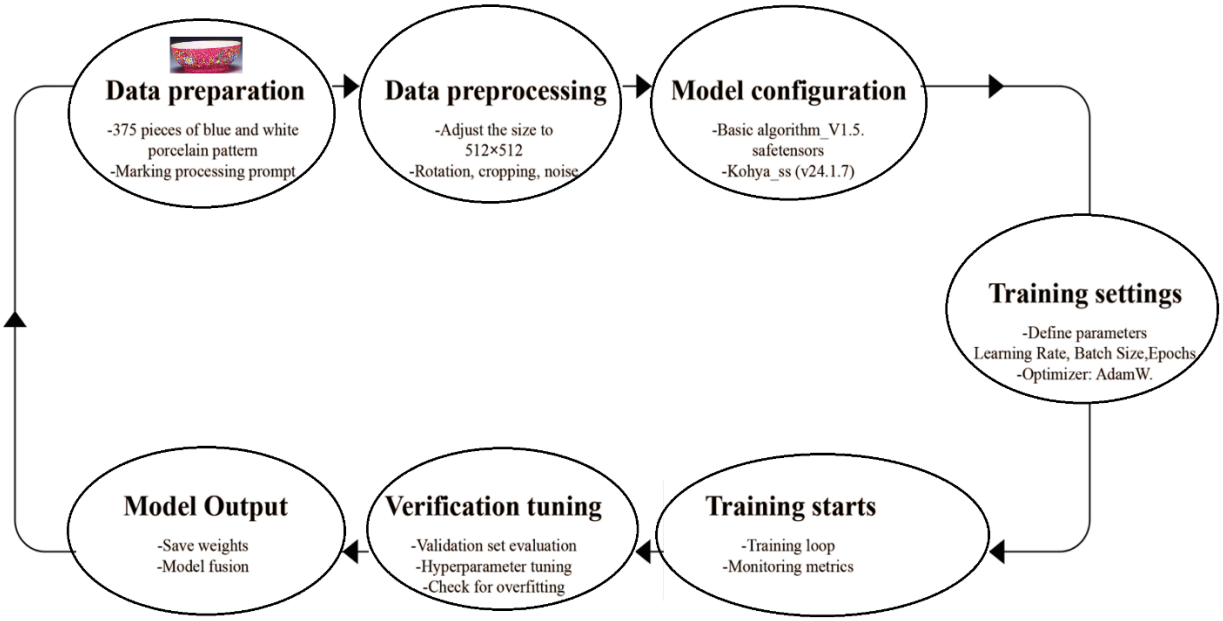
Esthetic feature dataset for Falangcai porcelain patterns based on a hybrid method of investigation

Note. China Pattern Online Museum.

Training with the Falangcai Porcelain LoRA Models

Generative Adversarial Networks (GANs) provide an unparalleled method for automatically generating high-quality pattern images in the study of cultural gene inheritance and creative creation of Falangcai porcelain patterns (Xu, 2024). This work developed a Stable Diffusion (SD) deep learning model using the esthetic feature library of Falangcai porcelain patterns as the data basis. Kohya_ss (v24.1.7), a community-developed complete toolkit for training, fine-tuning, and optimizing large-scale modeling of languages (LLM) and diffusing algorithms, was used to help the LoRA model development, as seen in Figure 5.

Figure 5.
Research methodology for LoRA training.



Note. Researcher's findings.

As a result, dynamic modifications to the training data were needed throughout the LoRA model's training, as Tables 8 and 9 show.

Table 8.
Training Parameters for Lora (1)

Dataset Size	Resolution	Batch Size	Max Epochs	Save Evenryn Epochs	Network Dim	Network Alpha	Clip Skip	LR	UNet LR
277	512×512	2	8	2	65	2	2	0.0001	0.0001

Note. Researcher's findings.

