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Developing a Conceptual Framework Based on Colour, Material and Finishing (CMF) to Enhance Smart Product Market Competitiveness

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ABSTRACT

As smart products increasingly shape user lifestyles, the role of Color, Material, and Finish (CMF) in influencing user perception, experience, and market competitiveness has become more critical. Traditional CMF approaches, however, remain limited in addressing the complex sensory and emotional needs of users in contemporary smart product design. To address this gap, this study proposes an extended CMFPSE framework, which integrates Pattern, Sense, and Emotion alongside traditional CMF elements, aiming to enhance both user experience and market differentiation. A systematic four-step research methodology was employed, consisting of identifying target objectives, conducting a literature review, determining key design variables, and developing the conceptual framework. The findings highlight that the strategic application of CMFPSE elements can strengthen brand storytelling, foster emotional connections, and meet user expectations, particularly in wearable and interactive products. By linking aesthetic, functional, and emotional factors, CMFPSE offers designers a multidimensional perspective that guides decision-making and enhances user engagement, brand identity, and market competitiveness. While the framework is conceptual and has not yet been empirically validated. Future research should focus on applying and testing the framework through user studies, interviews, and surveys to evaluate its effectiveness in real-world smart product design.

Keywords: CMF; CMFPSE; Conceptual Framework; Product Design; Smart Products

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INTRODUCTION

The CMF is a foundational aspect of industrial design, originally developed for sectors like automotive, fashion, and consumer electronics to enhance product aesthetics, usability, and consumer appeal. Over time, it has evolved into a critical method that ensures products meet functional requirements while resonating with users on a sensory level, significantly influencing purchasing decisions and brand

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loyalty. As shown in Figure 1, CMF plays a vital role in shaping design, manufacturing processes, and consumer perception, making it essential for driving sales appeal and market success (Ugale & Thakur, 2021). However, despite its importance, current CMF frameworks often lack the capacity to fully address the emotional and experiential dimensions increasingly demanded by users of smart products. This gap indicates a pressing need for an extended framework that integrates additional variables—such as user interaction, emotional resonance, and sensory feedback—to enhance competitiveness in rapidly evolving markets. As time goes on, CMF has evolved from a visual enhancement tool into a strategic method that ensures products meet functional requirements while resonating with users on a sensory level. The CMF framework plays a vital role in shaping design, manufacturing processes, and consumer perception, significantly influencing purchasing decisions and fostering brand loyalty (Huang & Cui, 2021).

