Evaluation of Solid Wood Smart Home Product Design Schemes Based on AHP-CRITIC-TOPSIS and Generation Z Preferences

Chengyu Hu and Yin Zhao *

To investigate Generation Z's design preferences for solid wood smart home products and the factors influencing their choice of design solutions, the AHP-CRITIC-TOPSIS integrated evaluation model was applied. The KJ method was used to screen nine design proposals, and 14 evaluation criteria were established based on material appearance, material–technology integration, and emotional needs. The model combined subjective weights from AHP, objective weights from CRITIC derived from 159 questionnaires, and TOPSIS rankings. The results indicated that embedded-structure rationality, aesthetic harmony, maintenance convenience, and perceived rationality of heat-source layout were key indicators, with the S6 design ranking highest among the nine evaluated alternatives. This study provides a quantitative reference for sustainable innovation in solid wood smart home products.

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Keywords: Solid wood furniture; Smart home furniture; AHP; CRITIC; TOPSIS; Gen Z preferences

*Contact information: College of Furnishings and Industrial Design, Nanjing Forestry University, Nanjing, Jiangsu Province, 210037, China; *Corresponding author: zhaoyin@njfu.edu.cn*

INTRODUCTION

With the integration of Internet of Things (IoT) and artificial intelligence (AI) technologies into smart home and smart furniture design, furniture products are evolving from traditional static objects into sensor-enabled, interactive, and personalized systems (Alam *et al.* 2012; Jiang 2025). As a bio-based material widely used in architecture and furniture, wood is characterized by its renewability, sustainability, biodegradability, and environmental friendliness (Hu *et al*. 2023). Viewed through the lenses of environmental psychology and biophilic design, wood's natural color, texture, tactile qualities, and scent, together with the spatial ambiance created by these attributes, can shape users' aesthetic preferences, psychological comfort, perceived restrictiveness, and emotional experiences (Zhang *et al.* 2024; Cavaliere *et al.* 2026). Physiological experiments show that tactile contact with natural wood can reduce prefrontal cortical activity and increase heart rate variability (HRV), an indicator of parasympathetic nervous system activity, thereby promoting physiological relaxation (Ikei *et al.* 2018). As smart controls, interactive interfaces, and health management functions are integrated into wood-based furniture, smart wooden home products have emerged as a key direction for enhancing the added value of furniture (Fu *et al.* 2025).

Smart furniture still faces challenges in balancing technological integration, user experience, and aesthetic design. Relevant studies indicate that while smart furniture can achieve health monitoring, fatigue relief, and intelligent interaction through the Internet of Things (IoT), sensors, big data, and artificial intelligence, it also faces challenges such as inconsistent design standards and insufficient technological application (Alaa *et al*. 2017; Hu *et al.* 2025). Meanwhile, as "digital natives," Generation Z relies on smart devices while also being affected by information overload, social media fatigue, and excessive digital connectivity (Mason *et al.* 2022); digital detox has become an important means of enhancing digital well-being (Radtke *et al.* 2022). Therefore, the visual textures, tactile feedback, and emotional value provided by natural solid wood materials can serve as key design entry points for alleviating digital fatigue and enhancing emotional comfort and quality of life (Sun and Wang 2025).

Currently, some solid wood smart furniture embeds electronic control modules, charging panels, or display interfaces directly into the furniture body (Xiong *et al.* 2023), which tends to disrupt the continuity of the wood grain and diminish the material's inherent natural feel and multisensory experience. Surface roughness and wood-structure variability also affect veneer surface quality (Kamperidou *et al.* 2022). The natural color, continuous grain, surface luster, and tactile experience of solid wood serve as crucial visual-tactile cues influencing users' aesthetic preferences and emotional responses (Zhang *et al.* 2024). At the same time, as a typical hygroscopic material, wood's moisture content is influenced by factors such as temperature, relative humidity, density, thickness, and pore structure (Liu *et al*. 2022), and involves a thermo-hygrometric coupling process (Younsi *et al.* 2006). Consequently, localized heat sources generated by embedded electronic components may disrupt the equilibrium moisture content and dimensional stability of the surrounding wood, increasing the risk of warping, shrinkage, and cracking (Silva *et al.* 2014; Fu *et al.* 2023).

In this context, the central challenge for solid-wood smart home products lies not simply in adding smart functions, but in achieving a balance among technological convenience, natural sensory experience, and material stability. Generation Z seeks both the efficiency and personalized services offered by smart devices and a reduction in overt digital distractions, while retaining the relaxing and soothing qualities provided by natural materials (Ikei *et al.* 2017; Rauter *et al.* 2024). Consequently, the application of smart technology in solid wood furniture should not be limited to overt displays such as screens, buttons, and cutouts, but should shift toward more concealed, restrained, maintainable, and structurally integrated design methods. Although existing research has focused on smart furniture technologies and applications (Mimoso *et al.* 2025), there remains a lack of systematic quantitative analysis regarding relationships such as "smart module layout—perceived dimensional stability," "technology embedding—wood grain continuity," and "user preferences—scheme optimization." Therefore, this study employs the AHP-CRITIC-TOPSIS integrated evaluation model, combining expert judgment with Gen Z user evaluation data, to conduct a comprehensive assessment of typical solid wood smart home product designs, thereby providing quantitative evidence for low-intrusiveness, sustainable material–technology integration design.

In this study, 'smart furniture' refers primarily to furniture with embedded electronic sensing, connectivity, or control functions. Modular assembly, reconfigurability, and design for disassembly are treated as complementary non-electronic smart design attributes because they support adaptation, repair, and long-term use.

