Connecting Culture and Cognition: A Structured Design Model for Ethnic Building Blocks Based on AHP-TOPSIS

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Against the backdrop of globalization and localization coexisting, integrating ethnic culture into children's educational products has become a significant topic in design research. This study takes Jingpo culture as its entry point, proposing a structured design and evaluation framework aimed at achieving dual objectives of cultural transmission and cognitive development through children's building block toys. A five-stage closed-loop process (cultural identification, user research, model construction, solution generation, and optimization validation) was established, alongside a three-dimensional indicator system encompassing cultural expressiveness, user functionality, and cognitive interactivity, comprising 14 evaluation metrics. By integrating the Analytic Hierarchy Process (AHP) with the Technique of Order Preference by Similarity to Ideal Solution (TOPSIS), three distinct building block design concepts (festival, attire, mythology) underwent quantitative assessment. Results indicate the attire-themed concept achieved the highest score (Ci=0.736), demonstrating optimal balance between cultural expression and cognitive suitability; The festival theme excelled in spatial interaction and collaboration, while the mythology

theme, though rich in narrative depth, presented challenges in cognitive accessibility. The innovation lies in introducing multi-criteria decision-making methods to culturally oriented toy design, validating the applicability and replicability of AHP-TOPSIS in educational product evaluation. The findings not only provide a methodological basis for the structured transformation and cognitive embedding of cultural elements but also offer practical strategies for developing children's products that integrate educational significance with cultural value.

Keywords: cultural toy design, children's cognitive development, Jingpo culture, AHP-TOPSIS evaluation, modular construction

Introduction

1.1 Research Background and Significance

In recent years, building block-based educational toys have demonstrated significant value in cultivating children's spatial perception, logical reasoning, and cognitive development due to their open-ended structural characteristics (Lin, Peng, Li, & Cang, 2022). Nevertheless, existing products predominantly focus on mechanical assembly and functionality, with limited integration of cultural elements, often falling short in enhancing cultural awareness and values education (Tang, Y. Q., 2022).

Against the backdrop of the national strategy to "enhance the sense of community for the Chinese nation," integrating minority cultures effectively into children's educational tools (Zhang & Shi, 2019) has become a critical design research topic. This integration necessitates constructing a visual, operationally robust, and sustainable cognitive framework (Zou, 2023).

The Jingpo people, a prominent ethnic minority in China's southwestern frontier, possess a rich cultural heritage encompassing symbolic totems, ritual ceremonies, and mythological narratives (Xiong & Peng, 2008). Their graphic and symbolic language holds immense educational potential (Feng & Xia, 2025). However, current development of children's products based on Jingpo culture remains fragmented and superficial. There is a lack of systematic design methodologies and scientific evaluation mechanisms to guide the effective transformation of cultural content into educational formats (Ren, X. L., Fu, J. Z., & Yu, P., 2002).

Therefore, this study proposes a structured design research framework emphasizing cultural extraction, cognitive transformation, and multidimensional evaluation. It aims to explore how cultural expressiveness, cognitive interactivity, and playfulness can be integrated into building

block toy design to achieve dual objectives of cultural transmission and cognitive development.

1.2 Research Questions and Objectives

Existing design methodologies for children's toys based on ethnic minority cultures generally lack comprehensive and systematic evaluation frameworks. This often results in superficial cultural representations that fail to adequately meet children's cognitive and experiential needs. Therefore, establishing a scientific, quantitative, and multi-attribute assessment mechanism is crucial for guiding design decisions and enhancing the educational and cultural efficacy of educational toys.

This study addresses the following core questions:

RQ1: How can a multi-attribute evaluation system be constructed to systematically measure the comprehensive performance of culturally themed children's building blocks in terms of cultural expression, functional usability, and cognitive adaptability?

RQ2: Can the AHP-TOPSIS model provide scientifically effective support in evaluating culturally embedded children's toy designs, demonstrating reliability and operability in multi-alternative comparisons?

To address these questions, this study sets the following objectives:

Develop an evaluation indicator system encompassing three dimensions—culture, functionality, and cognition—and systematically define and classify its sub-indicators.

Employ the Analytic Hierarchy Process (AHP) to determine indicator weights, ensuring logical consistency and scientific rigor in the evaluation framework.

Integrate the Technique of Partial Observation by Similarity to the Ideal Solution (TOPSIS) to quantitatively assess and rank three Jingpo-inspired children's building block designs.

Validate the model's applicability in children's toy design and explore its potential for promoting educational product development and cultural heritage preservation.

