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Article

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Posted Date: October 28th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10533490/v1>

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Additional Declarations: No competing interests reported.

A Study on the Application of Hakka Plant-Dyed Colors in the Design of Rush Grass Crafts

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ABSTRACT

This study explores the integration of traditional plant dyeing techniques with Rush Grass weaving to revitalize Taiwan's dwindling fiber craft industry. By synthesizing Hakka cultural color symbols with contemporary modular lighting design, this research employs semiotic analysis and material experimentation to develop product prototypes. Experimental results indicate that plant-dyed rush grass retains high functionality, including significant moisture absorption and structural durability. The study establishes a color palette centered on "Hakka Red" and "Indigo Blue," enhancing the aesthetic and cultural value of the crafts. Consumer surveys reveal high market interest in culturally infused sustainable products, although concerns regarding maintenance persist. Ultimately, this research provides a framework for the sustainable development of traditional crafts through innovative color application and material transformation.

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1. INTRODUCTION

Taiwanese handicrafts possess profound historical depth and cultural value. Among them, rush grass (*Schoenoplectus triqueter*) weaving in Yuanli, Miaoli, was once an important export industry during the Japanese colonial period. However, with the rapid development of

industrialization and the widespread adoption of plastic products, many traditional crafts have gradually been replaced by mechanized production and modern materials, resulting in a significant decline in market demand. Consequently, traditional craftsmanship has faced severe challenges. Although local cultural organizations and communities have actively promoted rush grass crafts in recent years, market acceptance remains limited.

On the other hand, the scarcity of rush grass raw materials has led to rising costs. Combined with insufficient product development and a lack of innovative design, the rush grass industry struggles to maintain competitiveness in the contemporary market¹ (Hsieh & Pan, 1955). At present, there are only a little over ten nationally certified master-level rush grass artisans in Taiwan, most of whom are over the age of sixty. For fully handcrafted rush grass products, the lengthy production process and high labor costs make it difficult for product pricing to reflect actual production costs, further affecting the sustainable development of the industry.

In response to the need for transformation, how to break through the limitations of traditional handicrafts in terms of materials, design, and market positioning has become an urgent issue for the rush grass industry² (Wu et al., 2004). Against this background, this study, titled “*A Study on the Design Application of Hakka Plant-Dyed Colors in Rush Grass Craft*,” explores the contemporary development potential of rush grass crafts from the perspectives of market positioning, material innovation, and cultural translation.

This study particularly emphasizes the integration of heterogeneous materials, the transformation of local cultural symbols, and the application of plant dyeing techniques to enhance both the functional and aesthetic value of products. It aims to transform rush grass crafts from traditional handicrafts into cultural commodities that can be integrated into modern daily life. The research inspiration stems from interactions with local artisans and community members in Yuanli, Miaoli.

It was observed that they regard rush grass as a carrier of culture and emotion, symbolizing not only the preservation of tradition but also expectations for future

development. Ultimately, this study aims to promote the sustainable development of rush grass crafts through innovative design practices and to align with Sustainable Development Goal (SDG) 11: *Sustainable Cities and Communities*, providing a concrete pathway for the preservation and revitalization of Taiwanese cultural heritage.

2. LITERATURE REVIEW

The literature review of this study primarily focuses on the distribution and geographical relationships of the Hakka ethnic group, ethnic color systems and cultural symbolism, the historical development of indigo dyeing culture, and the local development of rush grass craftsmanship. It aims to systematically examine the interrelationships among “ethnicity, environment, industry, and color” within Hakka culture. Furthermore, this study explores how indigo dyeing colors form their distinctive meanings through lived practices and cultural symbolism, and further extends the discussion to the material application and design translation of rush grass craft. These analyses serve as the theoretical foundation for subsequent design practice and interpretation in this research.

2.1 Hakka Ethnic Distribution and Geographical Relationships

The Hakka ethnic group originates from migratory populations in southern China, primarily settling in the border regions of Guangdong, Fujian, and Jiangxi provinces. Due to historical upheavals and agricultural colonization movements, they later migrated to Taiwan (Luo, 1965). Large-scale Hakka migration to Taiwan mainly occurred during the Kangxi to Qianlong periods of the Qing Dynasty. In Taiwan, Hakka communities are primarily distributed across hilly and foothill regions, including Taoyuan, Hsinchu, Miaoli, Meinong in Kaohsiung, and Neipu in Pingtung.

Miaoli, particularly areas such as Yuanli and Sanyi, is one of the most important Hakka settlements and also a major center of rush grass weaving in Taiwan. Its geographical

condition lies within a transitional zone between coastal alluvial plains and foothills, making it highly suitable for rush grass cultivation. This interrelationship among “ethnic distribution–industrial formation–material culture” has shaped the intertwined development of Hakka dyeing culture and rush grass craftsmanship.

According to *The Development History of Hakka Ethnic Groups in Taiwan* published by the Hakka Affairs Council, Hakka culture demonstrates strong regional specificity and industrial dependence, and its traditional color system is closely related to agricultural lifestyles. Hakka communities in Taiwan are mainly distributed in Taoyuan, Hsinchu, Miaoli, and the Six Dui region of Pingtung. The Taoyuan–Hsinchu–Miaoli region, characterized by hilly terrain and river terrace landscapes, provided suitable conditions for dye plant cultivation, forming early indigo dyeing clusters. In contrast, the Six Dui region in southern Taiwan developed different forms of plant dye applications under subtropical climatic conditions.

According to statistical data from the Hakka Affairs Council, Hakka people account for approximately 20% of Taiwan’s total population. Their settlement patterns are closely associated with access to water resources and forested environments. Ethnographic studies indicate that geographical conditions influence both the acquisition of dye materials and the control of dye concentration, thereby affecting variations in color expression. For instance, differences in mineral content in water sources between Longtan (Taoyuan) and Beipu (Hsinchu) result in variations in indigo tone after oxidation. Such geographically induced color variations form localized identity systems, constituting distinct “regional color styles.” This phenomenon aligns with Tim Ingold’s concept of “environment and skill co-constitution,” which emphasizes that techniques are not isolated systems but are generated through the integration of ecological conditions and embodied practice.

2.2 Hakka Ethnic Colors and Cultural Symbolism

At the level of color symbolism, blue carries multiple meanings within Hakka culture. According to Edward T. Hall's (1959) analysis of cultural symbolic systems, color as a cultural sign acquires specific meanings depending on the lifestyle patterns of a given ethnic group. In the Hakka context, blue is not a symbol of power or luxury but rather represents restraint, resilience, and a labor-oriented ethic.

Taiwanese craft researcher Lin Hui-Cheng notes that architectural colors in Hakka settlements tend to feature low-saturation gray-blue and earth tones, blending harmoniously with mountainous natural environments and reflecting an "invisible aesthetics." This aesthetic orientation is also reflected in textile dyeing practices, which emphasize low-saturation and high-stability color systems.