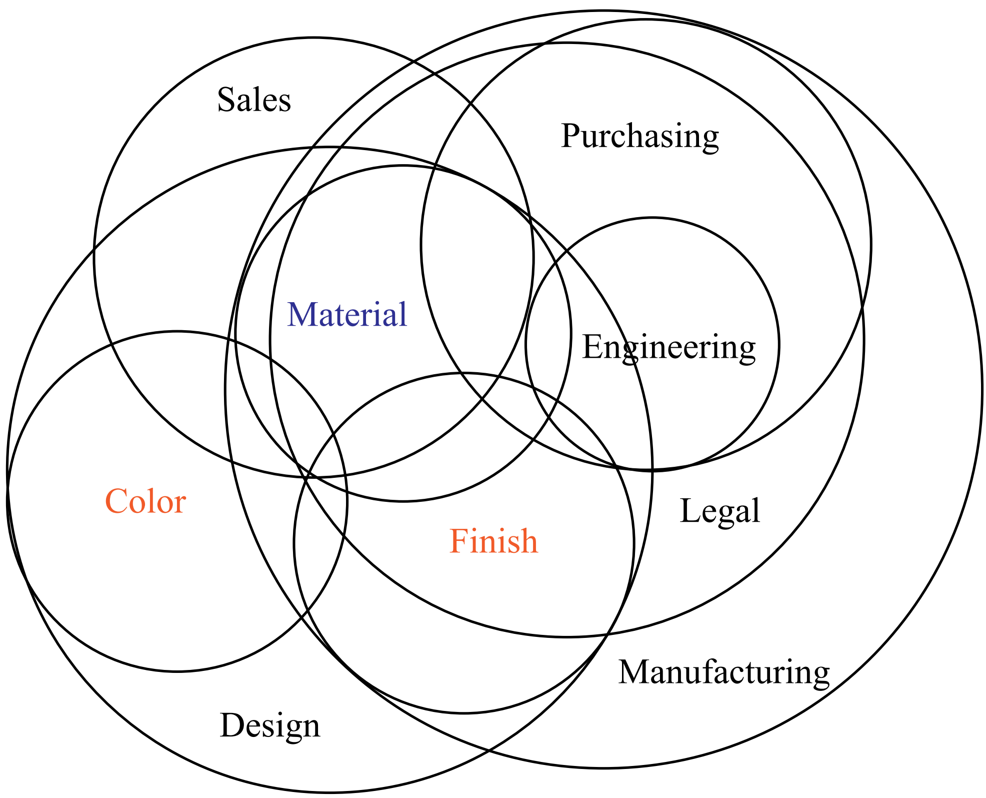

Figure 1. The importance of CMF in influencing design, manufacturing, sales, and purchasing

As the smart product market expands over the decades (Figure 2), there's a growing recognition that traditional CMF needs to evolve to address the complexity of these products and the intensifying competition. As smart products equipped with advanced technologies for enhanced connectivity and interactivity become more prevalent, the role of CMF has become increasingly crucial. This framework shapes user perception by influencing first impressions and ongoing interactions, impacting perceived value, usability, and desirability (C. Zhou et al., 2024). Recent studies underscore the growing importance of adaptive CMF design in smart products. For instance, integrating color schemes with biometric feedback in wearables enhances user experience by aligning aesthetics with functionality (Inseong, 2019). The CMFP framework extends traditional CMF by adding pattern as a key element for multisensory engagement (Xu & Fang, 2022), while AI-driven customization in CMF enables elderly care products to be tailored to individual needs, improving both functionality and emotional connection (He & Zhang, 2023).

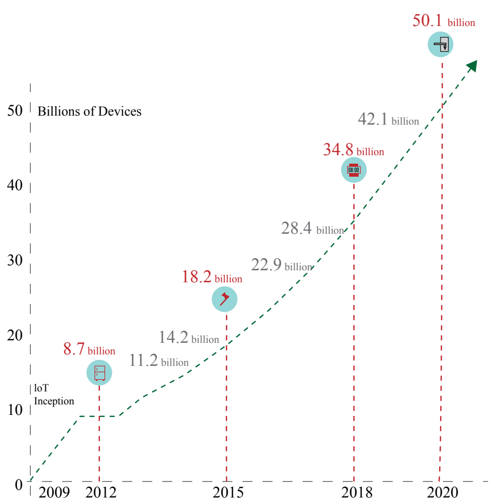

Figure 2. Annual growth of smart products (Jinglong, Che Me, & Qisen, 2024)

As smart products continue to evolve, CMF frameworks need to be improved to expand beyond traditional color, material, and finish considerations to incorporate user interface touchpoints, interaction design, and dynamic responsiveness. These extensions are essential for enhancing product differentiation, user engagement, and brand loyalty. However, there is currently no updated, comprehensive CMF framework that integrates these elements, limiting designers' ability to address users' complex sensory, emotional, and functional needs, particularly in wearables and smart devices, where a seamless experience and emotional resonance are critical for competitiveness. This research aims to fill this gap by developing a conceptual CMF-based framework that integrates both traditional and extended design variables, providing initial guidance for designing smart products that optimize user experience and market performance.

METHODOLOGY

This study adopted a four-step research method (Figure 3) to develop a conceptual framework aimed at enhancing market competitiveness for smart products (Zhu et al., 2025). The framework integrates original CMF (Color, Material, Finish) design variables with additional strategic variables relevant to user experience and product appeal (Jinglong, Che Me, & Ahmad, 2024).