Research Hypothesis:

This study hypothesizes that the AHP-TOPSIS model can achieve a comprehensive evaluation of cultural expressiveness, user functionality, and cognitive interactivity in culturally oriented children's building block design, providing effective quantitative support for multi-scheme comparison and optimization.

1.3 Scope of Research and Expected Outcomes

This study focuses on children aged 8–9 in Dehong Prefecture, Yunnan Province. Three representative elements of Jingpo culture—festival totems, costume patterns, and mythological symbols—were selected as research materials (Shi, Y. R. 2013). Based on these elements, three corresponding modular design schemes were proposed. Subsequently, a multi-attribute evaluation system based on the AHP-TOPSIS model was constructed to rank and validate the design schemes according to their cultural, functional, and

cognitive values (Tan, Y. J., Yang, X. Y., Zhang, Z. F., & Zhang, J. J., 2023). This study is theoretical in nature, covering the construction of the indicator system, weight calculation, and ranking model, but does not include product prototyping, user testing, or market deployment.

The research aims to address a prevalent issue in cultural toy design: the imbalance between expressive content and evaluative rigor (Liu, F. C., 2022). The anticipated contributions are as follows:

Methodological Innovation: This study pioneers the application of the AHP-TOPSIS decision model to the design process of culturally themed children's toys, establishing a replicable and scalable evaluation methodology for educational product design.

Cultural Visualization Mechanism: By mapping Jingpo cultural elements into structured visual forms, this research introduces a systematic strategy for transforming intangible cultural symbols into tangible cognitive tools, thereby enhancing visibility and interactivity.

Cognitive Adaptability Validation: Based on the cognitive characteristics of the target age group, this study constructs a three-dimensional evaluation framework encompassing cultural representation, functional operation, and cognitive engagement, providing a reference paradigm for balancing cultural content with children's specific learning needs.

1.4 Paper Structure

This paper, titled "Connecting Culture and Cognition: A Structured Design Model for Ethnic Building Blocks Based on AHP-TOPSIS," follows the IMRAD format with the following structure:

Part II: Literature Review—Reviews relevant research on integrating ethnic minority cultures into design, cognitive development through building block toys, and the application of AHP and TOPSIS in design evaluation. This establishes the methodological foundation for this study.

Part III: Research Methodology—Introduces the construction of a multi-attribute evaluation framework encompassing cultural, functional, and cognitive dimensions. AHP is employed to determine weights, while TOPSIS is used to rank design proposals.

Part IV: Design Concept—Describes the development of three design proposals based on Jingpo cultural themes (festival totems, costume patterns, and mythological motifs). These proposals reflect Jingpo cultural significance and age-appropriate cognitive interactions.

Part V: Results and Discussion—Presents evaluation outcomes and rankings for the three design proposals, analyzing their strengths and weaknesses in cultural expression, usability, and cognitive engagement.

Part VI: Conclusions and Future Directions—Summarizes key findings, assesses the validity of the AHP-TOPSIS model in this context, discusses limitations, and proposes future research directions

for educational product design and cross-cultural innovation studies.

Literature Review

This section reviews the literature from three perspectives: (1) the design transformation of ethnic cultural elements; (2) children's cognitive development and toy interaction; and (3) the application of multi-attribute decision-making methods in design evaluation. It aims to clarify the theoretical foundation and identify research gaps to support the development of children's building block toys with cultural significance and cognitive adaptability.

2.1 Mechanisms of Design Transformation of Ethnic Cultural Elements

Ethnic culture is an important resource in design. It provides visual forms, symbolic systems, and collective identities that can give cultural depth to educational products (Luo, L. 2023). The effective integration of these cultural elements should not be superficial or merely decorative. Instead, a structured process—often described as "translation-reconstruction-adaptation"—is essential to reconcile symbolic content with user needs and modern usage environments (Gao, X. 2023). In particular, in the visual system of ethnic minorities in China, ordered totemic patterns, ritual arrangements, and color traditions are powerful carriers of cultural identity and cognitive value (Zou, M. X. 2014). Jingpo clothing features geometric symmetry, vibrant colors, and rhythmic patterns as core design elements. Their clothing embodies intergenerational identity, while myths and festivals embody layers of graphic logic and symbolic meaning (Luo, T. P. 2003).

Incorporating Jingpo cultural elements into educational toys like building blocks requires a balance between semantic authenticity and children's visual preferences and behavioral habits. Design should strive for a dual purpose: making cultural content cognitively recognizable and formally actionable. This transformational process allows children not only to see the culture but also to interact with and internalize it.