EXPERIMENTAL

Method

AHP is used to extract expert subjective weights (Saaty 1990), while CRITIC calculates objective weights based on standard deviation and correlation coefficients (Diakoulaki *et al.* 1995), and TOPSIS performs ranking by comparing the distances between alternatives and positive and negative ideal solutions (Lai *et al.* 1994). Related studies examine product attributes and customer satisfaction (Lin *et al.* 2017) and apply integrated models to furniture design evaluation and user needs analysis (Miao *et al.* 2024; Yu *et al.* 2024; Ouyang *et al.* 2026). This study constructed an evaluation index system that incorporates key wood-science characteristics, including dimensional stability and the light-transmission properties of thin wood veneers. It analyzed Gen Z preferences and screens for optimal solutions, providing a quantitative basis for the material–technology integration and sustainable design in solid wood smart home products.

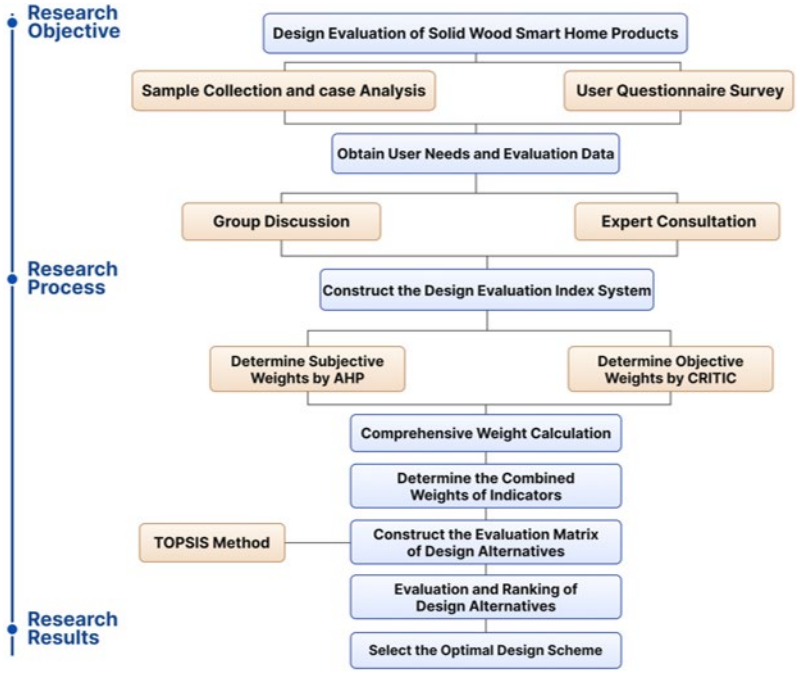
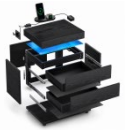


Fig. 1. Flowchart of the Integrated AHP-CRITIC-TOPSIS evaluation model

Sampling

The KJ method was used to identify representative design samples (Cheng and Leu 2011) through four steps: case collection, sample-card development, focus-group classification, and representative design selection (Yu *et al.* 2024). More than 20 cases were collected from brand and design websites, e-commerce platforms, smart-furniture databases, and relevant literature. Eligible products used solid wood as a primary or key structural material and incorporated smart functions such as wireless charging, LED lighting, touch interaction, Bluetooth speakers, hidden displays, or sensor control. After incomplete or redundant cases were excluded, nine alternatives, coded S1–S9, were retained. To compare their embedded structures, heat-source layouts, and maintenance approaches, Table 1 summarizes the product types, smart functions, appearance renderings, exploded views, and material–technology integration features

Table 1. Design Alternatives and Structural Exploded-View Placeholders

Sample	Product Image	Exploded-view Image	Product Type	Smart Function	Integration Feature /Brief Description
S1			Smart storage	Sensor lighting; countertop module	Top-area integration; complete front grain with localized smart modules
S2			Smart study desk and chair	Lighting; storage; learning support	Desktop integration; ergonomic curves with visible function modules
S3			Smart bedside cabinet	Charging; lighting; side control	Partially exposed integration; rounded wooden body with edge light.
S4			Smart sideboard / TV cabinet	Control panel; ambient lighting	Small embedded panel with hidden bottom lighting and horizontal wood form.
S5			Smart storage / shoe cabinet	Touch control; disinfection; drying	Semi-hidden integration; smart functions mainly inside drawer structure.
S6			Smart bedside / storage cabinet	Wireless charging; storage; drawer modules	Structure-integrated design; clear zoning and modules combined with storage.
S7			Smart bedside cabinet	Charging; lighting; control panel	Highly visible integration; dark body with blue lighting and strong tech expression.

S8			Smart wardrobe	Smart lock; touch panel; interior lighting	Door-panel integration; wood panels, glass display and embedded control.
S9			Smart office / study desk	Charging; control panel; desktop modules	Multi-point desktop integration for office and study use.