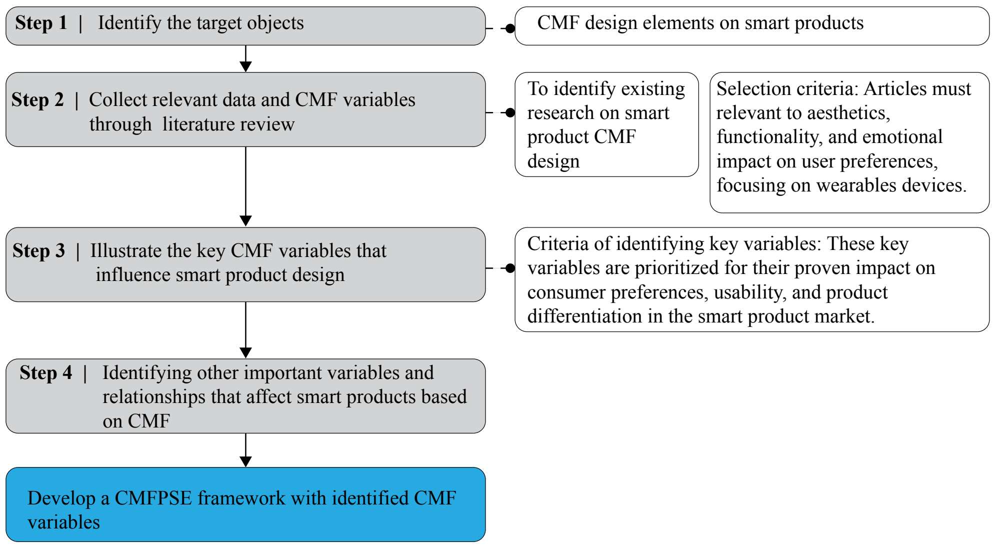

Figure 3. Four step method (Zhu et al., 2025)

Step 1: Identification of Research Objectives

The first step involved identifying the research objectives, focusing on the core objects of study—CMF (Color, Material, Finish) design elements—as applied to smart products. Smart products were chosen because they represent a rich intersection of form, function, and user interaction, where design variables have a direct impact on aesthetics, usability, and user perception. By clearly defining the research objectives at this stage, the study establishes a focused scope for the literature review and framework development, ensuring that the analysis of CMF elements is aligned with the goal of enhancing smart product appeal and market competitiveness.

Step 2: Literature Review Synthesis

Research Approach and Database Selection

The second step involved a synthesis literature review, which was conducted using a structured approach referred to as the "Literature Review Synthesis Process." (Ibrahim, 2008). Relevant academic sources were collected from databases including Scopus, Web of Science, and IEEE Xplore, and related articles were searched according to keywords in this search strategy (Terwee et al., 2009). Topics were identified based on Ibrahim's research question's construct categorization technique for identifying four different RQ constructs— "WHO", WHAT", "HOW1" and "HOW2"—to formulate research questions and keywords. In this paper, WHO is smart product, WHAT is market competitiveness, HOW1 means CMF, and HOW2 refer to CMF framework.

Topic Definition and Search Strategy

According to four RQ constructs, four topics can be defined to collect the articles: a) The colour application in smart products; b) The material application in smart products; c) The finish application in smart products; d) Additional elements applied in smart products. The search for relevant articles was conducted under these keywords: (CMF* OR CMFP* OR "CMF design" OR "CMF principle") AND ("smart product*" OR "intelligent product*" OR "product* design" OR product*) AND ("market compet*" OR market) AND (framework* OR guideline*).

Screening and Selection of Relevant Articles

After those titles were searched and abstracts screened among the whole research articles from 2015 to 2025, 74 articles were initially identified. The original literature was manually screened. Inclusion criteria were: 1). Focus on CMF applications in product design; 2). Relevance to aesthetic, functional, and emotional aspects of user experience; 3). Emphasis on smart products. Exclusion criteria were: (1) Smart products topic not related to CMF theory; (2) CMF application not in the field of smart products. Each selected article was examined for its contribution to identifying variables related to consumer perception, usability, emotional engagement, and product distinctiveness. According to the criteria, 21 articles were finally selected for this review through a detailed search inquiry.

Step 3: Identification and Prioritization of Key CMF Variables

The third step was identification and prioritization of key CMF variables, from the reviewed literature, key CMF variables influencing smart product design were extracted and analyzed. These were prioritized based on: a). Frequency of mentions across articles; b). Empirical evidence of impact on user preferences; c). Contribution to usability, aesthetic perception, and brand differentiation. This step ensured that only variables with demonstrated influence on market competitiveness were retained for framework construction (Li et al., 2025).

Step 4: Identification of Additional Variables and Framework Construction

The last step was identification of additional CMF variables and construction of framework. Beyond core CMF elements, the review also identified additional influential variables, including user behavior trends, ergonomic needs, and technological integration features. Relationships among CMF and these extended variables were mapped to understand how they collectively shape product appeal and competitiveness. Overall, this methodology provides a comprehensive approach to developing CMF framework for smart products design. The use of a literature review synthesis process and the identification of key variables and relationships provide a solid foundation for developing a conceptual framework that integrates prioritized CMF variables with supplementary elements influencing smart product design success (Zhu et al., 2025).

