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Integrating Traditional Bamboo Weaving Techniques into Modern Home Appliance Design: A Case Study on Air Purifiers

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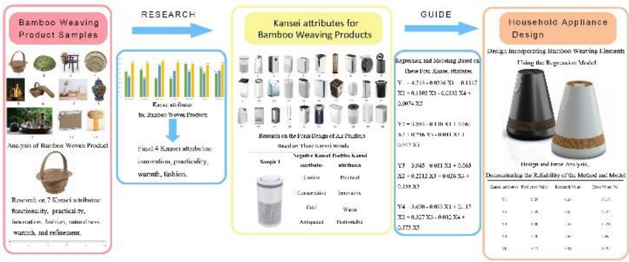
Graphical abstract



Abstract

As global demand for sustainable materials grows, traditional bamboo weaving remains an underutilized eco-solution. This study bridges that gap by transforming this renewable craft into functional modern designs, offering both cultural preservation and environmental benefits. This study revitalizes traditional bamboo weaving through sustainable integration into air purifier design by: modernizing craftsmanship via scientific frameworks, innovating bamboo applications for contemporary needs, and securing their cultural-ecological relevance in evolving lifestyles. Consumers' attitudes toward bamboo-woven products and their most valued design characteristics are investigated through a questionnaire survey. Based on the findings, perceptual design preferences for bamboo-woven products are summarized and applied. Using air purifiers as a case study, the Kansei Engineering design method is employed to develop a model that aligns with consumers' Kansei attributes. This design model is then refined to derive an optimal version. The study also includes practical application in designing an air purifier guided by the optimal design model. A final verification demonstrates that the design model meets expectations and offers an operable approach to integrating traditional bamboo weaving with modern product design. This work challenges the tradition-modernity divide, positioning craftsmanship as a dynamic driver of regenerative futures.

Keywords: Sustainable design, Traditional craftsmanship, Bamboo weaving, Home appliance, Kansei Engineering.

1. Introduction

In the context of global climate change and escalating environmental challenges, the product design and manufacturing industries are increasingly compelled to adopt sustainable practices that harmonize ecological preservation, cultural heritage, and technological innovation (Guo *et al.* 2018; Muhammad *et al.* 2021; Omer *et al.* 2025). Traditional craftsmanship, such as bamboo weaving, embodies centuries of accumulated knowledge in utilizing natural materials efficiently and sustainably (Chotiratanapinun 2011). However, these artisanal techniques face existential threats from industrialization and the dominance of synthetic materials, risking the erosion of cultural identity and environmentally responsible practices (Gao *et al.* 2024). Concurrently, modern home appliance design—a sector historically reliant on energy-intensive plastics and metals—is undergoing a paradigm shift toward circular economy principles and low-carbon solutions (Stadelmann *et al.* 2018; Hischier *et al.* 2020). This convergence of challenges and opportunities invites a critical exploration: How might traditional bamboo weaving techniques be reimagined to enhance the sustainability and aesthetic value of contemporary home appliances?

Bamboo, a rapidly renewable resource with excellent mechanical properties and wear resistance (Wu *et al.* 2020; Borowski *et al.* 2022), has long been celebrated in Asian cultures for its versatility and symbolic ties to resilience (Ziaee *et al.* 2022). Countries such as China, Japan, India, and Thailand have developed advanced bamboo weaving techniques, utilizing local bamboo resources to craft a variety of daily necessities and production tools, thereby maximizing both the functionality and artistry of bamboo materials (Chotiratanapinun 2011; Cai *et al.* 2024). For instance, when surplus rice was harvested or excess prey was hunted, individuals used bamboo-woven containers to store these reserves for future use. China's Sansui bamboo weaving and Japan's Kagome weaving technique exemplify exquisite material processing craftsmanship and artistic expression in bamboo craftsmanship, utilizing eco-friendly materials to mitigate environmental pollution (Luo *et al.* 2020).

Meanwhile, as a major contributor to global electronic waste and resource consumption, the home appliance industry faces significant pressure to adopt eco-design strategies (Hamrol *et al.* 2022). Current research primarily focuses on material recyclability and improving energy efficiency (Paul *et al.* 2022), yet these solutions often overlook local cultural resources and people's emotional connections. In contrast, revitalizing traditional bamboo weaving techniques can reduce reliance on non-renewable resources, safeguard intangible cultural heritage, and promote the sustainable development of traditional craftsmanship.