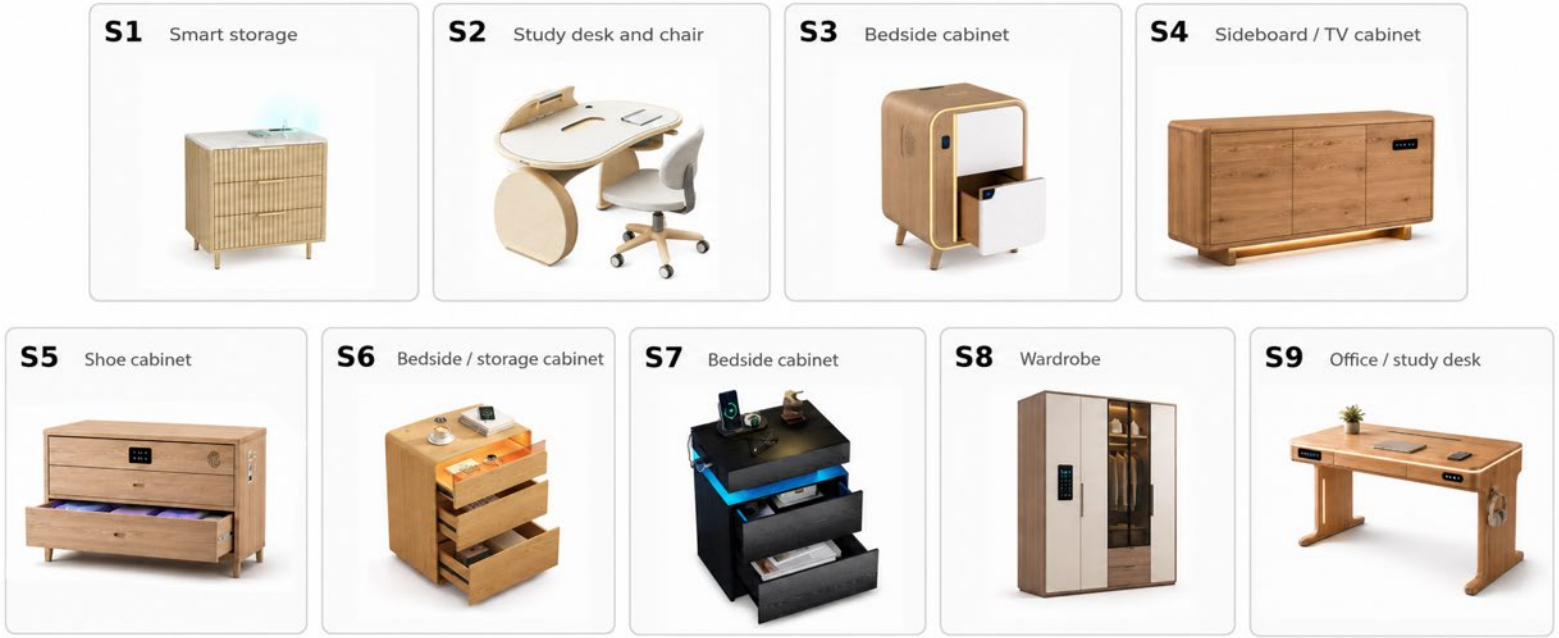


Fig. 2. Standardized visual comparison of the nine design alternatives (S1–S9)

Figure 2 presents S1–S9 in a standardized format for direct visual comparison. Because furniture type and function were not statistically controlled, the ranking evaluates complete product concepts rather than material–technology integration alone.

Calculation of Evaluation Indicator Weights Based on the AHP Method

This study used the Analytic Hierarchy Process (AHP) to determine subjective weights for evaluating solid-wood smart home products. AHP structures complex decisions hierarchically and converts expert pairwise comparisons into quantitative criterion weights (Saaty 1986; Ishizaka and Labib 2009). Widely applied in sustainable product and furniture design evaluation, AHP supports design decision-making, alternative selection, and indicator ranking (Lin *et al.* 2023; Liu *et al.* 2023; Chen *et al.* 2024).

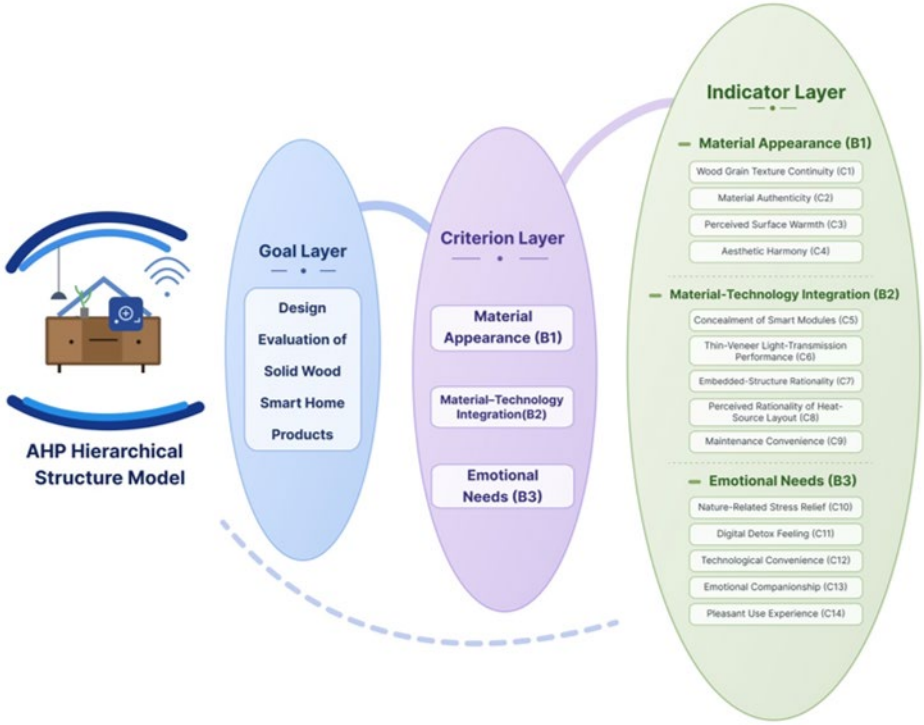


Fig. 3. AHP hierarchical structure model for solid wood smart home products

Given that solid-wood smart home products involve material aesthetics, Material–Technology Integration, and emotional needs, a single standard cannot comprehensively reflect their overall performance. Based on case studies, focus group discussions, and expert consultations, a three-level Analytic Hierarchy Process (AHP) model was constructed (Fig. 3). The goal level of the model is the "Evaluation Index System for Solid-Wood Smart Home Product Design (A)"; the criterion level comprises Material Appearance (B1), Material–Technology Integration (B2), and emotional needs (B3); and the indicator level encompasses 14 specific evaluation indicators.