Through ethnographic analysis, it can be observed that the use of indigo dye varies across daily life and ritual contexts. Everyday clothing is typically dyed in deep blue or indigo tones, whereas ceremonial occasions such as rituals and ancestral worship incorporate white or red elements, forming a contrasting color symbolism associated with ritual order. This layered use of color reflects the Hakka cultural understanding of order and ethical structure.

Color scholar John Gage (1999), in *Color and Culture*, argues that color preferences among different ethnic groups reflect both environmental adaptation and social values. The Hakka preference for deep blue and indigo tones is closely related to their mountainous living environment and values of simplicity and restraint. Furthermore, the red-and-blue contrast found in Taiwanese Hakka floral textiles demonstrates a visual system in which blue serves as the foundational color structure. This "blue as base with red accents" chromatic logic constitutes a key feature of Hakka visual culture (see Table 1).

Insert TABLE 1 here

2.3 Historical Formation of Hakka Indigo Dyeing Culture

According to Ma (2010) in *The Transformation and New Development of Taiwan's Indigo Dyeing Craft Industry*, Tainan was historically a major distribution center for indigo dye materials derived from *Strobilanthes* and *Indigofera*. Yongle Street in the old Tainan Prefecture City was once densely populated with dye workshops, described as being “closely packed like a comb,” making it the most prominent dyeing hub in Taiwan.

In Houbi District of Tainan, the place name “Jingliao” reflects its historical association with indigo cultivation. In earlier times, the area was unsuitable for rice cultivation and was primarily dry farmland. Large-scale cultivation of indigo plants and sugarcane once formed important local industries, and indigo dye was transported via river ports for export to mainland China. Neighboring regions such as Guiren and Liujia in eastern Tainan, as well as Puzi and Minxiong in Chiayi County, also developed small-scale *Indigofera* cultivation zones. These areas, often named “Jingpu,” were located near rivers to facilitate water use for dye production.

In the Hakka settlement region historically known as the “Liudui,” indigo cultivation and dye production began early in the migration period. In particular, Meinong extensively cultivated *Indigofera tinctoria*, supplying dye workshops in nearby areas such as Neipu, where indigo-dyed blue cloth was produced for the traditional Hakka *dajin* blue garment. Historical dye workshops such as the Wen family dye house in Meinong and the Yitai dye house in Neipu still preserve stone pressing structures resembling ingot shapes used in dye processing.

Based on industrial distribution maps from 1860–1895 and the 1904 *Industrial Promotion Report of Changhua Prefecture*, regions in central Taiwan—including the Changhua Plain, coastal areas of Taichung (Qingshui), and Miaoli—were once major production zones of *Indigofera*. The dye produced in rural households was mainly sold to dye workshops in Lukang or exported. According to Lin (2009), historical trade routes such as those along the Tamsui, Keelung, Xindian, and Sanxia river systems reveal extensive “indigo

production corridors.” Dye materials from areas such as Nuannuan, Jinshan, and Shengkeng were transported via waterways to Wanhua (Monga) for distribution.

The Sanxia region, historically known for its dye workshops, began cultivating *Indigofera* and *Strobilanthes* as early as 1822 (Qing Dynasty Daoguang period), with laborers recruited from mainland China. By 1851, merchants from Monga further expanded indigo cultivation in mountainous areas such as Ziwikeng and Daliao, establishing “jingliao” facilities in river valleys for dye production (Ma, 2010, pp. 169–171).

Indigo dyeing culture has deep historical roots within Taiwanese Hakka society. The Hakka blue garment (*blue shirt*) is primarily dyed with indigo extracted from *Strobilanthes cusia*. The dyeing process involves oxidation-reduction reactions, where dye molecules penetrate fibers and stabilize upon oxidation, resulting in excellent color fastness and durability. Color history studies indicate that blue in East Asian cultures is closely associated with labor and nature, differing from European traditions where it is linked to nobility or religion.

Traditional Hakka indigo dyeing primarily uses *Strobilanthes cusia* or *Indigofera* species. According to the *History of Taiwan Indigo Dye Craft Development* published by the National Taiwan Craft Research and Development Institute, the development of indigo dyeing in Taiwan is closely aligned with Hakka settlement distribution. As noted by Luo (1933), the Hakka people originated from northern China and migrated southward over multiple historical periods, eventually settling in Fujian, Guangdong, Jiangxi, and Taiwan. This migration process shaped adaptive cultural traits and influenced material culture, including dyeing and textile crafts.

Indigo dyeing is not only a practical technique but also a visual marker of ethnic identity. According to Ma (2010), Hakka communities in northern and northwestern Taiwan developed indigo dyeing systems using *Strobilanthes cusia* as the primary dye source. Indigo-dyed clothing, due to its durability and suitability for agricultural labor, came to symbolize a culture of practicality and frugality. From an ethnographic perspective, blue is

not merely a color choice but the result of interactions among environment, economy, and cultural ethics. The repeated use and repair of indigo-dyed textiles reflect the Hakka values of thrift and material conservation, closely linked to their mountainous agricultural lifestyle.

Blue in Hakka culture is therefore not merely an aesthetic preference but a dual system of practical function and symbolic meaning. From an ethnographic perspective, color emerges through long-term interactions among environmental adaptation, technological development, and cultural values (Geertz, 1973). The emergence and continuity of Hakka indigo dyeing reflect the mutual construction between livelihood needs and ethnic identity.

At the functional level, indigo dye exhibits excellent durability and resistance to washing, making it suitable for agricultural environments. Natural indigo dye contains compounds that, through oxidation, form stable molecular structures that resist degradation. Studies in traditional dyeing confirm that indigo-dyed fabrics are less susceptible to microbial growth and insect damage, making them suitable for long-term outdoor labor (Cardon, 2007). In agricultural societies, clothing must endure frequent washing and sun exposure; thus, the stability of indigo dye makes it particularly practical.

Moreover, dark blue tones effectively conceal stains from soil and labor, reducing maintenance costs. This reflects rational decision-making under resource-limited conditions. According to Luo (1933), the Hakka people developed a cultural ethos of frugality and pragmatism during long migration and land reclamation processes, which is embodied in their material culture.

However, understanding blue solely from a functional perspective is insufficient. In cultural contexts, color also carries symbolic meaning beyond physical function (Hall, 1976). In Hakka culture, blue gradually came to represent simplicity, diligence, and a restrained ethical system. The deep, subdued tones correspond to the modest and pragmatic identity of the Hakka people, forming a visual representation of moral values.