This study proposes an interdisciplinary framework integrating traditional bamboo weaving craftsmanship with modern air purifier design for home applications, with three primary objectives: (1) to quantitatively validate the integration efficacy through Kansei Engineering by establishing design parameter-user response correlations, (2) to develop a hybrid design protocol reconciling traditional weaving patterns with aerodynamic performance requirements, and (3) to deconstruct the tradition-modernity dichotomy by positioning craftsmanship as an active agent in sustainable innovation through consumer analytics. We demonstrate how traditional handicraft techniques–when processed through scientific methodologies—can meet contemporary aesthetic expectations while enhancing daily life, thereby advocating a design philosophy where technology dynamically interacts with ecological-cultural values to transform heritage into proactive drivers of regenerative futures.

2. Literature Review

2.1. Bamboo Weaving Products

Bamboo weaving is one of the oldest and most renowned traditional crafts (Sun *et al.* 2022b), with a history spanning over 5,000 years. As early as the Neolithic Age, people recognized bamboo as a highly flexible and easily woven material with many valuable uses. Bamboo weaving products, serving as sustainable alternatives to synthetic materials, have been widely utilized across Southeast Asian nations and have played a pivotal role in both production systems and daily life for centuries (Porras *et al.* 2012).

In certain parts of the world such as China and India, the continuous advancement of industrialization and urbanization has led to significant migration from rural areas to urban centers (Maparu *et al.* 2017). These shifts have transformed living environments and lifestyles, resulting in a shrinking market for traditional bamboo-woven products. The proliferation of industrial materials like plastics has further created numerous alternatives to traditional bamboo items; changes in consumer preferences have further compounded this trend, with younger generations often favoring the convenience and efficiency of industrially produced goods (Meng 2021). Together, these factors have placed significant pressure on the bamboo weaving market, prompting reflection on how to sustain and adapt this craft in modern society.

In recent years, growing awareness of environmental concerns (Mausam *et al.* 2024; Rajesh *et al.* 2024) and the need for conserving cultural heritage has brought renewed attention to bamboo products as natural, environmentally friendly, and culturally valuable. In some reasons, bamboo weaving is preserved and passed down as an officially designated intangible cultural heritage (Tang 2019). In China, for instance, bamboo weaving was included in the second batch of the National Intangible Cultural Heritage list on June 7, 2008. Similarly, local governments in Tasikmalaya, Japan are actively supporting bamboo product manufacturers and promoting the region as a hub for handicraft production (Amira 2021). India has embarked on numerous bamboo industry projects at both central and local levels, emphasizing revitalization of the rural economy through the bamboo product sector (Sawarkar *et al.* 2020).

Many scholars have underscored the natural, eco-friendly, and sustainable qualities of bamboo-woven products (Silva *et al.* 2020; Li *et al.* 2022). Some scholars are dedicated to exploring the artistic characteristics of bamboo, focusing on the study of the heritage of bamboo weaving art (Cai *et al.* 2024). For example, Japanese bamboo weavers have innovated in texture, weaving techniques, and forms of expression to create new forms of bamboo art (GUO 2017). Zhang *et al.* (Zhang *et al.* 2023) integrated VR technology into a bamboo weaving experience, exploring how emerging technologies can support the sustainable study of intangible cultural heritage.

Researchers have also approached bamboo weaving from a design and innovation perspective, arguing that traditional bamboo weaving skills should not merely be preserved but also reformed and modernized to remain relevant. Efforts to expand the application of bamboo weaving into new fields have emerged to allow these skills to evolve with the times. Among them, Zheng and Zhu (Zheng *et al.* 2021) explored the incorporation of bamboo weaving into modern furniture design to promote sustainable bamboo furniture through cultural awareness. Shinohara *et al.* (Shinohara *et al.* 2024) investigated computational methods for designing architectural components based on traditional bamboo weaving techniques, expanding the application of bamboo craftsmanship into the field of architecture. Similarly, Guo *et al.* (Guo *et al.* 2021) have worked on market positioning and structural adjustments to traditional bamboo-woven products, facilitating their transformation for modern use, thereby facilitating the transformation of traditional bamboo weaving.