Based on the alignment between research expertise and evaluation criteria, 10 faculty members were specifically selected from the college to form the AHP expert panel. The panel consisted of 4 experts in furniture design and engineering, 2 in wood materials and manufacturing, 2 in smart furniture and product design, and 2 in ergonomics and human-computer interaction, including 6 professors and 4 associate professors. Each expert independently completed four pairwise comparison matrices using Saaty's 1–9-

point scale. The corresponding evaluation results were aggregated element by element using geometric means to construct four group evaluation matrices, in which a CR value < 0.10 indicated acceptable consistency.

Table 2. 1–9 Degree Scale

Scale value	Significance
1	Equally important
3	Slightly important
5	Significantly important
7	Very significantly important
9	Extremely important
2, 4, 6, 8	Intermediate values between adjacent scales

Once the judgment matrix was constructed, the relative weights of the criteria layer and the indicator layer were calculated. To ensure the reliability and scientific validity of the experts' judgments, a consistency check was performed on the judgment matrix. First, the maximum eigenvalue $\lambda_{\max}$ was calculated according to Eq. 1,

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(AW)_i}{W_i} \quad (1)$$

where A denotes the judgment matrix, W denotes the weight vector, n represents the order of the judgment matrix, and $(AW)_i$ and W_i denote the matrix product and the corresponding component of the weight vector, respectively. The consistency index CI was calculated by Eq. 2.

$$CI = \frac{\lambda_{\max}-n}{n-1} \quad (2)$$

Next, the consistency ratio CI was calculated using Eq. 3,

$$CR = \frac{CI}{RI} \quad (3)$$

where RI denotes the random consistency index. A judgment matrix passes the consistency test when $CR < 0.10$; otherwise, it must be adjusted and recalculated (Saaty 1990), reducing inconsistencies in expert judgments and improving weighting reliability.

After the consistency test, the matrix was normalized and weights were calculated. Each indicator's global AHP weight was obtained by multiplying its criterion weight by its local weight, with higher values indicating greater influence. The resulting subjective weights were combined with CRITIC objective weights to produce composite weights for TOPSIS ranking.

Calculation of Objective Weights for Evaluation Metrics Based on the CRITIC Method

The CRITIC method was used to determine objective weights based on indicator contrast intensity and inter-criterion conflict, with standard deviation representing discriminatory power and correlation coefficients reflecting information overlap (Diakoulaki *et al.* 1995; Krishnan *et al.* 2021). The survey targeted Generation Z users born between 1995 and 2009 and was distributed through the WJX platform and university student groups. Of the 170 questionnaires collected, 11 were excluded: four were incomplete, one was completed in less than the prespecified minimum response time, one exhibited straight-lining, one was a duplicate submission, one contained internally

inconsistent responses, two failed the attention checks, and one was completed by a respondent outside the target age range owing to unintended redistribution of the questionnaire. Each invalid questionnaire was classified according to its primary reason for exclusion, yielding a final sample of 159 valid responses (93.5%). The questionnaire collected demographic information, five-point ratings of 14 indicators across nine schemes, and overall preference rankings. Ratings were converted into scores of 20, 40, 60, 80, and 100. "Perceived Rationality of Heat-Source Layout" was assessed perceptually in terms of structural safety and layout rationality rather than actual dimensional changes in wood. Mean scores formed the initial decision matrix, and CRITIC weights were calculated through normalization, correlation and conflict analyses, and information-content calculation for subsequent integrated weighting and TOPSIS ranking.

Step 1: Construct the decision matrix. After averaging the questionnaire score data, the initial decision matrix was obtained. The decision matrix X is shown in Eq. 4,

$$X = [x_{ij}] = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (4)$$

where i = 1, 2, ..., m, and j = 1, 2, ..., n. In this study, m = 9, representing 9 design alternatives; n = 14, representing 14 evaluation criteria. The matrix element xij represents the average score of the i-th design alternative for the j-th evaluation criterion.

Step 2: Construct the standardized decision matrix. To eliminate the influence of different data ranges on the evaluation results and ensure comparability among the indicators, the initial decision matrix was standardized. Because all indicators in this study are benefit-oriented—meaning higher values indicate better performance of the scheme—standardization was performed using Eq. 5.

$$x'_{ij} = \frac{x_{ij} - \min\limits_{1 \le i \le m} x_{ij}}{\max\limits_{1 \le i \le m} x_{ij} - \min\limits_{1 \le i \le m} x_{ij}} \quad (5)$$

Step 3: Calculate the correlation coefficients between indicators. The correlation coefficient ρ_{jk} between indicators measures the degree of correlation between the j-th and k-th indicators. A higher coefficient correlation indicates a greater overlap in the information provided by the two indicators, and the independent contribution of that indicator should be reduced accordingly. The formula for calculating the correlation coefficient is shown in Eq. 6,

$$\rho_{jk} = \frac{\sum_{i=1}^{m}(x'_{ij} - \bar{x}'_j)(x'_{ik} - \bar{x}'_k)}{\sqrt{\sum_{i=1}^{m}(x'_{ij} - \bar{x}'_j)^2}\sqrt{\sum_{i=1}^{m}(x'_{ik} - \bar{x}'_k)^2}} \quad (6)$$

where xj' and xk' represent the average standardized scores of the j-th and k-th indicators, respectively.