RESULTS AND DISCUSSION

CMF design plays a crucial role in shaping the user-product relationship, making products feel intuitive, aesthetically appealing, and aligned with user values. In smart products, where user expectations extend beyond functionality to include emotional, tactile, and visual engagement, CMF design remains a key differentiator. This section presents the CMFPSE (Color, Material, Finish, Pattern, Sense, Emotion) framework, which expands traditional CMF by integrating pattern, sensory, and emotional elements to enhance user experience and market competitiveness. The framework development follows the four-step research method outlined in Section 2, with Figures 4–6 illustrating the framework components and their hierarchical structure.

Core CMF Elements

Color contributes to emotional resonance, brand identity, and demographic targeting. For instance, neutral tones such as black, white, and silver in premium devices such as Apple iPhone convey sophistication and reliability, while vibrant options in wearables (e.g., Fitbit) enable personalization. However, color perception is culturally and contextually dependent: red may represent luck in some regions but signal caution in others (Xu et al., 2022). Thus, designers must consider cultural, product category, and target-age implications when selecting color palettes.

Material affects both aesthetics and functionality. High-end materials like aluminum or carbon fiber provide durability, lightness, and a premium feel, whereas sustainable materials, such as recycled plastics, align with environmentally conscious consumers (Baron, 2024). The tactile experience of materials further shapes usability and perceived quality (Du et al., 2023). Nevertheless, the choice of material is constrained by manufacturing feasibility, cost, and product-specific requirements, which should be carefully evaluated during design.

The finish of a product, whether glossy, matte, or textured, contributes to both its look and its functionality. A matte finish, for example, not only gives products a refined, subdued appearance but also has practical benefits like reducing glare and hiding fingerprints, which improves usability. This is evident in the design of Google Pixel phones, where a matte finish is applied for better grip and easier handling. Some smart products offer interchangeable finishes, allowing users to switch between different textures or appearances, enhancing customization. This creates a sense of personalization and adds versatility to the product's design (Huang & Cui, 2021). Figure 4 illustrates the basic CMF elements and their relevance to smart product design. The figure integrates the three variables—color, material, finish—highlighting their interplay in shaping product perception.