2.2 Children's Cognitive Development and Toy Interaction

Building toys are widely recognized as tools for promoting early childhood development, particularly for children aged 6 to 9, which Piaget (1951) identified as the concrete operational stage. During this stage, children begin to demonstrate enhanced spatial awareness, logical reasoning, and symbolic understanding. Therefore, toys can serve as a channel for cultivating spatial construction, rule understanding, and problem-solving skills (Clavio & Fajardo, 2008).

Toy design for this age group requires not only age-appropriate complexity but also symbolic elements that stimulate curiosity, interaction, and reflection (Richards, Putnick, Suwalsky, & Bornstein, 2020). Three key dimensions of cognitive adaptability are crucial in toy design:

1) Operational adaptability: Toy components should be compatible with the child's developmental stage in terms of assembly complexity and motor skills.

2) Symbol recognition: Embedded visual elements and graphics should stimulate exploration and foster associative learning. 3) Interactive Feedback: The design must provide visual, tactile, or structural feedback loops to reward problem solving and reinforce learning (Colin, Belpaeme, Cangelosi, & Hemion, 2016).

For culturally oriented toys, this is even more complex. If culture is presented solely as static, decorative elements, it can become cognitively rigid and even overwhelming. Instead, cultural symbols should be designed as part of the cognitive experience—for example, through color matching, shape classification, or modular interactions—so that the learning process becomes a cycle of "cultural content → cognitive structure → operational behavior" (Thirumurthy, V. 2003).

2.3 Cultural Embedding in Children's Product Design

Cultural visualization strategies are gaining increasing attention in educational product design, particularly for children. Their goal is not simply to showcase culture but to make it experiential—allowing children to perceive, interact with, and internalize cultural knowledge through play (Acevedo, 2019).

There are three main strategies for embedding culture in children's toys:

Graphic totemic reinterpretation: extracting traditional geometric and symbolic patterns and repurposing them as visually appealing elements (Huo & Skliarenko, 2024);

Gamification of ritual structures: transforming ethnic rituals or traditions (e.g., dances, festivals) into game mechanics or interactive scenarios (Kimura, Kato, Yokoyama, Matsuura, & Nakajima, 2025);

Mythological narrative extension: using ethnic folklore and legends as thematic content for game-based storytelling (Huang & Huang, 2013).

Jingpo culture provides rich material for these strategies. For example, their "Munao Long Song" festival features rhythmic dance formations, totem poles, and unique clothing patterns, all of which can be reimagined as modular gameplay. Similarly, their myths—such as solar origin stories and clan totems—provide a rich foundation for symbolic exploration (Liu, D. P. 2010).

However, designers must go beyond mere symbolic reproduction. Cultural embedding should involve a deeper structural shift, reconfiguring cultural elements to accommodate children's perceptual and cognitive systems. For children aged 8-9, this requires simplifying abstract concepts, constructing visual scaffolding (such as color and shape combinations), and guiding interactions to promote meaningful engagement. Ultimately, culture must not only be "seen" but also cognitively experienced—through a design approach that connects morphology (form) and cognition (function).

2.4 Culturally Driven Cognitive Construction Strategies

To promote cultural learning through block play, design must integrate ethnic elements into the core

cognitive interaction process. This can be achieved by constructing a three-stage play experience:

1) Cognitive Entry Point Design: Introducing cultural features (e.g., colors, textures, patterns) early in the interaction to stimulate cognition and curiosity (Jameson, 2005).

2) Cognitive Path Guidance: Using progressive construction tasks and failure/reconstruction cycles to deepen symbolic understanding and model behavior (Fu, 2025).

3) Cognitive Feedback Mechanisms: Providing a sense of closure and satisfaction through recognizable cultural outcomes (e.g., totemic forms or dance formations), linking visual outcomes to abstract cultural concepts (van Loon & Roebers, 2021).

This design avoids "semiotic layering" in favor of "cognitive embedding"—an approach that integrates culture into the logic of interaction. For example, a toy that reflects the circular axis structure of the Mu Nao Zong Ge dance can guide children to reconstruct this geometric structure, thereby understanding its cultural rhythms and spatial order through direct manipulation. In this way, building block toys have evolved from tools for spatial construction to a medium for cultural cognition, achieving a synergy between play, learning, and cultural inheritance.

2.5 Application of the Multi-Attribute Decision-Making Method (AHP-TOPSIS)

As design problems become increasingly complex, particularly when balancing educational, cultural, and interactive objectives, subjective judgment alone is no longer sufficient. The Multi-Attribute Decision-Making Method (MCDM) has become a valuable tool for evaluating and optimizing these multi-factor design options (Peters, Koolschijn, Crone, van Duijvenvoorde, & Raijmakers, 2014).