Step 4: Calculate the conflict index. Based on the correlation coefficients between indicators, the degree of conflict between each indicator and the others was calculated. The conflict index Rj for the j-th indicator is given by Eq. 7.

$$R_j = \sum_{k=1}^{n} (1 - \rho_{jk}) \quad (7)$$

A larger Rj value indicates a higher degree of conflict between the j-th indicator and the other indicators; that is, the more independent the information contained in that indicator is, and the greater its contribution to the evaluation system.

Step 5: Determine the objective weights. First, the standard deviation σj of the standardized value of the j-th indicator was multiplied by its conflict index Rj to obtain the information content Cj of that indicator, as shown in Eq. 8.

$$C_j=\sigma_j R_j \quad (8)$$

Finally, the information content of each indicator was normalized to obtain the objective weight Wj for each indicator, as shown in Eq. 9,

$$W_j=\sum_{j=1}^{C_j} C_j \quad (9)$$

where W_j represents the objective weight of the j-th evaluation criterion. A larger value of W_j indicates that the criterion has a stronger ability to distinguish between different alternatives and exhibits less information overlap with other criteria; therefore, it carries greater importance in the objective evaluation. The objective weights obtained using the CRITIC method were combined with the subjective weights calculated using the AHP method to form the composite weights required for the subsequent TOPSIS ranking of alternatives.

Calculation of the Weighted Average

According to Eq. 10, the AHP subjective weights are denoted as W_i, the CRITIC objective weights as W_j, and the composite weights S_i are calculated using multiplicative normalization; n = 14. The composite weights serve as the final indicator weights for the TOPSIS ranking.

$$S_i=\sum_{j=1}^{n} W_i \times W_j \quad (10)$$

In TOPSIS calculations, the initial judgment matrix was first vector-normalized to construct a weighted normalized matrix. Subsequently, the positive and negative ideal solutions were identified, and the distances between each alternative and these ideal solutions were calculated. Finally, the alternatives were ranked. A higher C value indicates that an alternative is closer to the ideal solution and has a better overall performance.

RESULTS AND DISCUSSION

AHP Calculation Results

Based on the goal-level judgment matrix shown in Table 3, the calculated weights indicate that material–technology integration (B2) received the highest weight, at 51.0%, followed by material appearance (B1, 28.9%) and emotional needs (B3, 20.1%). This suggests that experts placed greater emphasis on the compatibility between solid wood materials and smart technologies in the evaluation of solid-wood smart home products. Tables 4 through 6 present the judgment matrices for the indicators under each criterion layer. The local weights of the indicators were calculated from these matrices, and their global weights were obtained by multiplying the local weights by the corresponding criterion-layer weights. Table 7 reports the consistency test results. The CR values for the goal level, B1, B2, and B3 were 0.001, 0.006, 0.019, and 0.003, respectively, all of which were below the threshold of 0.10, confirming that the judgment matrices passed the consistency test and could be used for subsequent weight calculation. Among the 14 indicators, Embedded-Structure Rationality (C7) had the highest global weight, at 17.9%,

followed by Perceived Rationality of Heat-Source Layout (C8, 11.2%), Aesthetic Harmony (C4, 10.9%), and Maintenance Convenience (C9, 10.3%). These results indicate that the evaluation of solid-wood smart home products should emphasize embedded module structure, dimensional stability in heat-generating areas, maintainability, and aesthetic coordination, thereby ensuring material–technology compatibility rather than merely adding smart functions. The local and global subjective weights of the 14 evaluation indicators are summarized in Table 8.

Table 3. Goal-Level Judgment Matrix

	B1	B2	B3
B1 Material Appearance	1.000	0.549	1.487
B2 Material–Technology Integration	1.820	1.000	2.462
B3 Emotional Needs	0.672	0.406	1.000

Table 4. B1 Subcriterion Judgment Matrix

	C1	C2	C3	C4
C1 Wood Grain Texture Continuity	1.000	0.475	0.856	0.418
C2 Material Authenticity	2.103	1.000	1.722	0.721
C3 Perceived Surface Warmth	1.168	0.581	1.000	0.471
C4 Aesthetic Harmony	2.391	1.386	2.122	1.000

Table 5. B2 Subcriterion Judgment Matrix

	C5	C6	C7	C8	C9
C5 Concealment of Smart Modules	1.000	1.357	0.367	0.626	0.633
C6 Thin-Veneer Light-Transmission Performance	0.737	1.000	0.306	0.390	0.448
C7 Embedded-Structure Rationality	2.725	3.270	1.000	1.687	1.868
C8 Perceived Rationality of Heat-Source Layout	1.597	2.565	0.593	1.000	1.072
C9 Maintenance Convenience	1.580	2.233	0.535	0.933	1.000

Table 6. B3 Subcriterion Judgment Matrix

	C10	C11	C12	C13	C14
C10 Nature-Related Stress Relief	1.000	1.269	0.980	2.587	0.747
C11 Digital Detox Feeling	0.788	1.000	0.737	2.054	0.550
C12 Technological Convenience	1.021	1.358	1.000	2.919	0.691
C13 Emotional Companionship	0.387	0.487	0.343	1.000	0.299
C14 Pleasant Use Experience	1.339	1.819	1.446	3.346	1.000