Furthermore, blue is closely connected to mountainous natural environments. Hakka settlements are predominantly located in hilly regions where daily life is closely integrated

with nature. Lin Hui-Cheng (1995) notes that Hakka architectural and settlement colors tend toward low-saturation gray-blue and earth tones, reflecting an aesthetic of harmony with the natural environment. Indigo textiles visually resonate with mountain landscapes, making color a mediating interface between people and environment. This aligns with Ingold's (2000) "dwelling perspective," which emphasizes that skill and cultural practice emerge within environments rather than being imposed upon them.

Finally, blue also plays a role in constructing kinship and land identity. In Hakka society, clan organization and ancestral worship are central to social structure. Indigo-dyed clothing, used in both daily life and ritual contexts, reinforces visual cohesion and emotional connection within the ethnic group. As Geertz (1973) argues, cultural symbols derive their power from transforming abstract values into tangible forms. In this sense, Hakka blue serves as a symbolic medium that materializes land attachment, frugality, and collective identity.

In summary, blue in Hakka culture embodies an intertwined system of functional utility and symbolic meaning. On one hand, its durability and resistance meet the needs of agricultural life; on the other, its deep tonal qualities symbolize simplicity and land-based identity. From an ethnographic perspective, blue is not an isolated color phenomenon but a cultural system integrating environment, livelihood, and values. This understanding provides a theoretical foundation for subsequent design translation of Hakka plant-dyed colors into rush grass craftsmanship.

2.4 Local Characteristics and the Cultural Context of Rush Grass Craft

Rush grass (*Lepironia articulata*) craftsmanship is primarily developed in the Yuanli area of Miaoli, which is also an important Hakka settlement. According to research reports published by the National Taiwan Craft Research and Development Institute, early rush grass crafts in Yuanli were predominantly in their natural color, and plant dyeing techniques were later introduced, leading to diversified color expressions.

From an ethnographic perspective, the integration of rush grass and indigo dye is not merely a material combination but a process of cultural reinterpretation. When indigo dye penetrates rush grass fibers, it produces chromatic layers distinct from those of cotton textiles, and the resulting variations in texture and luster generate a new visual vocabulary. This transformation can be understood as a form of “cross-material cultural continuity,” through which the spirit of Hakka indigo dyeing is reactivated within contemporary craft design.

In addition, rush grass weaving techniques also embody women’s labor memory and household economic history. When Hakka plant-dyed colors are integrated into rush grass structures, a dual significance emerges at the intersection of ethnic culture and local industry, reflecting a process of cultural capital reproduction. The rush grass industry in Yuanli flourished during the Japanese colonial period and was later exported to the Japanese straw mat market after World War II. According to archival materials and related studies from the National Museum of Taiwan History, rush grass weaving in Yuanli, Miaoli, was closely linked to Hakka household-based cottage industries, forming a family-centered production system.

Ethnographic field observations indicate that the natural color of rush grass is a pale beige tone, which creates a low-saturation contrast when combined with indigo-dyed textiles. Hakka indigo cloth is often used for edging, decoration, and structural reinforcement. The weaving patterns also visually resonate with Hakka floral textile motifs. This intertwined relationship among “material, color, and ethnic memory” forms a localized cultural system. As Geertz (1973) notes, symbolic systems are embodied in material objects that constitute everyday lifeworlds; in this context, rush grass and indigo dye function as material carriers of Hakka cultural existence.

The primary materials used in this study include rush grass, wood, metal hardware, and tungsten filament bulbs. Among these, *Schoenoplectus triqueter* (commonly known as Dajia rush grass) is selected as the main weaving material. Belonging to the Cyperaceae family, this plant features triangular stems, lightweight yet highly durable fibers, and is also referred to as “Yuanli rush grass.” It is widely cultivated in the Miaoli Yuanli region and has long served as

a key material for hat mats and various rush grass products. According to historical records, Dajia rush grass has been commercially recognized as one of the most successful natural fibers, with production records dating back more than two centuries (Zhang, 2010).

The main distribution area of Dajia rush grass is central Taiwan, particularly concentrated in Dajia and Yuanli. The Japanese colonial period marked the peak of rush grass craftsmanship, during which straw hats, mats, and cigarette cases were widely produced, with straw hats being the most iconic product. Dajia rush grass is a perennial sedge plant that thrives in paddy fields and wetland environments. Under optimal conditions, its stems can reach heights of 90 to 120 cm. Depending on harvest time, it is categorized into spring grass (harvested in June) and autumn grass (harvested in September). Its fibers possess high tensile strength, excellent hygroscopicity, and a natural fragrance, making it an ideal material for everyday crafted goods.

Globally, natural fibers have long been widely used in traditional crafts across different cultures. For example, bamboo and rattan weaving in Sri Lanka, Himalayan nettle fiber textiles in Nepal, banana fiber crafts in India, flax weaving in Māori culture of New Zealand, and water hyacinth crafts in Thailand all demonstrate the close relationship between material and local culture. These crafts not only possess environmental sustainability but also continue to develop through plant dyeing practices, workshop promotion, and market integration (Shimada & Kurata, 1908).

This study draws upon these global practices by integrating Yuanli rush grass with innovative design strategies to promote cultural inheritance and develop products with contemporary relevance. In terms of weaving techniques, this study adopts several traditional patterns based on material properties, including over-one weave, over-two weave, net flower weave, and pineapple flower weave (Fig. 1–4).

The over-one weave is the most fundamental interlacing technique. The over-two weave involves interlacing two strands, commonly used in mat production due to its density and durability. The net flower weave extends the over-one structure into a mesh pattern, allowing

continuous visual variations and is widely applied in bags and hats. The pineapple flower weave, named for its resemblance to pineapple skin, is a more complex and time-consuming technique that results in thick, layered textures.

In summary, rush grass not only possesses excellent functional properties such as moisture absorption, breathability, deodorization, and dyeability, but its weaving techniques also demonstrate high levels of craftsmanship value and cultural significance.

Insert FIG. 1 here

Insert FIG. 2 here

Insert FIG. 3 here

Insert FIG. 4 here

From a materials science perspective, rush grass belongs to the Cyperaceae family. Its stems exhibit a triangular hollow structure, and its fiber composition is primarily cellulose, providing good elasticity and breathability. However, the outer surface contains natural waxy substances, which make dye penetration relatively lower compared to cotton textiles. Therefore, when applying plant dyeing techniques to rush grass, pretreatment and dyeing procedures must be adjusted to improve color uniformity and dye adhesion.

Previous studies on textile dyeing have indicated that the bonding stability between natural dyes and cellulose-based materials depends on the selection of mordants and the control of dye bath temperature. In addition, the molecular structures of different plant dyes also influence color saturation and light fastness.

3. METHOD

This study adopts a mixed-method research approach combining qualitative and quantitative methods. First, a literature review was conducted to systematically analyze the history of indigo dyeing, rush grass craftsmanship, Hakka ethnic distribution, and color culture, establishing the theoretical foundation of this research.