Most previous research has centered on bamboo weaving itself and its applications in areas such as jewelry, furniture, and building materials. However, there is a scarcity of research on the application of bamboo weaving techniques in the field of home appliances. Given the low-power consumption and minimal heat generation characteristics of household appliances, bamboo-woven materials comply with electrical safety standards (Zhou *et al.* 2024). Moreover, their inherent tactile warmth and organic texture provide exceptional user-friendliness in appliance applications (Zhao *et al.* 2024). The material's structural integrity and sustainable lifecycle further validate its suitability for meeting both operational longevity and circular economy requirements (Phuong *et al.* 2020; Muhammad *et al.* 2024). This comprehensive analysis confirms the technical and commercial viability of integrating bamboo weaving into appliance manufacturing."

2.2. Sustainable Innovations in Home Appliance Design

The home appliance industry accounts for 8% of global e-waste, driven by planned obsolescence and non-recyclable materials (Forti *et al.* 2020). While advancements in energy efficiency dominate sustainability discourse, material innovation remains a critical frontier (Zhang *et al.* 2021; Sun *et al.* 2022a). Contemporary research on home appliances predominantly prioritizes industrialization, technological modernity, aesthetic trends, and functional utility, often overshadowing opportunities to integrate sustainable, culturally rooted materials like bamboo weaving into design paradigms (Suryadi *et al.* 2019). Some researchers, highlighting the importance of design (Arcos *et al.* 2020), have suggested that home appliances be designed with energy conservation and sustainability as top priorities (Kinoshita 2020). Others have noted the sustainability and versatility of bamboo (Wang *et al.* 2021; Chaudhary *et al.* 2024) in exploring its potential application in modern household products. Recent studies highlight bamboo's potential as a sustainable alternative to plastics in product design, owing to its biodegradability, low embodied energy, and suitability for modular applications (Xu *et al.* 2023).

Despite this, relatively little research has focused on incorporating traditional bamboo weaving into household appliance design. The present study seeks to narrow this gap by applying bamboo weaving methods to household appliances, contributing to this underexplored area while offering new possibilities for integrating traditional craftsmanship with modern technology more broadly.

3. Methods and Analysis

3.1. Research Approach

To advance sustainable design practices, we employed a mixed-methods exploratory survey to systematically identify consumer preferences for bamboo product features, prioritizing attributes that align with aesthetic appeal, functional utility, and ecological responsibility. The study progressed through several steps, as illustrated in **Figure 1**. Actually, the three parts of this study correspond to the four components of Kansei Engineering research, as illustrated in the lower section of **Figure 1**.

The first step involved collecting bamboo products as samples and applying the evaluation scale method from Kansei Engineering to perform design research (Diego-Mas *et al.* 2022). This step established a relationship between bamboo products and consumer evaluations. The second step focused on using consumers' aesthetic preferences as a starting point (Fang *et al.* 2024), then leveraging these design features to inform and guide the design of household appliances (Barravecchia *et al.* 2020).

Figure 1. Research flow and Kansei workflow.

3.2. Bamboo woven Product Investigation

3.2.1. Sample Collection

We collected 50 images of bamboo products, encompassing both traditional items and innovative designs across various fields. After categorizing these products and eliminating duplicates, we chose 11 bamboo items as samples for this design survey, as shown in **Figure 2**. Samples 1, 2, 4, and 6 are traditional and commonly used bamboo products, while Samples 3, 5, 7, 8, 9, 10 and 11 are more innovatively designed bamboo products.

Figure 2. Bamboo-woven product samples.

We conducted a questionnaire survey to gather insights into consumers' opinions on currently available bamboo products from a consumer-centric approach. The survey targeted adults of various ages and educational backgrounds, with a primary focus on people aged 18 to 40, to capture perspectives from the current generation of consumers (Zou *et al.* 2024).

We identified 20 descriptive terms pertinent to bamboo products and, after removing synonyms, narrowed the list to 7 key characteristics: functionality, practicality, innovation, fashion, naturalness, warmth, and refinement. These terms were used to evaluate consumers' attitudes toward the sample products from diverse perspectives.

As shown in **Figure 3**, consumers assigned a score to each sample product based on its alignment with the seven select characteristics. Higher scores correspond to closer alignment, with a maximum of 100 points.