Table 7. Consistency Test CR chart

n	A	B1	B2	B3	Total
CR	0.001	0.006	0.019	0.003	0.00725

Table 8. Weight Value of Subjective Evaluation Index System

A	B	Average weight (W′)	Wi	Sort
Material Appearance B1	C1 Wood Grain Texture Continuity	0.150	0.043	12
Material Appearance B1	C2 Material Authenticity	0.296	0.086	5
Material Appearance B1	C3 Perceived Surface Warmth	0.175	0.051	8
Material Appearance B1	C4 Aesthetic Harmony	0.379	0.110	3
Material–Technology Integration B2	C5 Concealment of Smart Modules	0.131	0.067	6
Material–Technology Integration B2	C6 Thin-Veneer Light-Transmission Performance	0.095	0.048	9
Material–Technology Integration B2	C7 Embedded-Structure Rationality	0.353	0.180	1
Material–Technology Integration B2	C8 Perceived Rationality of Heat-Source Layout	0.219	0.112	2
Material–Technology Integration B2	C9 Maintenance Convenience	0.202	0.103	4
Emotional Needs B3	C10 Nature-Related Stress Relief	0.219	0.044	11
Emotional Needs B3	C11 Digital Detox Feeling	0.169	0.034	13
Emotional Needs B3	C12 Technological Convenience	0.226	0.045	10
Emotional Needs B3	C13 Emotional Companionship	0.084	0.017	14
Emotional Needs B3	C14 Pleasant Use Experience	0.302	0.061	7

CRITIC Calculation Results

After screening, 159 of the 170 returned questionnaires were retained for the CRITIC analysis. The mean ratings of the nine design alternatives across the 14 evaluation indicators were used to construct the initial decision matrix, as shown in Table 9. To eliminate the effects of different numerical ranges and ensure comparability among the indicators, the initial matrix was normalized using the range normalization method, and the resulting normalized matrix is presented in Table 10. Based on the normalized matrix, the correlation coefficients, conflict measures, and information content of each indicator were calculated. The resulting CRITIC objective weights and their rankings are summarized in Table 11. The results indicate that Perceived Surface Warmth (C3), Aesthetic Harmony (C4), and Technological Convenience (C12) received relatively high objective weights, suggesting that these indicators showed greater discriminatory power in Generation Z users' evaluations. In contrast, Digital Detox Feeling (C11), Embedded-Structure Rationality (C7), and Perceived Rationality of Heat-Source Layout (C8) received relatively low objective weights, indicating smaller differences among users' evaluations of the nine design alternatives.

Total Weight Calculation Results

In the calculation of the composite weights, both the subjective AHP weights and the objective CRITIC weights were taken into account. The AHP weights reflect experts' judgments regarding the importance of evaluation criteria for solid wood smart home products, while the CRITIC weights reflect the discriminative power and information content of each criterion in the rating data from Gen Z users. After calculation using the multiplicative normalization formula, the final composite weights for the 14 evaluation criteria were obtained, as shown in Table 12.

Table 9. Initial Judgment Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
S1	58.93	61.60	60.79	62.36	64.21	60.06	59.97	62.58	62.36	61.67	60.57	57.04	61.76	58.11
S2	58.65	58.14	59.06	60.57	62.14	57.48	62.14	62.14	59.75	62.45	59.65	62.92	58.96	63.33
S3	56.92	65.06	63.33	59.25	62.23	63.87	61.01	62.58	63.93	60.35	61.16	57.80	59.69	58.55
S4	60.35	59.15	61.95	60.82	61.19	60.85	61.73	60.00	60.53	58.05	57.86	60.82	60.50	62.23
S5	63.93	62.61	61.29	59.25	56.51	60.97	61.54	62.55	58.99	62.96	60.88	61.98	58.65	65.44
S6	58.87	60.91	59.21	61.26	62.64	63.68	61.73	62.39	62.20	59.72	63.77	58.27	65.25	61.29
S7	61.32	60.66	62.92	60.28	60.82	66.07	60.60	60.53	59.34	62.17	58.84	60.00	60.19	60.00
S8	63.40	63.21	60.69	63.27	63.87	60.75	61.92	61.76	57.11	62.99	61.07	61.19	61.82	60.31
S9	62.55	64.40	62.45	59.21	63.68	53.81	63.87	63.49	60.38	62.67	60.00	61.89	61.79	62.42

Table 10. Normalized Matrix Table

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
S1	0.287	0.500	0.405	0.776	1.000	0.510	0.000	0.739	0.770	0.733	0.459	0.000	0.471	0.000
S2	0.247	0.000	0.000	0.335	0.731	0.299	0.556	0.613	0.387	0.891	0.303	1.000	0.047	0.712
S3	0.000	1.000	1.000	0.010	0.743	0.821	0.267	0.739	1.000	0.466	0.558	0.129	0.158	0.060
S4	0.489	0.146	0.677	0.397	0.608	0.574	0.451	0.000	0.501	0.000	0.000	0.643	0.280	0.562
S5	1.000	0.646	0.522	0.010	0.000	0.584	0.403	0.731	0.276	0.994	0.511	0.840	0.000	1.000
S6	0.278	0.400	0.035	0.505	0.796	0.805	0.451	0.685	0.746	0.338	1.000	0.209	1.000	0.434
S7	0.628	0.364	0.904	0.264	0.560	1.000	0.162	0.152	0.327	0.834	0.166	0.503	0.233	0.258
S8	0.924	0.733	0.382	1.000	0.956	0.566	0.500	0.504	0.000	1.000	0.543	0.706	0.480	0.300
S9	0.803	0.905	0.794	0.000	0.931	0.000	1.000	1.000	0.479	0.935	0.362	0.825	0.476	0.588