Two primary MCDM techniques are:

Analytical Hierarchy Process (AHP): This method decomposes the decision problem into a hierarchical structure and then derives priority weights through pairwise comparisons. This method excels at constructing qualitative judgments and coordinating expert consensus.

TOPSIS: This method ranks options based on their relative distance to the ideal solution. It is particularly suitable for comparative evaluation of multiple design options under competing criteria.

The AHP and TOPSIS methods combine to determine the weights of various criteria (e.g., cultural representation, cognitive functionality, and usability), while TOPSIS ranks design options based on their alignment with the ideal image across all criteria. This hybrid model captures subjective nuance while maintaining objective rigor (Wang & Ban, 2022).

In the field of culturally-oriented children's toys, this approach can be used to evaluate different prototypes or design iterations. It provides a structured, transparent process for prioritizing proposals based on their balance between form, function, and cultural integrity. Specifically, this study used the AHP-TOPSIS model to construct a three-dimensional evaluation system focusing on

cultural expression (symbolicity, authenticity), cognitive interactivity (learning outcomes, age-appropriateness), and user functionality (safety, operability). Integrating this model into the design workflow allows for scientific validation of creative concepts and transforms intuitive judgments into data-driven design decisions.

2.6 Research Gaps Summary

Despite significant progress in the relevant field, several key research gaps remain:

1) Lack of Cultural Structure Integration: Most cultural toy designs treat ethnic elements as superficial decoration, failing to transform them into interactive cognitive structures that enable meaningful learning (Hirschfeld, 1996).

2) Inadequate Matching of Cognitive Development and Constructive Behavior: There is a gap in designing building block systems that meet the cognitive characteristics of 8-9 year old children, particularly in guiding symbolic comprehension, inductive reasoning, and spatial logic (Perret, 2015).

3) Lack of Quantitative Evaluation Frameworks: Many cultural design decisions still rely on qualitative judgments or expert ratings. The lack of a structured multi-attribute evaluation model hinders the scientific comparison and optimization of design solutions (Bedford, Quigley, & Walls, 2006).

2.7 Research Focus and Innovation Pathways

Based on the identified gaps, this study uses Jingpo cultural elements as a design foundation, aiming to construct an integrated design evaluation model that supports cultural cognition and scientific validation. This research focuses on three key paths:

Cultural Extraction and Modular Transformation: Transforming Jingpo symbolic elements into cognitively operable toy modules.

Cognitive Adaptation and Interaction Design: Integrating cultural content into behavioral and symbolic learning pathways suitable for children aged 8-9.

Quantitative Evaluation Based on AHP-TOPSIS: Developing a multi-metric evaluation model to assess the educational, cultural, and functional value of design proposals.

By forming a closed-loop process of "cultural input → cognitive guidance → model evaluation," this study provides a systematic methodology for the design of children's educational building block toys rooted in ethnic cultural heritage.

Methodology

This study employed a five-stage closed-loop research process: cultural identification, user research, model building, solution generation, and optimization and validation. (Figure 1)

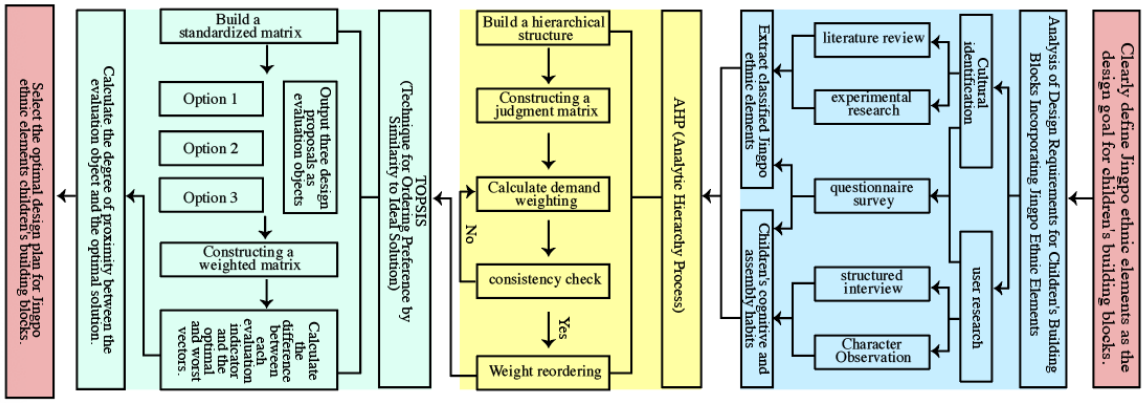
First, through literature analysis and field research, we extracted and classified architectural symbols, totemic patterns, and festive imagery from Jingpo culture, creating a design component library. These elements have structural and visual potential for children's toys.