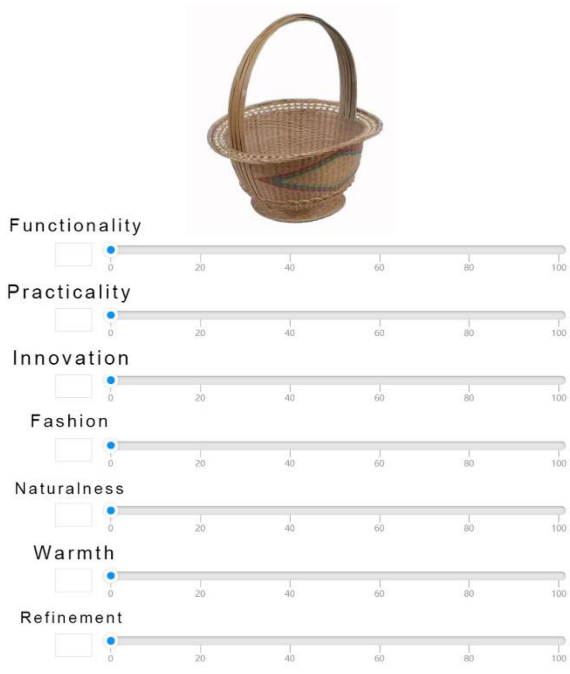


Figure 3. Portion of questionnaire on bamboo-woven products.

3.2.2. Analysis of Findings

A total of 35 questionnaires were randomly distributed to participants, with 30 valid responses collected, yielding an 85% response rate. The sample size limitation (n=30) is acknowledged. We recommend interpreting these findings as preliminary evidence warranting verification through larger-scale studies.

Only 23% of respondents reported having used traditional bamboo-woven products, while 77% stated they had never used such items. This highlights the necessity for innovating traditional bamboo product designs so that they can remain relevant in today's social environment and integrate into the lives of modern consumers.

Sample 8 showed the lowest average score (51.7), as depicted in **Figure 4**. Sample 8 combines bamboo weaving with porcelain, exploring new forms of expression for bamboo weaving techniques. Among its attributes, practicality received the lowest score (38.87) while innovation scored the highest (66.47). This suggests that while consumers recognize the innovative efforts in Sample 8, they also expect such designs to incorporate practical functionality.

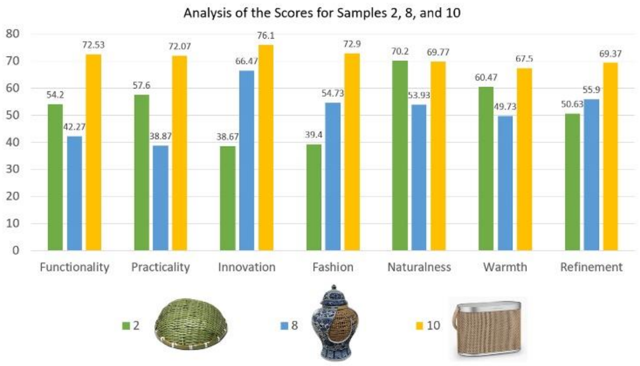


Figure 4. Scores for Samples 2, 8, and 10.

Sample 10 - with the highest average score (71.46) - represents the expansion of bamboo-woven products into new domains, transcending their traditional functions such as storage, transportation, and protection. This sample reflects a proactive effort to integrate bamboo-woven products into modern life through innovative design. The high score assigned to Sample 10 indicates that consumers embrace such an innovative approach.

Sample 2 also drew attention in terms of its scoring profile. This sample exemplifies traditional bamboo-woven products that focus primarily on practicality but lack aesthetic appeal or modern design features. Its low score reveals dissatisfaction among contemporary consumers with unchanged, wholly traditional bamboo-woven products.

Based on a comprehensive analysis of the survey results, traditional bamboo-woven agricultural products scored low in innovation and fashion but relatively high in warmth. Conversely, innovative bamboo-woven products received their highest scores for practicality, innovation, and fashion. From this, we can infer that the "Kansei attributes" consumers associate ultimately with bamboo-woven products include: innovation, practicality, warmth, and fashion (**Table 1**).

Table 1. Kansei attributes.

Initial 20 Kansei attributes	Select 7 Kansei attributes	Final 4 Kansei attributes
simple, naturalness, breathable, lightweight, vintage-inspired, warmth, elegant, culturally rich, unique, functionality, aesthetically pleasing, approachable, delicate. eco-friendly, innovation, rustic, practicality, colorful, fashion, refinement	functionality, innovation, naturalness, practicality, warmth, fashion, refinement	innovation, practicality, warmth, fashion

3.3. 3.3. Design of Household Appliances

As discussed in this section, we utilized consumers' Kansei attributes as identified in the survey to guide the design of household appliances. Air pollution has emerged as one of the most critical global challenges in recent decades, accounting for approximately 7 million premature deaths annually (Scaffaro *et al.* 2023). As an effective household appliance for mitigating indoor air contamination, air purifiers demonstrate significant efficacy in eliminating airborne microorganisms, particulate matter (PM2.5/PM10), and toxic gaseous compounds (VOCs, NOx, etc.) (Scaffaro *et al.* 2024). This substantiates their vital role in safeguarding human health through engineered environmental remediation. Simultaneously, air purifiers were prioritized as a strategic application for bamboo weaving integration due to bamboo's inherent material properties - such as natural porosity, and antimicrobial efficacy - which synergistically align with the functional requirements of air purification systems, including airflow optimization, noise reduction, and sustainable material circularity. Therefore, this study selects air purifiers as the application case for investigation.