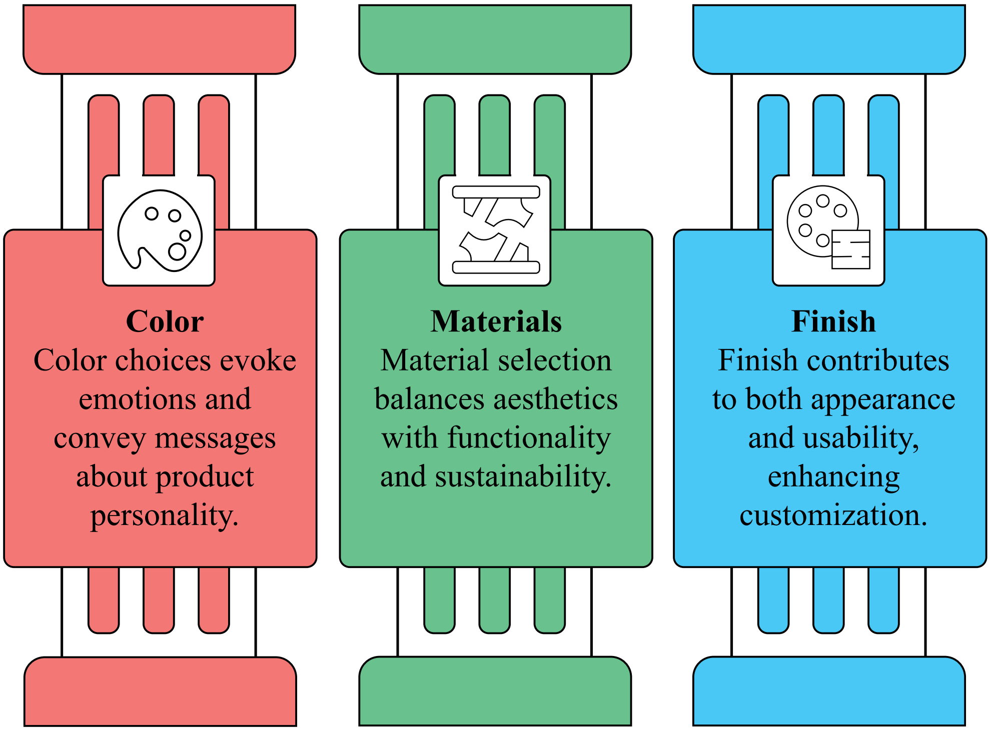

Figure 4. Basic elements of product design in CMF

Extended CMFPSE Elements

In addition to color, material, and finish, the design elements of pattern, sense, and emotion play a significant role in the CMFPSE framework, figure 5 concluded the additional critical elemetns of CMF design on smart products. influencing user experience and product interaction on deeper levels. Patterns can define a product's aesthetic identity and contribute to its distinctiveness. Whether simple, repetitive designs or intricate textures, patterns add another layer of visual interest to a product, breaking monotony and enhancing the design's appeal. For instance, geometric patterns or textured surfaces on smart devices like speakers can convey modernity, creativity, or technical sophistication. Beyond aesthetics, patterns can improve usability. Raised or engraved patterns, such as ridges or grooves, can enhance grip and make the product more ergonomic, particularly for smart products that require regular handling. Patterns can also guide user interaction, subtly directing the way a product is held or operated (Jan, 2000).

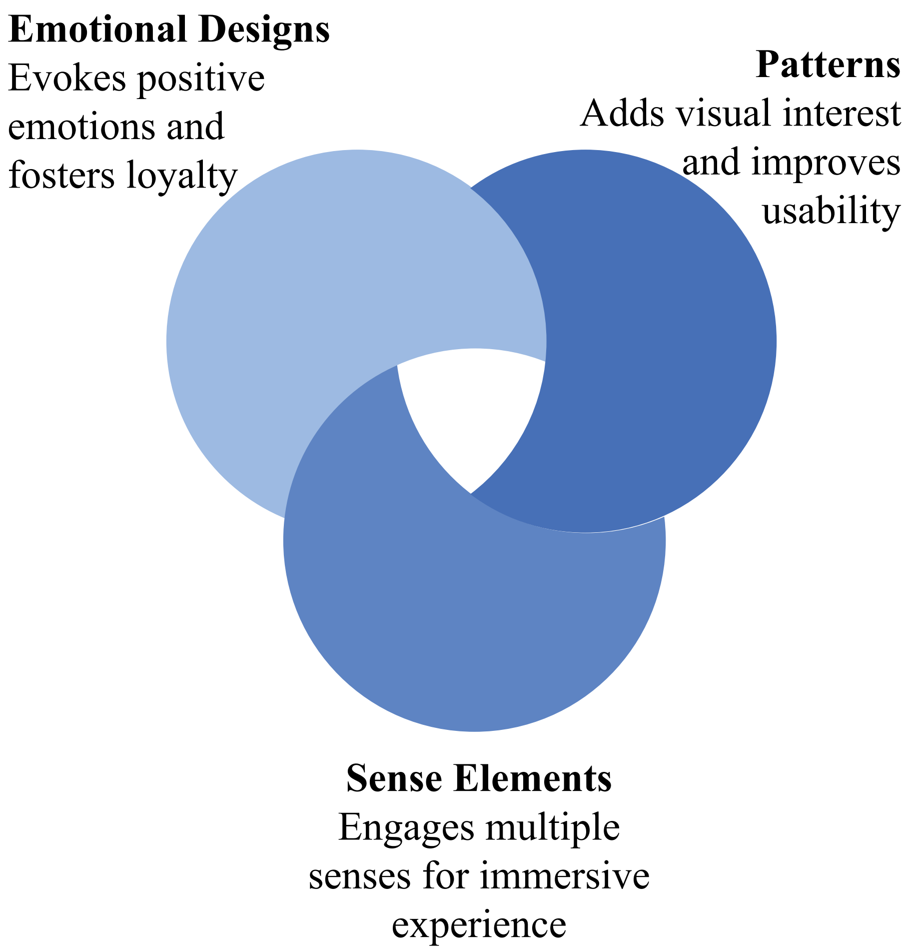

Figure 5. Additional elements enhancing product design in CMF

The integration of sensory elements into product design involves engaging more than just sight. Tactile feedback (touch), auditory cues (sound), and even temperature (heat or coolness) can create a more immersive experience. For instance, smart devices like Nest Learning Thermostat often use a combination of tactile and visual feedback, with a rotating dial that clicks softly, reinforcing actions through sensory cues. Many smart products now integrate haptic feedback, where users feel subtle vibrations or pressure responses to interactions. This can significantly improve user satisfaction, as it makes actions feel more immediate and tangible. Smartwatches and fitness trackers often use this feature to notify users without requiring them to look at the screen. Offering sensory customization, such as the ability to change sound notifications, haptic strength, or screen brightness, can make the product feel more personal and in tune with the user's environment and preferences (Hu & Yan, 2023).