Second, an ethnographic research method was employed. Through field investigations and local interviews, the geographical relationships among Hakka settlements, indigo dyeing practices, and the rush grass industry were analyzed.

Third, botanical surveys and color layer analyses were conducted to investigate the distribution of indigo-bearing plants in Taiwan. Plant collection, dyeing experiments, and color stratification analyses were further carried out to examine dye performance and visual outcomes.

Meanwhile, design semiotics was incorporated to explore the cultural meanings and emotional cognition embedded in color systems. Finally, design outcomes were developed in the form of Hakka cultural lighting products, and questionnaires were used to evaluate whether the designs effectively conveyed Hakka color identity and design appropriateness (Fig. 5).

Insert FIG. 5 here

3.1 Ethnographic Research Method

This study adopts ethnographic research as its core methodology. Through thick description and participant observation, it seeks to understand the cultural meanings and symbolic structures of Hakka plant-dyed colors in the design application of rush grass crafts. Ethnographic research emphasizes the holistic relationship between symbols, actions, and everyday life within cultural systems (Geertz, 1973). Its aim is not merely documentation, but the interpretation of meaning within cultural contexts, thereby constructing a theoretical foundation for ethnic knowledge and design translation.

From an anthropological methodological perspective, Clifford Geertz proposed interpretive anthropology, arguing that culture is a web of meanings that must be understood within historical and local contexts. Meanwhile, James P. Spradley, in *The Ethnographic Interview* (1979), emphasized that ethnographic research should adopt an emic perspective to understand cultural practices from within, rather than imposing external analytical frameworks.

Based on this methodological foundation, this study integrates literature analysis, field interviews, and contextual comparison to reconstruct the cultural system of Hakka indigo dyeing. As anthropological research increasingly engages with large-scale societies, hybrid approaches combining ethnography and survey research have emerged. Since survey research deals with large and complex populations and relies on statistical analysis, ethnography serves as a complementary method that refines and contextualizes survey findings.

Accordingly, this study employs ethnography to analyze Hakka ethnic distribution and geographical relationships, ethnic color systems and cultural symbolism, the historical formation of indigo dyeing culture, and the local characteristics of rush grass craftsmanship. Through field investigations and interviews, it further examines the geographical relationship between Hakka settlements, indigo dyeing practices, and the rush grass industry.

3.2 Experimental Method

To verify the physical feasibility and functional performance of rush grass in lighting design applications, a series of experimental tests were conducted. First, breathability and moisture absorption tests were carried out (Islam & Hasan, 2024; Pavlovic et al., 2025; Wang et al., 2006) to determine whether rush grass is suitable as a heat-dissipating material for lighting structures. Second, fiber tensile strength tests were performed to evaluate whether the structural integrity of rush grass remains stable after dyeing treatment. Finally, odor emission experiments were conducted to examine whether thermal energy from the light source could effectively release the natural fragrance of rush grass.

These experimental results provide a scientific basis for design decisions, ensuring both functional reliability and structural stability of the product.

This study is grounded in the rush grass culture of Yuanli, Miaoli, combined with plant dyeing techniques and heterogeneous material integration to express cultural value and aesthetic qualities. In terms of color design, the natural dark brown of rush grass symbolizes tradition and material authenticity; plant-dyed deep red represents festive energy and vitality within Hakka culture; and indigo blue corresponds to the stability and continuity of indigo dyeing culture.

Through the combination of these three primary colors, the product not only reflects regional identity visually but also reinforces its cultural significance.

3.3 Design Semiotics

To further explore the cultural connotations and symbolic meanings embedded in rush grass lighting design, this study employs semiotic analysis to interpret design vocabulary (Wang, 2020). This approach enables the decoding of implicit non-verbal messages embedded in form, texture, and structure, translating them into design language (Wang, 2023).

For instance, circular forms and curved weaving structures are often associated with reunion and cultural fluidity, while rush grass weaving patterns reflect local craft traditions in Yuanli. Through semiotic analysis, the design outcomes ensure not only aesthetic value but also the effective transmission of cultural meanings.

The lampshade is constructed using traditional rush grass weaving techniques embedded with local symbolic patterns, while weaving density is adjusted according to lighting requirements to create layered light-and-shadow effects. Structurally, wood and metal components are combined to express a balance between softness and rigidity, and a modular system is adopted to allow easy assembly and replacement, enabling flexible applications in domestic, restaurant, and outdoor camping contexts.

From a theoretical design perspective, color in products is not merely decorative but functions as part of a semiotic system. In semiotic theory, color serves as the “signifier,” while the “signified” refers to its cultural meaning. When designers embed specific cultural colors into products, they construct a narrative relationship that allows users to generate meaning through perception and interaction.

Therefore, this study treats color as a medium of cultural translation. Through ethnographic fieldwork, Hakka color vocabularies are collected and transformed into design language. Integrating the semiotic frameworks of Peirce, Saussure, Morris, Roland Barthes, Eco, and Katsumi Hoshino, this study analyzes how cultural symbols are selected, constructed, transformed, embedded, and integrated into craft products during the process of color transformation into commodities (see Table 2).

Insert TABLE 2 here

3.4 Questionnaire Survey Method

In this study, a questionnaire survey method was employed as one of the research approaches. The researcher designs a structured questionnaire based on the research objectives and distributes it to respondents either by mail or in person for completion. This method of using questionnaires as a data collection instrument is known as the questionnaire survey method.

Questionnaire surveys can be conducted through mailed questionnaires or face-to-face administration. The advantages of this method include: (1) it is suitable for large-scale surveys, is cost-effective, and allows the collection of a large sample size; (2) respondents are not restricted by time or location, and anonymity is ensured, making it appropriate for investigating sensitive issues; (3) it reduces interviewer bias and measurement error; (4) respondents have sufficient time to reflect on their answers; and (5) it is relatively low in cost (Zhang, 2001).

This study also adopts the questionnaire survey method to evaluate market acceptance and purchase intention toward rush grass lighting products (Chen, 2017). Through this method, the study examines whether design outcomes based on Hakka indigo dyeing crafts can effectively convey local cultural identity, color symbolism, and ethnic meaning. It also aims to bridge the perceptual gap between respondents and Hakka indigo craft design, thereby enabling a more precise analysis of consumer perceptions.

The questionnaire design includes respondents' familiarity with rush grass materials, their functional expectations of lighting products (such as breathability and moisture absorption), and their perceived recognition of aesthetic form and cultural symbolism. By collecting large-scale responses from target consumer groups, this study identifies user preferences and market demand, which serve as important references for product optimization and future commercialization. This ensures that rush grass lighting design possesses strong market potential.