Second, behavioral and perceptual data were collected from 8-9-year-old children through structured questionnaires and task-based observations. This phase identified user needs based on four key dimensions: morphological complexity, color harmony, modular connectivity, and cultural understanding.

Third, based on the collected cultural and user data, this study established a multi-level indicator system consisting of three primary dimensions and fourteen secondary indicators. Experts then conducted pairwise comparisons and used the analytic hierarchy process to calculate indicator weights to ensure logical consistency.

Fourth, based on different Jingpo cultural themes—festival scenes, totemic costumes, and mythological imagery—three building block design solutions were developed. The TOPSIS method was used to assess each solution's proximity to the ideal solution, leading to a comprehensive ranking of the solutions. Finally, child-based model testing and feedback collection were conducted to validate the top-ranked solutions. The initial designs were then refined to increase adaptability and engagement, thereby establishing a scientific, user-centered design evaluation mechanism.

Figure 1: Five-stage closed-loop research process (author's own drawing)



3.2 Indicator Construction and Evaluation Model

To systematically evaluate building block toys that incorporate Jingpo cultural elements, this study constructed a three-tiered analytic hierarchy process (AHP) model: (Figure 2)

Target Layer (A): Comprehensive Optimization of the Design of Children's Building Blocks Incorporating Jingpo Cultural Elements.

Criteria Layer (B1-B3):

· B1: Cultural Expression—Use of Color, Material Texture, Decorative Patterns, and Form Integrity.

·B2: User Functionality—Game Variety, Structural Stability, Safety, Clear Feedback, and Ease of Operation.

·B3: Cognitive Interactivity—Quality of Guidance, Cultural Uniqueness, Immersive Scenarios, Developmental Fit, and Emotional Engagement.

Sub-Criteria Layer (C1-C14): Detailed Evaluation Indicators for AHP/TOPSIS Calculations.

This structure ensures that cultural authenticity, practical functionality, and cognitive relevance are all considered in the evaluation, forming a coherent framework from input to output in design decision-making.

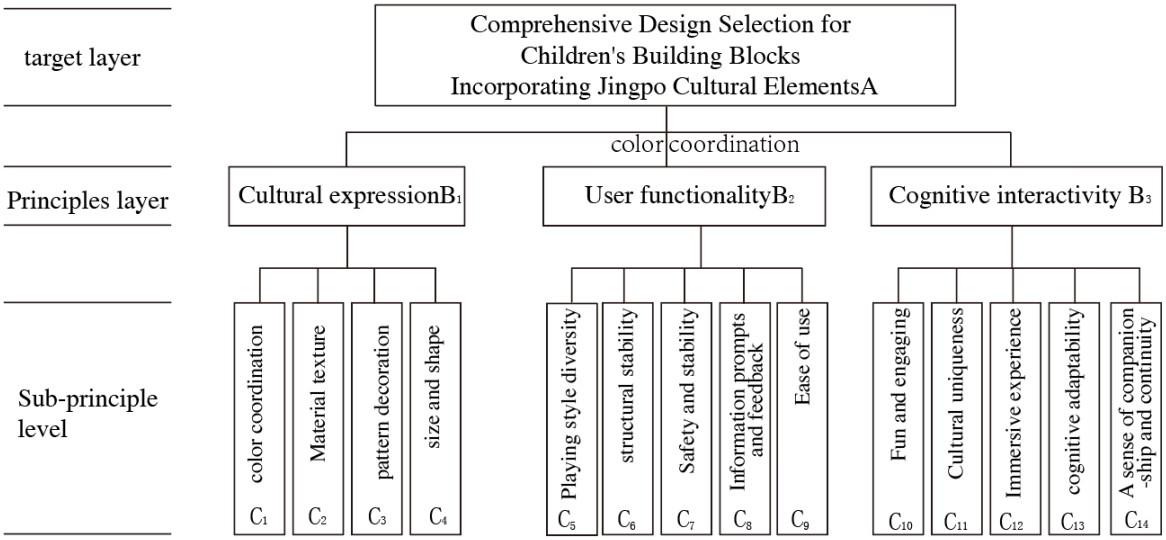


Figure 2: AHP hierarchical model (drawn by the author)

3.3 AHP Weight Assignment

Experts conducted pairwise comparisons of the three main criteria. The resulting AHP judgment matrix and weight assignments are as follows:

Consistency Ratio (CR) = 0.0079 < 0.1 → the matrix passes consistency validation.