Table 9.
Training Parameters for Lora (2)

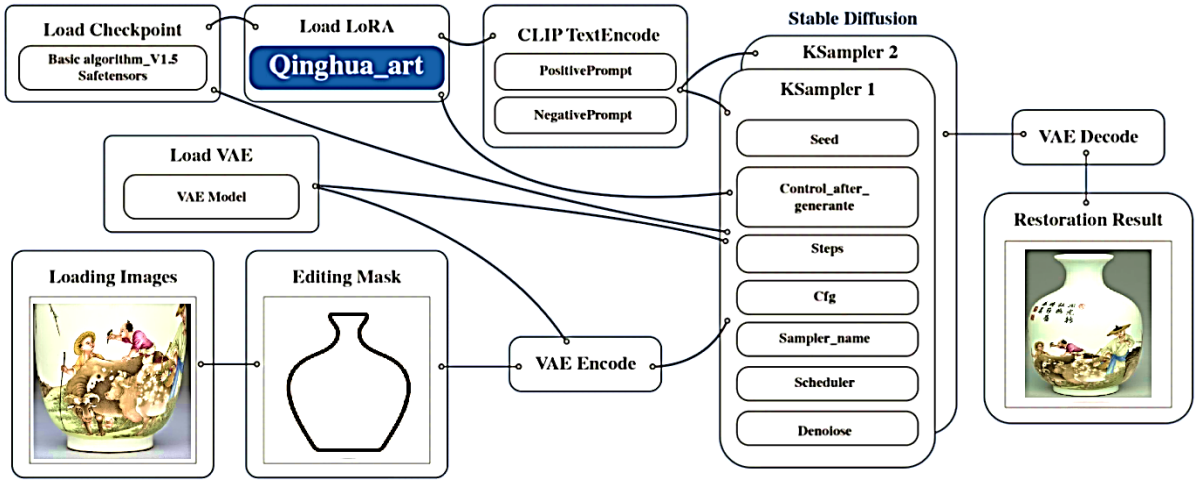
Text Encoder	LR LRScheduler	LR Restart Cycle's	Persistent Data loader Workers	Noise Offset	LoCOn COnvDIm	Conv Alpha	Approx. Training Time
0.0001	Cosine_with_restarts	1	2	0.2	4	0.1	1

Note. Researcher's findings.

Innovative design workflow for Falangcai porcelain pattern

As shown in Figure 6, this study created a novel design workflow for Falangcai porcelain designs utilizing artificial intelligence-generated content (AIGC). It provides an effective and adaptable solution for the digital inheritance and contemporary creative design of Falangcai porcelain patterns by combining the Stable Diffusion (SD) framework, Low-Rank Adaptation (LoRA) technologies, and optimal text generation instruction (Dai, 2024). This method encourages the creative application of traditional abilities in the digital age by enabling designers to quickly simulate and assess creative Falangcai porcelain design plans without depending on tangible resources.

Figure 6.
Innovative Falangcai porcelain design process based on Comfy UI



Note. Researcher's findings.

Utilizing sustainable design theory to create novel design pathways for Falangcai porcelain

It is now essential for the design community to include sustainable development ideas into the creative design of traditional cultural arts due to the ongoing escalation of global resource use and environmental strain (Park, 2021). The development of Artificial Intelligence-Generated Contents (AIGC) technology and the digitalization of traditional cultural DNA have created new opportunities for creative and sustainability cultural heritage architecture.

The primary objective of this investigation was to investigate particular approaches for fusing Falangcai porcelain production with sustainable design concepts. Different Falangcai porcelain design plans may be effectively simulated and replicated virtually using generating artificial intelligence (AIGC) technology, especially the LoRA model on the Stable Diffusion platform. Without using actual resources, designers may quickly create and assess many

Falangcai porcelain design plans, greatly lowering the design processes' environmental impact (Peng, 2024).

The Falangcai porcelain patterns' aesthetic qualities, the transfer of cultural legacy, innovation, utility, sustainability, technological controllability, user happiness, and market adaptation were among the many aspects that were examined. A thorough and methodical examination was carried out (for specifics, see Tables 10 and 11).

Table 10.
Comparative analysis of Plans A and B in multiple domains

No.	Evaluation Dimension	Average Score of Plan A	Average Score of Plan B
1	Is it possible to replicate Falangcai porcelain patterns' aesthetic qualities?	4.31	3.91
2	Is it possible to successfully pass on the cultural and historical significance of Falangcai porcelain?	3.78	3.54
3	Can innovation be demonstrated?	4.28	3.87
4	How does it perform in terms of functionality?	3.15	2.98
5	Does it include sustainable design principles?	3.24	3.19
6	Is AIGC technology controllable and effectively implemented technically?	4.07	3.15
7	How satisfied are users with the design plan produced by AI?	4.51	3.77
8	Does the design plan produced by AI have great market adaptability?	3.98	3.22

Note. Researcher's findings.