In addition, Hakka plant and cultural elements carry distinct color and symbolic meanings. The New Bloom Flower symbolizes family prosperity and lineage continuity; Tung flowers represent diligence and simplicity; Mugwort signifies protection and warding off evil; blue clothing reflects pragmatism and labor aesthetics; banana plants symbolize inclusiveness and harmony with nature; tea plants represent humility and social interaction; night-blooming flowers convey protection and tranquility; and Hakka floral textiles represent unity and ethnic identity (see Table 3).

Insert TABLE 3 here

3.5 Questionnaire Survey and Statistical Analysis

A total of 100 questionnaires were distributed in this study, with a valid response rate of 100%. Among the respondents, the majority were aged 10–19 years (32%) and 20–29 years (30%), followed by those aged 50–59 years (22%).

In this study, *M* (Mean) refers to the average score of all respondents, used to represent the overall level of agreement or perception. A higher mean value indicates a stronger degree of recognition or acceptance. *SD* (Standard Deviation) represents the degree of dispersion of responses; a smaller SD indicates higher consistency among respondents, while a larger SD suggests greater variation or divergence in opinions.

This questionnaire is based on a Likert scale design, in which respondents evaluate each item using a 1–5 rating scale. The collected data were quantitatively analyzed to assess attitudes, cognition, and levels of identification regarding Hakka plant-based cultural elements and their symbolic meanings.

The results indicate the following ranking of symbolic perception of Hakka cultural and botanical elements: blue clothing ($M = 4.72$, $SD = 0.51$) ranked highest, followed by Hakka floral textiles ($M = 4.65$, $SD = 0.55$), New Bloom flower ($M = 4.58$, $SD = 0.57$), tung flower ($M = 4.46$, $SD = 0.60$), tea plant ($M = 4.39$, $SD = 0.62$), mugwort ($M = 4.31$, $SD = 0.64$), night-blooming flower ($M = 4.22$, $SD = 0.66$), and banana plant ($M = 4.10$, $SD = 0.70$).

The first-ranked symbolic element is Hakka blue clothing (Indigo Blue), followed by Hakka floral textile (Cochineal Red).

4. RESULTS

This chapter presents the experimental and analytical results of the study, covering three main aspects. First, design semiotic analysis is applied to interpret the symbolic meanings of rush grass lighting design in terms of color, form, material, and structure, including cultural symbolism, functional attributes, and intrinsic value. Second, plant dyeing and physical property experiments are conducted to verify the feasibility of rush grass in terms of moisture

absorption, breathability, tensile strength, and dye affinity, while also analyzing how dyeing affects craft aesthetics and cultural expression. Third, a questionnaire survey is used to investigate consumer perception, usage preference, and purchase intention, thereby evaluating market potential and product development direction. Overall, this chapter integrates design, material, and market perspectives to provide empirical evidence for the study.

4.1 Design Semiotics

This study applies design semiotic theory to analyze rush grass lighting products, drawing on Peirce's triadic model of signs and Roland Barthes' concepts of denotation and connotation. The design symbols are categorized into three levels: "external aesthetic of the sign," "behavioral aesthetic of the sign," and "internal aesthetic of the sign" (Wang, 2018).

At the level of external aesthetic of the sign, the color design of the lighting product conveys multiple symbolic meanings. The natural dark brown of rush grass represents nature and traditional craftsmanship, emphasizing the material's organic origin and its connection to the land, highlighting the coexistence of craftsmanship and environment. The woven lampshade incorporates plant-dyed fibers in two dominant colors: deep red symbolizes festivity and vitality in Hakka culture, commonly associated with traditional costumes and ceremonial occasions; deep blue extends from indigo dye culture, representing stability, tranquility, and cultural continuity, expressing the expectation of craft inheritance. In addition, circular and curved weaving structures symbolize unity and cultural fluidity, creating soft and layered lighting effects.

The behavioral aesthetic of the sign is reflected in structural and functional design. The lighting product integrates rush grass weaving, wood, and metal materials, adopting a modular structure that allows disassembly and replacement, enabling flexible application in restaurants, study spaces, and outdoor camping environments. This corresponds to Morris's

pragmatic dimension of semiotics, emphasizing the functional role of signs in use (Wang, 2022).

At the internal aesthetic of the sign level, the rush grass lighting embodies the lived memory and craftsmanship spirit of Yuanli, Miaoli. It symbolizes the perseverance and intergenerational transmission of artisanship. This cultural meaning corresponds to Barthes' notion of connotation and myth (Wang, 2024), transforming the lighting object from a functional product into a carrier of cultural narrative.

4.2 Plant Dyeing Experimental Results

To verify the physical properties of rush grass, a moisture content test was first conducted. Three samples of treated rush grass were cut, air-dried, and then oven-dried at 103°C to determine absolute dry weight. The results showed moisture contents of 9.01%, 8.83%, and 8.68%, with an average of 8.84%. These findings indicate that rush grass has excellent breathability and rapid drying properties, explaining its traditional use in mats, bedding, and floor coverings.

Further dyeing experiments focused on plant dye applications. Due to the presence of natural wax layers on the surface of rush grass, direct dyeing was ineffective. Therefore, a bleaching pretreatment was first applied, followed by dyeing using cochineal powder and indigo powder, with acetic acid used as a mordant. After drying at 45°C, the dyed samples successfully produced deep red and deep blue tones. Comparative analysis showed no significant reduction in fiber tensile strength after dyeing, indicating that plant dyeing does not compromise weaving performance (Fig. 6–7).

The indigo blue represents stability, cultural inheritance, and land connection, while cochineal red symbolizes vitality and ritual celebration within Hakka culture. In addition, aroma extraction experiments using alcohol solution revealed that rush grass contains a mild natural fragrance, although no significant oil-based compounds were detected. This suggests

limited extractable aromatic value, but indicates potential for future sensory design applications.

Insert FIG. 6 here

Insert FIG. 7 here

4.3 Questionnaire Survey Results

To evaluate market acceptance and purchase intention toward rush grass lighting products, a total of 100 questionnaires were distributed, with a valid response rate of 100%.

Among the respondents, the largest age groups were 10–19 years (32%) and 20–29 years (30%), followed by 50–59 years (22%), indicating that both younger and middle-to-older age groups represent potential consumer markets.

Regarding awareness of rush grass materials, 80% of respondents reported that they had only heard of rush grass but had never encountered it directly or were completely unfamiliar with it, with this lack of familiarity being particularly concentrated among the 10–29 age group.

In terms of product preference, most respondents showed a strong inclination toward functional products featuring deodorizing, breathable, and moisture-absorbing properties. In contrast, younger respondents demonstrated higher interest in cultural and creative (design-driven) products. The key purchasing considerations were closely related to Taiwan's humid climate, with moisture absorption and breathability identified as the most important decision-making factors.