As depicted in **Figure 5**, the weaving process of bamboo products naturally creates holes and woven textures that form hollowed-out areas, enabling interaction between internal and external space. Similarly, the air intake and exhaust systems of air purifiers draw in external air for filtration and disinfection before expelling it. These devices also feature hollowed-out sections and patterns so that air can circulate between the interior and exterior. The presence of these shared elements creates a strong basis for establishing a connection between bamboo weaving and air purifier design.

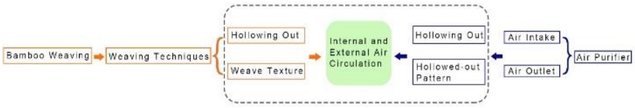


Figure 5. Correlation between bamboo-woven products and air purifiers.

3.3.1. Collection of Air Purifier Samples

We applied the Kansei Engineering method to the design of air purifiers in this study. To begin, we gathered images of 80 air purifiers from various brands and price ranges. These images were screened and categorized to isolate those that comprehensively represent the various components of air purifiers. Redundant or indistinct images were eliminated, resulting in a final selection of 30 images. Backgrounds and logos were removed from the images and numbers were assigned to each, resulting in the set shown in Figure 6.

Figure 6. Air purifier samples.

The design elements of an air purifier were defined as independent variable X. These elements were classified into five categories: the display interface, air intake, air outlet, base, and overall form, denoted as X1, X2, X3, X4, and X5, respectively. Kansei Engineering has limitations in interdisciplinary applications—notably its inherent subjectivity and challenges in scalability (Huang *et al.* 2012; Quan *et al.* 2018). To obtain more precise results, these five morphological elements were further subdivided into various structural forms. A breakdown of these morphological design elements is presented in **Table 2**.

Table 2. Decomposition of air purifier design.

Categories	Classifications	
Display interface X1	 Circular X11	 Square X12
Air intake X2	 Gradual X21	 Uniform X22
Air outlet X3	 Parallel X31	 Radioactive X32
Base X4	 Isomorphic X41	 Heteromorphic X42
Overall form X5	 Regular X51	 Irregular X52

Display interface X1

The display interface morphology was categorized into circular X11 and square X12. If the display interface exhibits both circular and square shapes, it was classified based on which one is dominant.

Air intake X2

Air intakes were classified by the shape and arrangement of holes. Those with varying sizes and shape were defined as “gradual arrangement” X21, while those with consistent size and shape were classified as “uniform arrangement” X22.

Air outlet X3

Similarly, air outlets were categorized by their morphological arrangement as “parallel arrangement” X31 or “radial arrangement” X32.

Base X4

The base X41 can either be integrated into the body design if it is of the same model or shape, or be separate X42 if it is of a different shape and cannot be seamlessly integrated into the body design.

Overall form X5

Regular forms X51 were characterized as cylindrical or cubic, whereas any other morphology was considered “irregular” X52.

Table 3. Perceptual evaluations of samples (partial).

Sample 1	Negative Kansei attributes	Score Value	Positive Kansei attributes	Dependent Variables
	Useless	-3□ -2□ -1□ 0□ 1□ 2□ 3□	Practical	y1
	Conservative	-3□ -2□ -1□ 0□ 1□ 2□ 3□	Innovative	y2
	Cold	-3□ -2□ -1□ 0□ 1□ 2□ 3□	Warm	y3
	Antiquated	-3□ -2□ -1□ 0□ 1□ 2□ 3□	Fashionable	y4

Table 4. Numerical values for research findings.