Table 11.
Expert Preference Evaluation for Plans A and B

Description	Choice	Frequency	Percentage
Which design, in your opinion, most accurately captures the aesthetic qualities of Falangcai porcelain when considering its sustainable design and inheritance of artistic values?	Plan A	9	96.9%
	Plan B	5	89.4%
Which design is your favourite in terms of modern porcelain aesthetics?	Plan A	11	94.7%
	Plan B	4	64.7%

Note. Researcher's findings.

RESULT AND DISCUSSION

The use of AIGC technology for the manufacture of Falangcai porcelain and its effects on the preservation of cultural heritage will be thoroughly examined in this section's study of the research findings. This work is based on the Kano-AHP hybrid model, grounded theory, and AIGC image creation technology. This study used Falangcai porcelain as the research subject, methodically and scientifically investigated the aesthetic qualities of porcelain patterns, created a multidimensional database of desirable characteristics for Falangcai porcelain patterns, and used AIGC technology to maintain traditional aesthetics while fostering the efficacy of creative and environmentally friendly design methodologies.

The design process was broken down into five phases. The design object was first thoroughly examined using grounded theory in order to identify the essential cultural genes and aesthetic components of Falangcai porcelain. Second, user needs were examined and the design direction was made clear using the KANO-AHP hybrid model. An AIGC-based cultural gene inheritance database and design methodology were then built throughout the conceptual design and creative development stage, greatly reducing creation time and iteration cycles. Intelligent manufacturing and design were eventually attained by incorporating sustainable design ideas into the design process to improve compatibility with the environment.

Table 12 illustrates how the sustainable innovative design model suggested in this study achieves notable improvements in a number of areas, including design concepts, choosing materials, tools for designing, design procedures, production processes, user participation, environmental impact, and sustainable innovation design, when compared to conventional Falangcai porcelain design pathways. The application value of AIGC technology for the inheritance of Falangcai porcelain cultural genes and ecologically conscious design is validated by this methodical investigation, which also offers a useful theoretical framework and useful technique for fusing traditional culture with modern technologies.

Table 12.
A Comparative Study of the AIGC Sustainable Innovative Design Model and Conventional Falangcai Porecelain Production

Comparison Dimensions	Conventional Porcelain Design Model in Falangcai porcelain's	AIGC Sustainable Innovative Falangcai Porcelain Design Model
Design Concept	Prioritizes the preservation of traditional aesthetic values and historical and cultural symbols over sustainability.	This method emphasizes cultural variety and sustainable development by fusing Falangcai porcelain features with modern aesthetics through the incorporation of AIGC technology into the design process.
Material Selection	It depends on conventional materials and pays little attention to environmental and low-carbon regulations.	Reduces carbon emissions during manufacturing by methodically assessing the ecological impact of resources and giving low-carbon, recyclable, and ecologically friendly materials priority.
Design Tools	Depends on antiquated techniques like manual modeling and hand sketching, which lengthens design cycles.	Utilizes AIGC technologies and extensive model training to accomplish data-driven and intelligent design, increasing design efficiency and speeding up creative production.
Design Process	Master artisans dominate the design process, which lacks data-driven tactics and insufficient user requirements research.	emphasizes data-driven strategies in line with user demands and employs a methodical, phased design process that includes comprehensive object research, user demand evaluation, large-scale training of models, conceptual innovation creation, and integration of environmentally friendly options.
Production Process	Manual craftsmanship, which is characterized by drawn-out, time-consuming procedures and significant resource use, is the primary method of production.	Reduces resource input, increases production efficiency, and optimizes manufacturing procedures by implementing intelligent, partially or completely automated workflows.
User Participation	Inadequate user participation in the design process is caused by a lack of outlets for user feedback.	Enhances user engagement and interactivity by directly incorporating user feedback and preferences into the design process through the application of grounded theory and the KANO-AHP model to assess user needs.
Environmental Impact	Lacks comprehensive environmental evaluations and has insufficient control over pollution reduction and resource usage.	Uses techniques including reduction, reuse, recycling, repair, and redesign to improve design and manufacturing processes and minimize environmental effect in accordance with carbon neutrality principles.