Regarding purchase intention, although respondents generally perceived rush grass products as relatively expensive, they still expressed higher-than-expected willingness to purchase. Some participants indicated that the higher price was mainly due to material

scarcity and labor-intensive handcrafted production. However, if the product demonstrates durability, cultural uniqueness, and aesthetic value, consumers are still willing to accept the price.

The findings suggest that the future development of rush grass products should emphasize breathability, moisture absorption, and aesthetic qualities, while strengthening cultural design attributes to highlight product differentiation and enhance market competitiveness.

The questionnaire results (N = 100) further indicate that younger consumers show a high willingness to purchase cultural and creative products that combine deodorizing and breathable functions. In terms of color configuration, the contrast combination of Indigo Blue and Cochineal Red most strongly evokes associations with Hakka cultural identity.

The color specifications are as follows: Indigo Blue is defined by LAB values (L26, a9, b-22) and RGB values (R60, G58, B95); Cochineal Red is defined by LAB values (L40, a51, b35) and RGB values (R172, G47, B41). These results confirm the effectiveness of the color strategy adopted in this study (Fig. 8–10).

Insert FIG. 8 here

Insert FIG. 9 here

Insert FIG. 10 here

5.DISCUSSION

This chapter discusses the evaluation of research findings, product design outcomes, study limitations, and future research directions. First, a SWOT analysis was conducted to comprehensively examine the current development of the rush grass weaving industry in Yuanli, Miaoli. The results indicate that rush grass craftsmanship possesses strong cultural heritage, well-established techniques, active governmental support, and environmentally friendly and skin-compatible material properties, all of which represent significant strengths

of the industry. However, the industry also faces multiple weaknesses, including declining market demand, insufficient raw material supply, an aging population of artisans, and difficulties in knowledge transmission. Although talent cultivation, innovative design, and heterogeneous material integration may contribute to market revitalization and cultural preservation, high production costs and strong substitutability of plastic materials remain significant threats. In addition, the industry is experiencing structural fragmentation, with contraction occurring across production, processing, and distribution systems. Senior artisans are gradually retiring, and the transmission of craftsmanship is becoming increasingly difficult. The shortage of raw materials is also becoming more severe, with reports suggesting the potential emergence of a “straw scarcity crisis,” which could significantly impact production. Since the industrialization era, plastic materials—due to their low cost and rapid manufacturability—have replaced rush grass products. At the same time, women traditionally engaged in rush grass weaving have shifted to industrial labor, leading to a rapid decline in the craft (Wang, 2003). Furthermore, younger generations show limited interest in rush grass craftsmanship, resulting in a lack of successors and an increasing risk of cultural extinction. Under these conditions, the transformation and innovation of rush grass craftsmanship have become urgent; however, limited resources and technical support present significant challenges to industrial revitalization. In terms of product design and outcomes, this study applies rush grass weaving techniques to lampshade design. The weaving density is adjusted according to lighting requirements, producing soft and layered lighting effects that highlight the material’s breathability and moisture absorption properties. The design also reflects the traditional craft philosophy of balancing rigidity and flexibility. The orthographic drawings clearly illustrate the structural proportions and external form of the lighting product, while the exploded view demonstrates the modular structure and how wood and metal components integrate with rush grass weaving to form a stable yet detachable system. The final prototype demonstrates the integration of natural rush grass color with plant-dyed tones (deep red and deep blue). Deep red symbolizes festivity and vitality within Hakka culture, while deep blue reflects the stability and continuity of indigo dyeing traditions, thereby emphasizing local cultural identity. The overall form incorporates circular and curved weaving structures, symbolizing unity and cultural fluidity. When illuminated by a tungsten filament bulb, the

gaps between rush grass fibers produce layered light and shadow effects while releasing a subtle natural fragrance, creating a lifestyle aesthetic that combines functionality with cultural atmosphere. This study names the product “Yùzhī Mèng” (Weaving Dream), where “weaving” directly refers to the core rush grass weaving technique, and “dream” symbolizes imagination and future possibilities. The name expresses the aspiration that traditional craftsmanship can be integrated into contemporary life and gain wider recognition, positioning the work not only as an object but also as a cultural carrier with symbolic and future-oriented meaning (Fig. 11–12).

Insert FIG. 11 here

Insert FIG. 12 here

5.1 Limitations of the Study

Despite the insights gained from material experimentation and prototype development, several research limitations must be acknowledged:

Sample Size and Geographic Coverage: The market perception and preference data in this study were collected from a localized survey sample (N=100) within Taiwan. While the sample captured key demographic groups (such as youth and middle-aged consumers), the findings may not fully represent broader consumer behaviors across different cultural contexts or international markets.

Color Fastness and Aging Behavior of Natural Red Dyes: Experimental results indicated that while indigo blue exhibited high color stability and uniformity, natural red dyes (derived from cochineal) showed slight color variations and susceptibility to fading after prolonged light exposure. Future research should incorporate standardized color difference (ΔE) measurements and accelerated light-fastness testing to establish precise quantitative durability profiles.

Material Fragrance and Physical Extraction Constraints: Chemical analysis indicated that rush grass fibers do not contain significant oil-based extractables. Consequently, while thermal energy from the lighting source gently releases a natural grass scent in the short term, the olfactory aroma gradually dissipates over time.

Cost and Maintenance Barriers: Although consumer interest in culturally infused lighting objects is high, the market adoption of handcrafted rush grass products is constrained by high manual labor costs, raw material scarcity, and maintenance concerns regarding humidity, mold, and dust accumulation in humid climate conditions.

5.2 Future Research Directions

Future research directions focus on the advancement of material improvement, design innovation, and the extended application of cultural dissemination. First, the development of rush grass material modification techniques (such as natural anti-mold treatments) and standardized production processes is recommended in order to enhance product durability and reduce maintenance complexity. Establishing such a systematic framework would contribute to improving the industrial applicability of rush grass as a sustainable craft material. Second, this study suggests exploring structural and aesthetic innovation through heterogeneous material integration. By combining rush grass with materials such as metal and leather in a modular design system, future products may achieve a more balanced integration of functionality and visual aesthetics, thereby expanding the design possibilities of traditional craftsmanship. Third, the integration of digital marketing strategies and immersive cultural experiences—such as hands-on workshops and cultural exhibitions—is proposed to enhance awareness and interest in rush grass craftsmanship among younger generations. Such experiential approaches may strengthen cultural engagement and intergenerational transmission. Finally, from the perspectives of sustainable development and environmental education, rush grass should be further positioned as an eco-friendly material within the global market. This aligns with the United Nations Sustainable Development Goals (SDGs) and promotes the sustainable continuation of traditional crafts in contemporary society. These proposed directions (Fig. 13–16) are expected to contribute to a balanced development of cultural preservation, design innovation, and market expansion, thereby supporting the long-term sustainability of local craftsmanship.