Table 11. Weights of Objective Evaluation Indicators

	Measure of conflict	Quantity of Information (Cj)	Wj	Sort
C1	12.383	4.011	0.073	7
C2	11.314	3.556	0.065	10
C3	14.157	4.755	0.087	1
C4	13.921	4.615	0.084	2
C5	12.967	3.716	0.068	9
C6	15.350	4.297	0.078	4
C7	11.912	3.151	0.057	13
C8	11.303	3.342	0.061	12
C9	14.623	4.155	0.076	6
C10	12.168	3.978	0.072	8
C11	11.732	3.120	0.057	14
C12	13.719	4.556	0.083	3
C13	12.254	3.513	0.064	11
C14	13.822	4.159	0.076	5

Table 12. Table of Total Weight Values

Indicator	Wi	Wj	Si	Sort
C1	0.043	0.073	0.045	12
C2	0.086	0.065	0.080	5
C3	0.051	0.087	0.063	8
C4	0.110	0.084	0.132	2
C5	0.067	0.068	0.065	7
C6	0.048	0.078	0.053	9
C7	0.180	0.057	0.146	1
C8	0.112	0.061	0.097	4
C9	0.103	0.076	0.112	3
C10	0.044	0.072	0.045	11
C11	0.034	0.057	0.028	13
C12	0.045	0.083	0.053	10
C13	0.017	0.064	0.016	14
C14	0.061	0.076	0.066	6

The results show that the composite weight for embedded-structure rationality (C7) is the highest at 0.146; followed by aesthetic harmony (C4) with a weight of 0.132; maintenance convenience (C9) ranks third with a weight of 0.112; and perceived rationality of heat-source layout (C8) ranks fourth with a weight of 0.097. Material authenticity (C2) and pleasant use experience (C14) also had relatively high composite weights, at 0.080 and 0.066, respectively.

Overall, the top-ranked indicators were primarily concentrated in the areas of material–technology integration and material appearance. This indicates that the design evaluation of solid wood smart home products relies not only on the presence of smart functions but also emphasizes the rational integration of electronic modules with the solid wood structure, the feasibility of post-installation maintenance, the perceived rationality of heat-source layout, and the overall aesthetic harmony. For Gen Z users, an ideal solid wood smart home product should ensure the convenience of smart functions while minimizing damage to the natural texture and structural stability of the solid wood material.

TOPSIS Calculation Results

As shown in Table 13, the study applied the TOPSIS method to the initial decision matrix using combined AHP-CRITIC weights. By calculating the distances to the positive and negative ideal solutions, a relative closeness coefficient (C) was derived, with higher values indicating superior performance. S6 ranked first (0.570), followed by S3 (0.562) and S9 (0.543); the overall ranking order was S6 > S3 > S9 > S8 > S1 > S5 > S7 > S4 > S2. Under the current evaluation criteria and weighting, S6 demonstrated the best performance regarding the rationality of the embedded structure, aesthetic harmony, ease of maintenance, and perceived rationality of heat source layout, whereas S2 ranked last (0.440). However, given the differences in product type and functionality among S1 through S9, S6's ranking may to some extent reflect preferences for bedside or storage-oriented furniture and their associated functions. Within their respective categories, S6 outperformed S3 and S7, while S9 outperformed S2 among the desk-type designs; nevertheless, these comparisons cannot rule out the influence of confounding factors related to product type.

Table 13. Relative Proximity of Programs

Sample	Positive ideal solution distance D+	Negative ideal solution distance D-	Relative proximity C	Sorting results
S1	0.0054	0.0056	0.512	5
S2	0.0058	0.0045	0.440	9
S3	0.0052	0.0067	0.562	2
S4	0.0054	0.0045	0.454	8
S5	0.0057	0.0052	0.474	6
S6	0.0043	0.0057	0.570	1
S7	0.0057	0.0049	0.462	7
S8	0.0053	0.0058	0.522	4
S9	0.0053	0.0063	0.543	3

Discussion

The results show that successful solid-wood smart furniture depends less on adding functions than on integrating smart modules with wood in a stable, harmonious, and maintainable manner. Material–Technology Integration (B2) received the highest subjective weight (51.0%). Embedded-Structure Rationality (C7), Perceived Rationality of Heat-Source Layout (C8), and Maintenance Convenience (C9) also ranked highly, highlighting experts' emphasis on structural, thermal, and maintenance performance.

These findings reflect the hygroscopic, anisotropic, and dimensionally variable nature of solid wood, which makes it sensitive to temperature, humidity, and localized structural interventions. Wood–water interactions and dimensional stability directly affect its physical properties and service performance (Engelund *et al.* 2013; Sargent 2019). Excessive attachments, exposed panels, embedded screens, or poorly designed openings may therefore disrupt grain continuity, weaken the natural material experience, and reduce structural reliability. Wood-based visual stimuli can also influence psychophysiological responses and stress recovery (Sakuragawa *et al.* 2005; Burnard and Kutnar 2015). Thus, structural rationality is essential to the aesthetic quality, emotional experience, and user acceptance of solid-wood smart furniture.

The CRITIC results reveal a distinction between expert judgment and Generation Z user perception. While experts emphasized structural integrity, thermal stability, and maintainability, user-derived objective weights were relatively high for Perceived Surface

Warmth (C3), Aesthetic Harmony (C4), and Technological Convenience (C12). This suggests that Generation Z users tend to evaluate solid-wood smart home products through directly perceptible material texture, visual coherence, and functional convenience. The combined use of AHP and CRITIC therefore helps balance professional constraints with user perception: AHP captures expert assessments of material and structural feasibility, whereas CRITIC reflects the variation and information content of user evaluations.