Innovation and Sustainable Design	There is little innovation and a focus on passing down craftsmanship while ignoring the needs of sustainable growth.	Uses data analysis and technical iteration to drive the concurrent growth of digitalization and green innovation in Falangcai porcelain design, deeply integrating design with sustainability principles.

Note. Researcher's findings.

Generally speaking, modeling in the context of art and design refers to an object's shape, frame, and appearance. Numerous methods, such as sculpture, painting, construction, and handicraft, are used to create this visual expression. Shape, structure, proportion, line, surface treatment, and other features are all included. Modelling is essentially a representation of an artwork's external shape and appearance. Changing the shape of lines, points, surfaces, and body blocks in ceramic tea ware allows for the modeling of visual patterns. The arrangement of forms and structures, as well as the overall aesthetic and coordinating qualities of these pieces, are highlighted in this procedure. The general shape of the teapot, teacup, tea bowl, and other items, the design of handles, lid knobs, and other locations, surface decoration, carving, etc. are all included in the modeling of a ceramic tea set. The ceramic tea set demonstrates a unique creative sense and cultural meaning in addition to fulfilling its utilitarian purpose thanks to the implementation of an efficient modeling design. The application of traditional Chinese cultural elements may be seen in the shape, structure, ornamentation, and other parts of a ceramic tea set's modeling design, resulting in an afternoon tea set that is infused with the unique flavour of traditional Chinese culture.

The design may be categorized as being in the conventional classical style. In this situation, it's critical to make sure the form is full and rounded, the lines are natural and smooth, and the center of gravity is steady. Other artifacts, such teapots, teacups, and tea cups, can also be used using this idea. An aura of historic elegance is evidenced by the modeling of old China and metal. Ceramic tea sets' handles and other components, including knobs, are made using conventional sculpture methods or by adding mythological creatures like unicorns, dragons, and phoenixes. The animals often represent fortunate, virtuous, and religious concepts.

The study explored the use of AI technologies, namely generative AI based on LoRA and Stable Diffusion, in the production of Falangcai porcelain. Its effects on both contemporary porcelain manufacture and traditional artistry were examined. According to this study, generative AI-assisted design may be used in contemporary porcelain manufacturing to quickly

produce a variety of design possibilities, greatly increasing creative efficiency and customizability.

Future research will also seek to create multidimensional criteria to analyze the efficacy of technological interventions in order to evaluate the function of AIGC in the transmission and preservation of cultural assets. The first parameter is called "esthetic fidelity," which assesses how closely AI-generated patterns resemble traditional handcrafted designs in terms of shape, lines, and colors. This helps determine whether or not AI-generated patterns may reactivate the "cultural gene" of Falangcai porcelain.

Falangcai is the term for imperial overglaze enamel porcelain that was created in the early 18th century, especially at the imperial workshops and Jingdezhen kilns during the Qing Dynasty. Cross-cultural interaction led to its growth; missionaries and court artists brought perspective painting skills and Western enamel pigment processes, which opened up new creative possibilities for porcelain ornamentation.

Pattern education often emphasizes two aspects in many conventional ceramic designs' curriculum, particularly those influenced by historical craft and skill-based pedagogy:

- **Formal Recognition:** Based on visual templates, students learn to recognize and imitate well-known themes, such as imperial insignia, figures, or flowery scrolls. This is similar to traditional apprenticeships, where mastery is assessed by adherence to conventional forms.
- **Technical Skill:** The primary learning objective is considered to be accurate execution, including brushwork, color layering, enamel application, and spatial composition. Assessments are dominated by formal characteristics such proportion, symmetry, and repetition patterning.

In 1716, a special enamelling workshop was established. Another painted enamel production facility was set up in Guanzhou (Custom district) at the same time or earlier. It is well known that the Jesuits lost power under Yongzheng's rule, and it is possible that this was mirrored in the technological methods they brought. The workshops in Beijing, Jingdezhen, or Canton, however, claim that whether they are private or imperial, the methods of alteration may also differ. Therefore, emphasizing the usage of various porcelain recipes or raw materials from the same era can serve as a distinguishing feature of several workshops.