Insert FIG. 13 here

Insert FIG. 14 here

Insert FIG. 15 here

Insert FIG. 16 here

5.3 Summary of Practical and Cultural Insights

The experimental results confirm that plant dyeing techniques are feasible when applied to rush grass materials without affecting their structural integrity or functional properties. At the cultural level, the findings reveal that when product colors are associated with Hakka cultural contexts, consumers' perception of cultural value is significantly enhanced. In this context, color is not merely a visual element but functions as a medium that carries historical memory and ethnic identity. Through design translation, rush grass lighting products are no longer merely craft objects but are transformed into narrative cultural artifacts. From a market perspective, although consumers demonstrate interest in culturally embedded design products, price and maintenance remain key factors influencing purchasing intention. Therefore, future product strategies should incorporate modular design and standardized production processes in order to reduce costs and improve repairability and long-term usability.

6.CONCLUSIONS

This study explores the integration of traditional rush grass (*Schoenoplectus triqueter*) weaving techniques with plant dyeing processes, combining local cultural narratives from Yuanli with contemporary modular lighting concepts to develop product prototypes that reflect cultural value and market interest. The empirical findings indicate that plant-dyed rush grass exhibits versatility in form design and material application. Through heterogeneous material integration and strategic color configuration (Indigo Blue and Cochineal Red), the prototype demonstrates an alternative aesthetic expression for traditional craftsmanship. The design outcome serves as an exploratory bridge connecting traditional fiber craft heritage with contemporary domestic living contexts. While traditional rush grass products in Taiwan have predominantly been confined to flat mats, hats, and daily accessories, this research provides a practical case study in transforming these natural fibers into three-dimensional household lighting objects. From a design dissemination perspective, the physical realization

of these prototypes offers local craft communities a feasible model for product diversification and suggests potential avenues for engaging younger audiences with cultural heritage. Nevertheless, certain limitations should be acknowledged. The market preferences identified in this study are based on a localized survey sample (N=100), and the broader commercial viability of such craft products remains subject to overcoming challenges in production costs, manual labor constraints, and long-term material maintenance (such as moisture and light-fastness management). In conclusion, this study offers an empirical framework for the cultural translation and material adaptation of traditional handicrafts. By integrating plant dyeing with modular design, it proposes a constructive direction for supporting the gradual transformation and sustainable continuation of Taiwanese craft heritage in modern life practices.

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Funding Declaration

This work was supported by the National Science and Technology Council (NSTC), Taiwan, Republic of China, under Grant No. NSTC 114-2637-H-020-001.

Data Availability

All datasets, research instruments, and supporting materials for this study—including the Academic Research Questionnaire, Informed Consent Statement, Survey Statistics Dashboard, statistical models, and experimental data—are provided within the Supplementary Information files and deposited in the Zenodo repository (DOI: 10.5281/zenodo.21963286).

Declarations

The questionnaire survey in this study is a minimal-risk, non-invasive research project featuring complete anonymity and non-sensitive topics, which conforms to the criteria for 'Research Review Exemption' under the Human Subjects Research Act and institutional research ethics guidelines. Prior to completing the survey, all respondents were informed of the research objectives, the principle of complete anonymity, and voluntary participation, and informed consent was duly obtained.

Ethics Approval and Consent to Participate

This study was conducted in accordance with Taiwan's Human Subjects Research Act (Ministry of Health and Welfare, Taiwan; reference: <https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=L0020176>) and the Declaration of Helsinki. The study protocol involves minimal risk, defined as risk not exceeding that encountered in ordinary daily life. The survey collected solely non-sensitive aesthetic evaluations and perceptual ratings regarding Hakka plant-dyed colors and rush grass craft design. All data were collected anonymously without any direct or indirect personal identifiers, and no individual participant data are disclosed. In accordance with statutory

criteria for research involving non-invasive, anonymous surveys with minimal risk, this research is exempt from formal Institutional Review Board (IRB) review. Informed consent was obtained electronically from all individual participants prior to their participation in the study.

Informed Consent

Informed consent was obtained from all participants prior to survey completion. To preserve anonymity, written signatures were waived; completing and submitting the online or paper questionnaire after reviewing the study information served as informed consent.

Acknowledgements

The author is grateful to the National Science and Technology Council (NSTC) of the Republic of China (Taiwan) for supporting this research under Grant No. NSTC 114-2637-H-020-001.

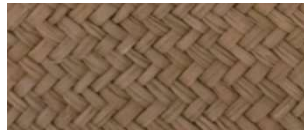


Fig. 1. Over-One Weave Pattern



Fig. 2. Over-Two Weave Pattern



Fig. 3. Net Flower Weave Pattern



Fig. 4. Pineapple Flower Weave Pattern

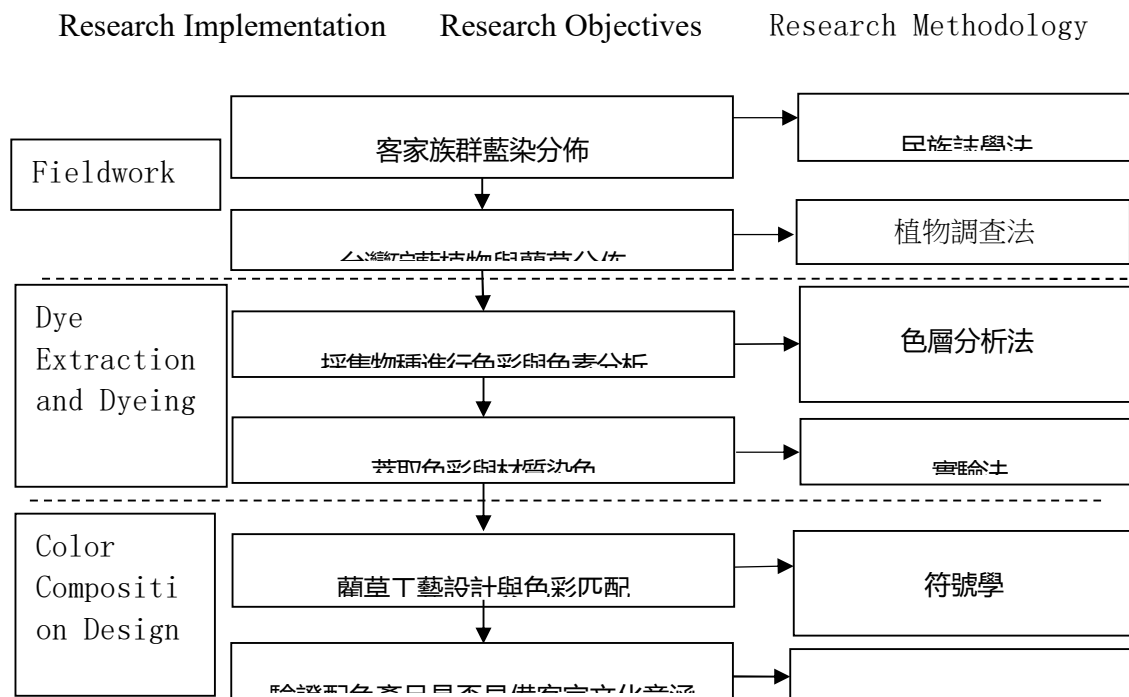


Fig. 5. Research Process



Fig. 6. Pre-bleaching Treatment of Rush Grass



Fig. 7. Dyeing Process of Rush Grass



Fig. 8. Blue Color Sample L26A9B-22 / RGB (60, 58, 95)