	Cultural Expressiveness	User Functionality	Cognitive Interactivity	weighting
Expressiveness	1	2	3	0.164
User Functionality	1/2	1	2	0.297
Cognitive Interactivity	1/3	1/2	1	0.539

The research results highlight that cognitive interactivity (53.9%) is the most critical factor, reflecting its crucial role in supporting development participation. User functionality (29.7%) ranks second, indicating the importance of security and usability. Cultural expression (16.4%), as a visual and symbolic support, helps enhance cultural identity and aesthetic appeal.

3.4 TOPSIS Evaluation Process

To quantitatively rank the generated design solutions, we use the TOPSIS method. This process consists of the following six steps:

Step 1: Construct the decision matrix (X):

x_{ij} : The performance score of scheme ion indicator j.

Step 2: Normalize the matrix (R):

$$R_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

Step 3: Apply AHP weights (V)

$v_{ij}=w_j \times r_{ij}$

Step 4 Identify ideal and negative ideal solutions:

$$V^{+}\{v_1^{+},\ v_2^{+},\ \ldots,\ v_n^{+}\},\ v_j^{+} = \max_i v_{ij}$$

$$V^{-}\{v_1^{-},\ v_2^{-},\ \ldots,\ v_n^{-}\},\ v_j^{-} = \min_i v_{ij}$$

Step 5 Calculate the Euclidean distance:

$$D_i^{+} = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^{+}\right)^2} \quad , \quad D_i^{-} = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^{-}\right)^2}$$

Step 6 Calculate relative proximity (C):

$$C_i = \frac{D_i^{-}}{D_i^{+} + D_i^{-}},\ i=1,\ 2,\ \ldots,\ m$$

The solutions are then ranked according to their Ci values, with higher values indicating a closer approach to the ideal solution.

This method integrates qualitative cultural analysis, quantitative user research, and a structured decision-making model (AHP-TOPSIS) into a unified evaluation process. It provides a clear and replicable path for the design of cognitive, interactive, and culturally embedded building block toys. By integrating Jingpo cultural content with children's developmental needs and scientifically evaluating design solutions, this method supports both educational goals and cultural heritage in product innovation.

Results

4.1 Analysis and Interpretation of Evaluation Results

Based on the TOPSIS analysis, Option B (Clothing Theme) received the highest proximity score (Ci = 0.736), ranking first among the three options. This indicates that the design based on traditional Jingpo costumes performed best overall in terms of cultural expression, user functionality, and cognitive interactivity. Its high score is attributed to the effective translation of cultural symbols into interactive modules, the engaging use of colors and patterns that facilitate symbol learning, and a balanced level of difficulty suitable for children aged 8-9. (Figure 3)

Option A (Festival Theme) ranked second (Ci = 0.631), particularly excelling in cognitive interactivity. Option A's construction of the spatial logic of rotating dance poses and its integration of collaborative assembly tasks meet children's developmental needs in spatial reasoning and social interaction. However, Option A's relatively low scores in module flexibility and individual pattern

recognition may have affected its overall ranking. (Figure 4)

Option C (Mythology Theme) ranked third (Ci = 0.529), primarily due to its relatively abstract narrative structure and high cognitive threshold. While narrative elements add depth and symbolic richness, the complexity of the visual metaphors and structural composition poses a challenge for younger users. This result suggests that mythological themes, while potentially immersive for cultural learning, require more sophisticated guidance mechanisms (e.g., step-by-step prompts or modular scaffolding) to fully function for the target age group.

Picture 3: Scheme B (Clothing Theme)

Picture 4: Scheme A (Festival Theme)

Picture 5: Scheme C (Mythological Theme)

4.2 Prototype Testing Feedback and Child Responses

After the quantitative evaluation, the researchers conducted prototype testing of the three solutions with 12 children aged 8-9. Through observation and post-task interviews, the researchers evaluated the correlation between the model rankings and actual user experiences.

plan	D_i^+	D_i^-	C_i	Ranking
A	0.213	0.364	0.631	②
B	0.148	0.413	0.736	①
C	0.276	0.310	0.529	③

Table 1: TOPSIS Evaluation Results

In Option B, children were the most engaged and independent, often actively creating creative color combinations and identifying clothing features without prompting. They expressed enjoyment and a clear understanding of the cultural elements involved.