Samples	x1	x2	x3	x4	x5	y1	y2	y3	y4
1	1	1	2	1	1	5.43	4.47	4.39	4.55
2	2	2	2	1	2	5.14	4.98	4.42	4.80
3	3	3	1	1	1	5.27	4.55	4.34	4.61
4	2	2	2	1	1	5.28	4.78	4.57	4.74
5	2	1	1	1	1	4.51	3.67	3.56	3.43
6	2	1	2	1	2	5.14	5.01	4.55	4.80
7	1	1	2	2	1	5.10	4.95	4.75	4.86
8	2	1	2	2	1	5.23	5.17	4.78	4.99
9	2	1	1	1	2	4.92	5.52	4.47	5.13
10	1	1	2	2	2	5.09	5.51	4.67	5.28
11	2	2	1	1	1	5.20	4.53	4.40	4.58
12	1	1	2	2	1	5.03	4.68	4.68	4.71
13	2	2	1	1	2	4.94	4.86	4.55	4.55
14	1	1	2	1	1	5.05	4.46	4.32	4.28
15	2	1	1	2	2	5.06	4.70	4.30	4.42
16	2	1	1	2	1	4.99	4.48	4.16	4.36
17	1	1	2	1	1	5.20	4.75	4.51	4.64
18	1	1	1	1	1	5.17	4.87	4.64	4.56
19	2	1	2	1	2	5.33	5.37	4.89	5.27
20	1	1	2	1	1	5.11	4.85	4.41	4.62
21	2	1	1	2	2	4.74	4.11	4.21	3.90
22	1	1	1	1	1	4.58	3.78	3.89	3.58
23	1	1	1	1	1	5.13	4.81	4.48	4.88
24	1	1	1	1	2	5.20	5.45	4.75	5.26
25	2	1	2	1	1	5.25	4.83	4.69	4.92
26	1	1	1	1	2	4.98	5.39	4.64	4.98
27	2	1	2	1	1	5.07	4.91	4.73	4.81
28	1	1	1	1	1	5.14	4.92	4.61	4.66
29	1	1	2	1	1	4.87	4.30	4.27	4.33
30	2	1	1	1	1	5.04	4.54	4.45	4.55

We matched the four perceptual terms identified for bamboo-woven products—innovation, practicality, warmth, and fashion—with their antonyms to create contrasting pairs: “useless-practical”, “conservative-innovative”, “cold-warm”, and “antiquated-fashionable”. Using the semantic differential (SD) method (Shi *et al.*

2012), each pair was extrapolated into a seven-point scale for participants to use to rate how well the samples aligned with these terms. The resulting scores were used to quantify individuals' personal impressions of the bamboo-woven samples.

Next, we conducted a questionnaire survey to investigate the relationship between Kansei attributes associated with bamboo-woven products and the design elements of air purifiers (**Table 3**). As the survey was disseminated through work-related groups, student organizations, and community platforms, participants represented multiple demographics: design students, academics, professional designers, and community residents. As the survey was conducted through an anonymous online questionnaire, the exact number of respondents from each demographic group could not be ascertained. 30 air purifier samples were evaluated over a total of 138 questionnaires, of which 132 were deemed valid.

3.3.2. Analysis of Findings for Air Purifiers

A statistical analysis was performed on the data collected from 132 valid questionnaires. The design elements of air purifiers were treated as the independent variable X, while four sets of emotional terms served as dependent variables Y1 (useless-practical), Y2 (conservative-innovative), Y3 (cold-warm), and Y4 (antiquated-fashionable), as shown in **Table 3**.

The corresponding Y values for each set of emotional terms were calculated as the average of their corresponding 132 questionnaires. The Y values corresponding to X and the questionnaire results are presented in **Table 4**. The X variables corresponding to the 30 air purifiers in **Figure 6** can also be found in **Table 4**.

Following this analysis, regression equations were obtained for Y1, Y2, Y3, and Y4, respectively.

The regression equation for Y1 is as follows:

$$Y1 = 4.713 - 0.0236\,X1 + 0.1317\,X2 + 0.1802\,X3 - 0.0332\,X4 + 0.0074\,X5\left(R^2 = 26.62\%\right) \quad (1)$$

For the regression equation of Y1, The regression equation for Y1 yields R^2=26.62%, which falls within the acceptable range of R^2=20%~50% for Kansei Engineering (Schütte* *et al.* 2004). Thus, this regression equation is deemed statistically credible. Subsequent regressions for Y2, Y3, and Y4 also produce R^2 values within this range, therefore further discussion regarding R^2 will be omitted hereafter. Coefficients for Y1 are shown in **Table 5**.

Table 5. Coefficients for Y1.