Fig. 9. Red Color Sample R172G47B41 / L40A51B35

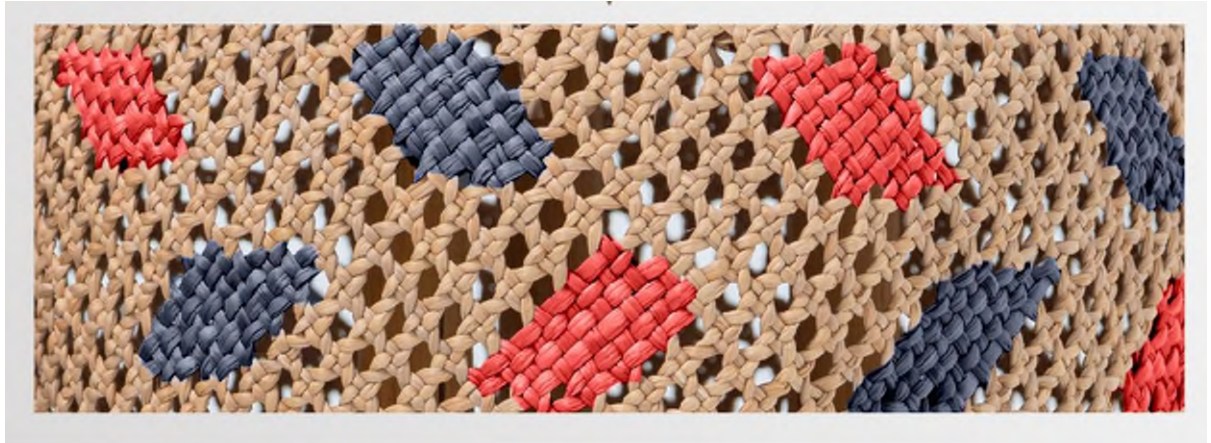


Fig. 10. Color Results of Dyed Rush Grass



Fig. 11. 3D Design of Lighting Series I (Rush Grass Craft)



Fig. 12. 3D Design of Lighting Series II (Rush Grass Craft)



Fig. 13. Conceptual Rendering of Lighting Design Series I (Rush Grass Craft Design)



Fig. 14. Final Output of Lighting Design Series I (Rush Grass Craft Design)



Fig. 15. Conceptual Rendering of Lighting Design Series II (Rush Grass Craft Design)



Fig. 16. Final Output of Lighting Design Series II (Rush Grass Craft Design)

Table 1 The Multiple Meanings of Blue in Hakka Culture: Functional and Symbolic Dimensions

Blue in Hakka Culture	Meaning
Functional aspects	Antibacterial, insect-repellent, stain-resistant, and washable; suitable for agricultural livelihoods
Symbolic meanings	Represents simplicity and frugality, connection to mountains and forests, and identification with family and land

Table 2 Theories of Semiotics by Major Scholars

Period	Scholar	Theory	Approach to Interpreting Signs
1839–1914 Founder of Pragmatism; Father of Semiotics	Charles S. Peirce	Triadic model of signs (sign, interpretant, object); three types of signs: iconic, indexical, symbolic	Interpretation through a three-layered semiotic structure
1857–1913 Swiss linguist	Ferdinand de Saussure	Paradigmatic axis, syntagmatic axis; signifier and signified	Vertical and horizontal structural analysis of form and meaning
1901–1979 American philosopher	Charles Morris	Syntax, semantics, pragmatics	Interpretation of denotation and connotation
1915–1980 French scholar	Roland Barthes	First-order meaning (denotation); second-order meaning (connotation, myth, symbolism)	Multi-layered interpretation of signs
1932 Italian scholar	Umberto Eco	Theory of codes; theory of sign production; denotation and connotation	Multi-level interpretation of sign systems
1988 Marketing and semiotics scholar	Katsumi Hoshino	Structure of commodity value	Interpretation of symbolic value from denotation to connotation

Table 3 Color and Semiotic Meanings of Hakka Plant Cultural Elements

Plant / Cultural Element	Hakka Cultural Context	Main Color Representation	Semiotic Level (Signifier / Signified)	Cultural Meaning in Hakka Context
New Bloom Flower (Ixora)	Six Dui "New Born Rice Cake Festival", rituals, and family celebrations	Red, orange-red	Signifier: floral form and red color; Signified: kinship, life continuity, and family reproduction	Fertility, family prosperity, ethnic continuity
Tung Flower	Hakka landscape; Northern Taiwan Tung Blossom Festival	White	Signifier: falling white blossoms covering landscapes; Signified: memories of labor and rural life	Hard work, simplicity, and Hakka spirit
Mugwort	Seasonal rituals, exorcism, folk medicine, and Hakka cuisine	Dark green, gray-green	Signifier: aroma and medicinal use; Signified: protection and purification	Blessing, protection, and health preservation
Blue Clothing (Indigo Dye from <i>Strobilanthes cusia</i> / <i>Indigofera</i>)	Hakka indigo-dyed clothing and textile culture	Indigo blue	Signifier: dye color; Signified: identity, social structure, and practical wisdom	Pragmatism, durability, and aesthetics of labor
Banana Plant	Common crop and daily material in Hakka settlements	Light green, yellow-green	Signifier: large leaf structure; Signified: protection and coverage	Practical wisdom and coexistence with nature
Tea Plant	Hakka tea culture and hospitality tradition	Dark green, brown	Signifier: tea leaves and processing; Signified:	Humility, sharing, and cultural exchange

			interpersonal relationships	
Night-blooming Flower (Michelia alba / related species in Hakka gardens)	Hakka nighttime festivals, garden planting, and women's cultural symbolism	White, pale yellow	Signifier: nocturnal blooming and fragrance; Signified: quiet resilience and subtle virtues	Family protection, night blessings, and hidden beauty
Hakka Floral Fabric	Traditional Hakka clothing and textile craft	Red, blue, yellow, green (multicolored)	Signifier: printed textile patterns; Signified: identity, regional culture, aesthetic inheritance	Unity, traditional aesthetics, and ethnic identity

Supplementary Files

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