In Option A, children were enthusiastic about the collaborative play elements, particularly the spinning center dance circle. However, some children required additional guidance to understand the cultural context of the festival.

In Option C, children's curiosity was piqued, but some children struggled with the abstract symbolism and required adult explanation to establish cultural connections, confirming the limitations identified in the TOPSIS evaluation.

These qualitative results largely supported the quantitative analysis, confirming the effectiveness of the AHP-TOPSIS model in predicting usability,

engagement, and cultural understanding outcomes in the context of children's products.

4.3 Summary of Results

This phase of research successfully applied a model-driven evaluation framework to compare building block toy designs across multiple cultural themes. Key findings include:

Clothing-themed designs demonstrated the best balance across all three evaluation dimensions, validating their potential as a reference model for culturally integrated educational toys.

Festival-themed designs excelled in interactive play mechanics and spatial construction, but enhanced modular differentiation was even more effective.

Mythology-themed designs demonstrated the highest narrative depth but require simplification or the addition of additional supporting structures to enhance cognitive accessibility.

Overall, the findings confirm that cultural expression alone is insufficient in children's toy design unless it is closely integrated with age-appropriate interactivity and functional design principles. This evaluation model supports a multi-perspective, evidence-based approach to design decision-making, providing a replicable approach for similar educational design scenarios.

Discussion

5.1 Interpretation of results and comparative analysis In the TOPSIS evaluation, Scheme B (clothing theme) achieved the highest proximity score (Ci = 0.736), indicating that it performed well in multiple evaluation criteria. Its success can be interpreted from three dimensions: (1) Balance between cultural expression and user function. Scheme B performed well in indicators such as cultural graphic recognizability (C1), color compatibility (C3), and ease of operation (C9). By embedding recognizable Jingpo patterns (such as diamonds and zigzags) and using high-saturation colors (black, red, and yellow), the scheme promoted immediate visual recognition and cultural association. Its interlocking module structure is intuitive and easy to operate, suitable for the development of children aged 8-9, and enhances the educational and entertaining experience. (2) Visual consistency enhances cognitive paths. Scheme B scored high in multi-path combination (C11) and cognitive feedback mechanism (C14). Its symmetrical design logic encourages repeated combination and exploratory construction, cultivating pattern recognition ability and structural memory ability. After the module is completed, a recognizable "clothing fragment" is formed, providing clear visual feedback and strengthening children's cultural understanding and cognitive achievement. (3) Reduce cognitive load through symbolic abstraction. Compared with the narrative-rich but abstract structure of Option C, the clothing theme simplifies cultural input through a visual symbol strategy: graphics → color → combination. This three-layer structure simplifies cognitive processing, making cultural content easier to understand and requiring less cognitive effort, making it very suitable for children in the middle stages of cognitive development. In

contrast, Option A (festival theme) and Option C (mythology theme) excel in immersion and narrative, respectively, but lack in operability and understanding threshold. The comparative analysis is as follows: (a) Cultural visualization: expression path and cognitive threshold Option A uses spatial layout (dance formation, totem and square) to recreate the ritual context. Although immersive and symbolic, it requires background knowledge or contextual prompts. Option B provides immediate visual recognition through repeated and simplified cultural symbols, which is more suitable for children's perceptual ability. Option C adopts a story-based structure that contains metaphors of altar, stairs and sun. Despite its rich cultural symbolism, its high level of abstraction raises the barrier to entry for children, sometimes leading to misunderstandings or disengagement.

(b) Operability: Module Logic and Action Coordination

 Option B excels in structural clarity and action compatibility, achieving smooth interaction.

 Option A's complexity is acceptable and its structure is relatively stable, but it requires more attention to component layout.

 Option C's structure is rich in layers and complex in elements.

5.2 Strategic Insights for the Design of Children's Cultural Toys This study provides a series of general insights for the effective design of culturally embedded cognitive toys: (1) Shift from symbolic replication to structural cognition. Effective design should not replicate static cultural images, but rather encode cultural knowledge into structural patterns with inherent logic. Festivals, costumes, and myths can be transformed into interactive modules that embody spatial or functional rules, helping children build structural understanding while engaging with cultural content. (2) Cognitive adaptability takes precedence over decorative accuracy. Design must be consistent with the user's developmental stage. Elements such as color association, ease of operation, and task reward feedback should be prioritized to match children's cognitive load capacity. Successful designs support the behavioral cycle of perception → operation → feedback. (3) Evaluation models enhance objectivity and strategic optimization. The AHP-TOPSIS model helps standardize design evaluation under multidimensional criteria, thereby reducing subjectivity. This systematization enables designers to make more informed, data-driven decisions, providing a replicable framework for developing culturally rich cognitive products. (4) Multi-theme series promote deep cultural understanding. A rich and thematically related toy set (e.g., festivals, costumes, myths) allows children to develop a richer connection with the target culture. This thematic layering supports the learning chain of "assembly → identification → association," deepening memory and appreciation.