When everything is considered, AIGC offers new opportunities for preserving cultural heritage in addition to improved inventiveness and efficiency for the production of Falangcai porcelain. But it also has to deal with a number of difficulties, such as data problems, cultural authenticity, acceptability by artisans, and copyright issues. It is thought that peaceful cohabitation with traditional handicraft may be accomplished in the future by methodically integrating AI technology with cultural heritage, encouraging the creation and dissemination of Falangcai porcelain cultural.

FINAL CONSIDERATIONS

A complicated relationship between craft method, symbolic language, and visual aesthetics may be seen in the Falangcai porcelain design process. Moving from formal recognition (surface replication) to semantic comprehension (meaningful pattern interpretation and deliberate creation) provides possibilities for more in-depth student participation, cultural awareness, and creative design results in modern ceramic design education.

Through the use of AIGC technology, this study was able to integrate traditional cultural genes with contemporary digital innovation, offering a workable solution for the digital transmission and preservation of cultural heritage while encouraging the long-term growth of the production of Falangcai porcelain. This study used the three-level coding method based on grounded theory to extract the multifaceted aesthetic properties of Falangcai porcelain, encompassing three core aspects: visual characteristics, craftsmanship features, and cultural meanings. It did this by combining AIGC technology with the cultural genes of the porcelain.

It is impossible to separate the use of traditional Chinese cultural themes in porcelain tea set design. In order to improve the usefulness, aesthetics, and modernity of ceramic cultural materials, these cultural elements may be turned into a design language by synthesizing and combining their resources and using the theory and practice of morphosemantics.

While spatial and spectral dimensional models are applied to imaging spectral data of Jingdezhen Falangcai porcelain's of various ages, the results demonstrate that while the accuracy of the spectral dimensional model is clearly superior to that of the spatial dimensional model, it is still less than the model's initial accuracy. Strong cultural history was highlighted by the outstanding performance of the plant and auspicious symbols. Patterns like lotus, peony, and flower patterns scored exceptionally well in both cultural symbolism and aesthetic value,

suggesting that their strong cultural relevance and aesthetic appeal provide significant opportunities for redesign and market adaption in modern design.

Differential performance was seen across current applicability and communicative power parameters. Dragon and phoenix designs are examples of animal motifs that excelled in cultural symbolism yet showed potential for development in terms of sustainability and modern applicability. Due to their complex designs and their reliance on particular cultural settings, these patterns have practical constraints in market translation and commercial application, despite their enormous cultural historical value. In summary, this research offered a thorough examination of the cultural values and potential modern applications of Falangcai porcelain patterns from a variety of angles. Additionally, it suggested certain design guidelines and optimization suggestions suited to various pattern kinds.

Furthermore, using training on the Falangcai porcelain aesthetic feature database, the study created an AIGC-assisted design workflow based on Stable Diffusion and LoRA technologies that successfully produced the creative design and effective replication of Falangcai porcelain patterns.

In order to increase the efficacy of the technology in cultural heritage preservation, further study might further enhance AIGC models to increase the precision and variety of pattern formation and investigate methods to integrate these models more closely with traditional crafting techniques.

In the following study, more sophisticated deep models will be used to concurrently extract spectral and spatial data in order to further investigate the potential of hyperspectral technology in the classification of various ages of Jingdezhen Falangcai porcelain’s.

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CRediT Author Statement

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- **Ethical approval:** This study was conducted in accordance with the ethical standards of institutional and national research committees. Informed consent was obtained from all individual participants involved in the semi-structured interviews and expert evaluations. The research involved no experimental procedures with human or animal subjects that required approval from an ethics committee beyond standard protocols for qualitative data collection and expert consultation.
- **Data and materials availability:** The datasets generated and analyzed during the current study, including the Falangcai porcelain pattern images compiled from the China Pattern Online Museum and the qualitative data from interviews, are not publicly available to respect the privacy of the participants and the terms of use of the source museum. However, the processed aesthetic feature library and the trained LoRA models are available from the corresponding author upon reasonable request.
- **Author contributions:** Qinyi YU: Writing – original draft, conceptualization, methodology, formal analysis, investigation, data curation, visualization. Norfarizah Mohd BAKHIR: Writing – review & editing, supervision, validation, project administration.

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