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	4.713	0.220	21.47	0.000	
X1	-0.0236	0.0788	-0.30	0.767	1.62
X2	0.1317	0.0933	1.41	0.171	1.65
X3	0.1802	0.0711	2.53	0.018	1.06
X4	-0.0332	0.0859	-0.39	0.702	1.10
X5	0.0074	0.0758	0.10	0.923	1.07

According to the regression equation for Y1 (useless-practical), X3 has the greatest impact at an impact coefficient of 0.1802, followed by X2 at 0.1317. Overall, X5 has the least impact on Y1 (0.0074), while the other two factors have a negative impact. The above findings can also be observed from the P-value analysis in **Table 5**.

By combining the regression equation for Y1 with the information given in **Table 1**, we found that setting the air outlet X3 to 2 (radial) and the air intake X2 to 2 (uniform) was most conducive to demonstrating the utility of the air purifier. When the display interface X1 was set to 1 (circular), the base X4 to 1 (integrated), and the overall form X5 to 2 (irregular), the utility of the device became slightly more evident. However, these factors had relatively minor influence and their effects were not statistically significant.

Using the same method, the regression equations for Y2, Y3, and Y4 can be obtained as shown in Equations 2-4 below.

$$Y2 = 3.863 - 0.130X1 + 0.061\,X2 + 0.246\,X3 - 0.041\,X4 + 0.542\,X5\left(R^2 = 35.39\%\right) \quad (2)$$

$$Y3 = 3.945 - 0.081\,X1 + 0.063\,X2 + 0.2212\,X3 + 0.026\,X4 + 0.158\,X5\left(R^2 = 23.26\%\right) \quad (3)$$

$$Y4 = 3.690 - 0.093\,X1 + 0.117\,X2 + 0.327\,X3 - 0.032\,X4 + 0.375\,X5\left(R^2 = 26.96\%\right) \quad (4)$$

Based on the comprehensive analysis above, in the regression equations for Y1, Y2, Y3, and Y4, X3 and X5 consistently exhibit significant effects. Moreover, the coefficients of X3 and X5 in the regression equations are positive, indicating that better evaluations are achieved when both X3 and X5 take the value of 2. Therefore, greater emphasis should be placed on the roles of X3 and X5 in subsequent analysis and design.

Four regression equations are obtained for Y1, Y2, Y3, and Y4. In each equation, only 1-2 of the variables (X1–X5) show statistical significance ($P \leq 0.05$). The authors suggest the following possible reasons: (1) The limited number of valid samples (n = 132) may reduce statistical power; (2) Subjective variations in individual ratings of Kansei attributes in the survey can introduce substantial bias. Therefore, these analytical results should be interpreted as hypothetical predictions rather than definitive conclusions.

4. Design Optimization and Verification

Numerical values for design elements X1, X2, X3, X4, and X5 for the air purifier corresponding to each set of emotional terms was derived based on the four regression equations described above. Taking Y1 as an example, as shown in Equation 1. When Y1 is at its maximum, the value of X1 should be 1, X2 should be 2, X3 should be 2, X4 should be 1, and X5 should be 2. The implication is that when the air purifier is most practical, the display interface should be circular, the air intake should be uniform, the air outlet should be radial, the base should be integrated with the main body, and the overall shape should be irregular. SX values derived from the similar regression equations for Y2, Y3, and Y4 are shown in **Table 6**.

Table 6. Relations of Kansei attributes and design elements.

	X1	X2	X3	X4	X5
Y1	1	2	2	1	2
Y2	1	2	2	1	2
Y3	1	2	2	2	2
Y4	1	2	2	1	2
Y0	1	2	2	1	2

The aforementioned models cater to each pair of emotional (or “perceptual”) terms. To develop an optimal design model that satisfies all four pairs, denoted as Y0, we conducted a longitudinal comparison of the values for each design element. For X1, values for Y1, Y2, Y3, and Y4 are all 1. Therefore, the optimal design Y0 has X1 set to 1. Similarly, the corresponding values for X2, X3, and X5 are all 2, indicating that the optimal design Y0 has a value of 2 for these elements. X4 only attains a value of 2 for Y3, and remains at 1 for all other models. In accordance with the majority rule, X4 can be reasonably assigned a value of 1. Therefore, the optimal design Y0 corresponds to X1, X2, X3, X4, and X5 values of 1, 2, 2, 1, and 2, respectively (**Table 6**). By substituting the values of X1-X5 into the four regression equations in Section 3.3.2. Analysis of Findings for Air Purifiers, the optimal values for Y0-Y4 can be obtained. These results are presented in the Predictive Value section of **Table 7**.