In essence, cultural toy design should not simply transmit traditions but activate culture through child-centered mechanisms. A structural, cognitive, and interactive integration must replace purely decorative approaches to lay the foundation for

toys that are educational, inclusive, and culturally meaningful.

Conclusion

This study explored the integration of Jingpo cultural elements with the design of children's cognitive building blocks and proposed a closed-loop design model based on the AHP-TOPSIS method. Through the development and evaluation of three differentiated theme schemes: festivals, costumes, and myths, the study achieved theoretical progress and practical verification.

6.1 Main Contributions

(1) Cultural transformation through structured modular design.

This study proposed a new paradigm for integrating cultural knowledge into children's toys - no longer just through text and graphics, but through a structured and operational form that conforms to children's learning behavior. The design framework advocates "structural logic + cognitive guidance" to achieve a deeper cultural experience through hands-on exploration.

(2) A comprehensive and multi-dimensional evaluation system was constructed.

This study proposed a scientific cultural education toy evaluation model by constructing a hierarchical structure containing 3 main dimensions and 14 indicators, breaking through the limitations of subjective or aesthetic-driven evaluation methods and supporting systematic product optimization.

(3) Application and verification of the Analytic Hierarchy Process-Best Solution (AHP-TOPSIS) model. This study successfully applied this hybrid model to the field of cultural children's toy design for the first time. The model facilitated weight allocation, multi-dimensional comparison, and scheme ranking, improved operational clarity, and demonstrated its adaptability to cross-disciplinary design challenges. (4) Empirical validation through cognitive and cultural engagement. All three design schemes promoted symbol recognition, spatial reasoning, and story comprehension to varying degrees, confirming the educational potential of gamified cultural content. The results confirm the feasibility of the "cognitive-cultural-operational" integration strategy in toy design and regional cultural communication.

(4) 6.2 Methodological Innovation: The Significance of AHP-TOPSIS This study demonstrates the value of introducing quantitative multi-criteria decision-making (MCDM) methods into the field of cultural product design, particularly in the field of educational toy design. Key innovations include: (1) Transparent structure and reliable decision-making. AHP ensures logical consistency in weight assignment, while TOPSIS provides objective comparison of solutions, thereby reducing subjectivity and enabling repeatable evaluation. (2) Coordinating different design goals. Cultural toys are often designed to achieve educational, cultural, and operational goals. The AHP-TOPSIS model supports holistic optimization, balancing these different needs within a single framework. (3) Connecting visual presentation with cognitive usability. The model not only evaluates the presentation of culture but

also the effectiveness of users internalizing culture—shifting the focus from fidelity to learning effectiveness. By doing so, the model contributes to a broader trend in design research: data-driven, interdisciplinary evaluation frameworks that connect cognitive science, cultural studies, and user-centered design. 6.3 Future Research Directions This study has laid a foundational framework, but the following areas are still worthy of further development: (1) Real-world prototyping and behavioral analysis. Future research should combine physical prototyping with material testing and conduct on-site user observation. This will help measure interaction frequency, assembly success rate, and learning retention rate, and deepen the understanding of the impact of design in the real world. (2) Cross-cultural extension and comparative testing. To explore the universality of the model, the framework can be applied to other ethnic groups or cross-cultural contexts. This will help evaluate how different user groups perceive and operate different symbol systems. (3) Digitalization of evaluation tools. Integrating AHP-TOPSIS into a real-time, digital design assistance platform, equipped with a visual dashboard and adaptive weight control, can greatly improve its practical usability for designers and educators. (4) Longitudinal study of children's cultural cognition. Future research should conduct longitudinal studies to track how children's cultural understanding, cognitive development, and design engagement evolve over time. Such data will provide valuable evidence for evaluating the continued educational impact and cultural communication effect of the proposed toy design. In summary, this study presents a structured, validated, and replicable approach for designing and evaluating culturally informed children's toys. By integrating cultural semantics with cognitive developmental mechanisms and combining modular design with quantitative evaluation, this research opens new possibilities for developing culturally meaningful, educationally effective, and strategically optimized products.

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