Emotionally resonant designs are those that evoke positive emotional responses, fostering trust, comfort, and attachment. For example, the Nest Learning Thermostat, with its smooth circular design, soft curves, and warm color options, evokes feelings of comfort and reliability, making it a product that fits seamlessly into home environments. This emotional connection encourages brand loyalty as users associate the product with a sense of warmth and ease. Products that resonate emotionally often lead to higher user satisfaction and long-term attachment. Smart baby monitors, for instance, incorporate emotionally soothing elements like soft lighting and gentle sound notifications, which reassure parents and build a sense of trust and reliability. Such emotional connections enhance the perceived value of the product and increase customer retention. The emotional aspect of design also extends to branding. Products that tell a story through their design—whether through symbolic patterns, meaningful colors, or thoughtful material choices—can emotionally engage users and strengthen their loyalty to the brand (L. Zhou et al., 2024).

CMFPSE Framework Structure

The CMFPSE framework (Figure 6) organizes design elements into three levels. The surface level encompasses material and finish, addressing engineering, durability, and aesthetics. The overlay level includes color and pattern, which support visual appeal, brand differentiation, and personalization. The interactive level covers sense and emotion, engaging multiple senses and fostering emotional connections. This hierarchical structure clarifies the framework's contributions beyond traditional CMF, demonstrating advantages such as enhanced multi-sensory engagement and emotional resonance. Compared to prior CMF frameworks, CMFPSE explicitly integrates emotional and sensory considerations, which are critical for wearables and smart devices. Limitations include the potential increase in design complexity, production cost, and cross-cultural adaptation challenges, which must be evaluated in real-world applications. Figure 6 synthesizes the framework levels, linking CMFPSE elements to specific user experience outcomes. This integration ensures that each methodological step—literature review synthesis, variable identification, prioritization, and framework construction, directly informs the framework development.

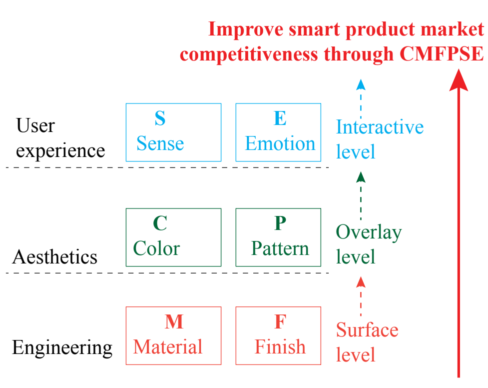

Figure 6. The proposed CMFPSE framework

CONCLUSION

In conclusion, this study advances the understanding of how color, material, and finish (CMF) influence user perception in smart product design by proposing the CMFPSE (Color, Material, Finish, Pattern, Sense, Emotion) framework. Building on the findings from comparative analyses of existing CMF applications in smart products, the framework synthesizes design elements that address both sensory and emotional dimensions of user experience. These additions are essential for enhancing product differentiation, deepening user engagement, and fostering long-term brand loyalty. By incorporating pattern, sensory engagement, and emotional resonance, the framework enhances product differentiation, user engagement, and brand loyalty. The key finding reveals that strategic use of CMFPSE elements—especially those targeting sensory and emotional dimensions significantly boosts product appeal and market competitiveness. A user-centered approach that balances functionality, aesthetics, and emotion can improve both product adoption and customer satisfaction.

Rather than asserting market outcomes, this research emphasizes the conceptual contribution of CMFPSE as an analytical and design-oriented tool. It provides designers and product developers with a structured means of integrating emotional and sensory factors alongside traditional CMF considerations. The framework therefore extends current CMF theory toward a more holistic, user-centered approach to product differentiation and experience design. This research contributes to academic discourse by extending the CMF paradigm into a holistic, experience-driven framework. However, this study's scope is limited to conceptual analysis and qualitative interpretation of smart product cases. The absence of empirical validation means that claims regarding market competitiveness or user behavior should be treated as indicative rather than conclusive. Future research should empirically test the CMFPSE framework across diverse product categories, cultural contexts, and user groups to evaluate its generalizability and practical impact.

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