The comprehensive weighting results further identify Embedded-Structure Rationality (C7), Aesthetic Harmony (C4), Maintenance Convenience (C9), and Perceived Rationality of Heat-Source Layout (C8) as the core indicators affecting design evaluation. This ranking suggests that the competitiveness of solid-wood smart home products depends on the coordination of technology, structure, aesthetics, and maintenance, rather than on the accumulation of smart functions. Specifically, the connection between smart modules and the wooden body, the degree of concealment, the position of cutouts, and the internal layout directly affect product performance. Meanwhile, the high weight of aesthetic harmony indicates that users still perceive solid-wood smart furniture as part of the domestic environment rather than as purely electronic equipment.

The TOPSIS analysis ranked S6 first (C = 0.570), reflecting balanced performance in embedded-structure rationality, maintenance convenience, aesthetic harmony, and usability. However, because S1–S9 represented different product typologies and functions, the higher ranking of S6 may partly reflect users' preference for bedside or storage furniture. The within-category comparison provides only descriptive evidence and cannot fully eliminate typology-related confounding.

The ranking of S6 suggests that Generation Z users value convenient smart functions, such as wireless charging, lighting control, and sensor-based interaction, while expecting furniture to preserve natural texture, visual coherence, and a low-interference user experience. Accordingly, design should prioritize material-compatible integration by minimizing rough cutouts, exposed screens, and intrusive controls; preserving wood-grain continuity; mitigating localized heat; and improving the removability and maintainability of smart modules.

Furthermore, the concept of "Shy Tech" provides a useful direction for solid-wood smart furniture, but its application should extend beyond visual concealment. Calm Technology and smart environment research emphasize that technology should be available when needed, recede into the background when not in use, and avoid disrupting existing spatial and behavioral patterns (Weiser and Brown 1995; Augusto *et al.* 2013). For solid-wood smart furniture, effective invisible technology should therefore satisfy three conditions: visual concealment, structural reliability, and functional maintainability. Only by integrating these three aspects can solid-wood smart furniture meet Generation Z users' dual expectations for digital convenience and natural comfort. The service life of a solid-wood furniture body can substantially exceed that of embedded electronics, batteries, displays, software, and communication protocols. To prevent digital obsolescence from shortening the product's useful life or making it appear outdated, smart systems should be detachable, replaceable, and upgradeable, using independent service bays, reversible fasteners, accessible cable routes, standardized power and data interfaces, and a useful passive mode when electronic modules are removed. These strategies allow future smart features to be attached or replaced without damaging the wooden body.

Although this study established a quantitative framework and identifies factors shaping Generation Z preferences, future research should extend in two directions. First, broader user groups and residential contexts should be included for comparative analysis.

Second, while renderings, exploded diagrams, and textual descriptions were suitable for early-stage evaluation, future work should incorporate physical prototypes, performance testing, long-term observation, and user experiments to examine tactile perception, heat-related material responses, and maintenance experience. These extensions would strengthen the framework's practical applicability to solid-wood smart furniture design.

The results identify embedded-structure rationality, heat-source-layout rationality, and maintenance convenience as experts' priority design considerations, while perceived surface warmth, aesthetic harmony, and technological convenience most clearly differentiated Generation Z users' evaluations. Because the questionnaire measured design ratings and preference rankings rather than purchase intention, these findings should not be interpreted as direct evidence of purchase-decision drivers.

CONCLUSIONS

1. This study indicates that the design focus of solid-wood smart home products should shift from the simple addition of smart functions to the coordinated material–technology integration. Embedded-structure rationality (C7) obtained the highest composite weight, suggesting that the placement and integration of smart modules are key factors affecting product evaluation. Therefore, electronic components should be integrated into the solid-wood structure in a way that avoids crude cutouts, exposed screens, and visually intrusive control panels, thereby preserving wood-grain continuity and overall aesthetic coherence.
2. Perceived rationality of heat-source layout and maintenance convenience are critical to the technical reliability of solid-wood smart furniture. The high weights of C8 and C9 indicate that smart module integration should consider the effects of heat generation, component aging, repair, and replacement on the long-term stability of solid wood. Future product development should therefore strengthen thermal insulation, heat dissipation, modular assembly, and serviceable structural design.
3. For Generation Z users, solid-wood smart home products should provide technological convenience while maintaining a natural, low-interference user experience. The CRITIC results show that perceived surface warmth, aesthetic harmony and technological convenience are important differentiating factors. Accordingly, the "Shy Tech" concept can be applied by embedding wireless charging, sensor control, lighting feedback, and notification systems within the furniture structure, allowing smart functions to be accessible when needed while remaining visually unobtrusive when not in use.
4. The TOPSIS results identify S6 as the highest-ranked design scheme among the nine evaluated alternatives, with the highest relative closeness coefficient of 0.570. This result suggests that successful solid-wood smart home products depend not on visual appeal or the number of smart functions alone, but on a balanced performance across structural integration, aesthetic harmony, maintenance convenience, and perceived heat-source-layout rationality. The strengths of S6 provide a reference for optimizing the dimensional relationships, interaction points, and structural connections between smart modules and the solid-wood body.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of Generative AI

The authors confirm that generative artificial intelligence tools were not used for data collection, data processing, statistical analysis, result generation, or the creation and editing of images, figures, tables, and diagrams. All research data, analytical procedures, results, and visual materials were independently completed and verified by the authors.

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