Based on the numerical values corresponding to X1, X2, X3, X4, and X5 in the optimal design model Y0, we derived several key design elements for the optimal air purifier: a circular display screen, a uniform air intake, radial air outlets, a base integrated with the main body, and an irregular overall shape. Accordingly, we conducted a design practice for an air purifier, as illustrated in **Figure 7**.

Figure 7. Air purifier design practice.

The air intake and outlet of the air purifier were designed with a bamboo-woven pattern and texture, also utilizing bamboo as the primary material. It should be acknowledged that the durability of bamboo weaving as the air intake and outlet ports of the air purifier has not been verified. Further testing and validation are required before mass production of this product. Two colorways were also established to accommodate diverse consumer preferences. Using the white model as an example, a questionnaire survey was conducted for the air purifier model Y0 as outlined in **Table 2**. 43 individuals were randomly selected for the survey, including design students, teachers, and members of the general public. The survey results have been incorporated into **Table 7** as part of the Research Value section.

Table 7. Perceptual evaluations of Y0.

Air Purifiers Y0	Kansei attributes	Predictive Value	Research Value	Error Value (%)
	Y1	5.29	6.26	18.15
	Y2	5.39	6.05	12.24
	Y3	4.80	5.53	15.21
	Y4	5.20	5.60	7.69
	Y0	5.17	5.86	13.32

As presented in **Table 7**, the predicted value for Y1 is 5.29, whereas the surveyed value is 6.26, yielding an error of 18.15%. The error is calculated using the formula: (Predictive Value - Research Value) / Predictive Value. Similarly, The predicted values for Y2-Y4 closely align with the research values, with all errors remaining below 20%.

The overall value for Y0 was calculated as the average of various considerations, producing an error of 13.32%. This error falls within the 15% margin, thereby validating the high reliability of the established Kansei Engineering model for air purifiers. Nevertheless, the relatively low R^2 values indicate significant unexplained variance in the regression model. In future studies, employing larger samples and incorporating additional variables (such as cultural bias, educational background differences, occupational variations, gender disparities, etc.) could help establish a more accurate Kansei Engineering model. Furthermore, a comparative analysis of different modeling approaches—including regression models, neural networks, response surface methodology (RSM), among others—could be conducted to evaluate their respective strengths and weaknesses in this field.

5. Conclusions

Bamboo weaving represents a vital socio-ecological heritage that sustains both cultural identity and traditional material practices across Asia. While historically rooted in utilitarian functions, this craftsmanship maintains contemporary relevance through its integration into modern home appliances—a critical strategy for preserving intangible cultural heritage during technological transitions. Consumer surveys demonstrate a discernible preference for bamboo-woven products, as their natural warmth and innovative designs consistently elicit positive feedback. We aimed to integrate bamboo weaving techniques into the design of household appliances in this study, leveraging the natural texture and warmth of the material to counterbalance the perceived coldness of modern devices. More importantly, we sought to expand the application of bamboo weaving skills into the realm of home appliances, embedding them into modern life. This approach may not only preserve traditional bamboo weaving techniques but also ensure their continued relevance in products that individuals use throughout their daily lives.

Using an air purifier as a case study, we incorporated consumers' Kansei attributes for bamboo-woven products into an optimized design. We developed an air purifier model aligned with consumer preferences by using a design methodology based on perceptual ergonomics. The model was subsequently optimized to achieve the best possible design that satisfies all perceptual considerations. To validate the model, we conducted a practical design exercise for an air purifier; the results confirmed that the optimal design model is both operable and practical, providing a workable reference for future designs.

This paper presents a design study on the application of bamboo weaving to household appliances, representing an attempt to integrate traditional craftsmanship into modern life while preserving its cultural significance. We hope that future research will continue to explore the inheritance and evolution of traditional craftsmanship.

Author Contributions

Conceptualization, L.D. and M.Z.; methodology, L.D.; software, Z.Q.; formal analysis, M.Z.; investigation, M.Z.; resources, L.D.; writing—original draft preparation, L.D.; writing—review and editing, M.Z.; supervision, M.Z.; project administration, L.D.; funding acquisition, L.D. and M.Z.; All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

This study was deemed exempt from IRB review under 45 CFR 46.104(d)(2) as it involved only anonymous surveys with no sensitive questions. Participants were informed of the anonymous nature of the study before proceeding.

Informed Consent Statement

Not applicable.

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Conflicts of Interest

The authors declare no conflicts of interest.

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