

A review on Colour, Material and Finish Design: meaning, state of the art and research perspective

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ABSTRACT

This paper presents a literature review that investigates CMF (Colour, Material, Finish) design through academic research to understand its historical development and increasing importance in modern design theory. The current context demands aesthetic experiences that drive emotional engagement between consumers and products, thus making CMF design a strategic possibility. The multidisciplinary nature of this approach, which incorporates elements from psychology, materials science, ergonomics, and marketing, enables the design of meaningful product interactions and influences user perception. CMF design exists throughout professional practice but lacks sufficient academic research due to its complex nature, which creates fragmentation.

This research conducts a Systematic Literature Review (SLR) using the PRISMA framework to analyse 113 relevant sources. The results were displayed according to thematic categories, examining their history, definitional complexity, constituent elements, and design processes. Research demonstrates that CMF design is crucial for enhancing product identity, improving the user experience, and fostering sustainable engagement through a balanced combination of visual, functional, and emotional dimensions.

The research adds to academic knowledge about CMF design, demonstrating its ability to drive sustainable innovation. The aesthetic design of experiences through CMF fosters emotional bonds between users and products, leading to increased product durability and sustainable consumption patterns. Overall, CMF design lends itself well to integration with reflections on sustainability and as a possible driver in specific strategies for sustainable design.

KEYWORDS CMF design; Color; Material; Finishing; Design approach; Design process

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1. Introduction

Modern society has rapidly transformed consumption patterns, driven by technological advancements and market competition. In *'Rethinking Value in a Changing Landscape'*, Brand and Rocchi (2011) explored how social change reshapes values and perceptions, referencing

Toffler's (1980) concept of cultural 'waves' moving from the agricultural to the industrial and then the information age. Building on this, Gardien et al. (2014) identified four main paradigms: Industrial, Experience, Knowledge, and Transformation economies. Each reflects a stage in post-war development where the roles and values of designers, brands, and consumers evolve (see Table 1).

					Transformation Economy
					Knowledge Economy
					Experience Economy
					Industrial Economy
Value proposition	Pride of ownership (commodities)	Targeted experiences (brands)	Empowering creativity (platforms, open tools)	Ethical value exchange (trust, collaboration)	
End-user benefit	Functional benefit	Attention for emotional, human needs	Sense of identity, self-actualisation	Attention for global and societal issues, ethical peace of mind	
Cause of decline	Commoditisation, cheap competition, eroding margins	Brands fight for consumer's attention in crowded landscape, brands address market segments rather than individuals	Self-indulgence, rampant individualism, brand distrust, global networks cause fast dissemination of unethical practices	Possible cause: unequal sharing of extracted value between stakeholders	
People Research objective	Fitting the product to the body and mind	Fitting the product to market segments, lifestyles and subcultures	Fitting the product to the individual's need for self-actualisation	Fitting the product not only to the individual but also to society and planet	
People Research methods	Human factors, ergonomics, anthropometrics	Consumer psychology, ethnography, consumer confrontation testing	User-generated knowledge, expert knowledge and scientific models, monitoring behaviour	Empathic, in-context experimentation and data collection through living labs	
Aesthetics	Functional, rational, universal, simple, pure, objective and absolutist	Diverse, eclectic, complex, ornamental, juxtaposed, subjective and marketing-led	User-generated, algorithmic, generative, aesthetics of interaction more important than aesthetics of appearance	Local executions based on parametric platforms	
Innovative integration (process tools)	Rational problem-solving	Market segmentation, Personas, Scenarios, Experience flows	Rapid co-creation, open innovation, experience prototyping	Parametric platforms, visual/tangible storytelling, Cradle2Cradle sustainability	
Brand	Communicates functional benefits	Communicates emotional benefits	Corporate brands move into the background, user become their own brands	Communicate transparently, instilling trust	

Table 1: The four paradigms. Graphic elaboration by the author from Gardien et al., 2014.

Contemporary society is navigating the fourth paradigm — an era centred on ethical value exchange. According to Gardien et al. (2014), this shift is driven by growing discontent surrounding environmental and ethical concerns. As markets become increasingly saturated, functionality and performance remain essential, but aesthetic and experiential qualities are increasingly guiding consumer choice.

Within this landscape, Colour, Material, and Finish (CMF) design emerges as a crucial design approach. Although the acronym is recent, its principles have long been established in design practice and craftsmanship, where the interplay of colour, material, and finish determines the desired results (Kim, Lee and Suk, 2023). Today, CMF design extends far beyond visual and tactile selection, operating as an interdisciplinary field intersecting

psychology, design, materials science and manufacturing (Zuo, 2020). It addresses evolving sustainability demands and shifting consumer behaviour, enabling new dynamics in production such as mass customisation: 'the practice of creating products and services explicitly linked to individual customers' (Christoph and Piller, 2003). Modular CMF combinations allow customisation without excess stock or cost, offering viable solutions that empower consumer choice (Deserti and Qian, 2010).

CMF design also mediates aesthetic and experiential balance, responding to the demand for empathy in design through sensory engagement. While traditional design privileged the visual sense (Wang and Luo, 2016), designers now seek to activate all five senses (Chiu, Chen and Liao, 2020). Through multisensory perception, consumers generate knowledge and experience (Schifferstein and Desmet, 2008), forming emotional responses that shape perceived value (Becerra, 2016). Managing these emotions becomes a strategic opportunity for market positioning and differentiation (Kato, Botella-Carrubi, and Ribeiro-Navarrete, 2023).

Despite its growing importance, CMF design has received limited attention in academic research and literature. Research has examined material perception and its hedonistic dimension (Rognoli, 2004; Del Curto, Fiorani, and Passaro, 2010; Lerma, 2010; Camere and Karana, 2018; Veelaert, Moons and Du Bois, 2022), yet systematic studies on the reciprocal influences between CMF design, perceptual experience, and affordance remain scarce. Originating as a practice-based, industry-driven field, CMF lacks consistent terminology and scholarly lineage. Studies addressing colour, material, and finish individually or in their interaction (Del Curto et al., 2010; Rognoli, Salvia and Levi, 2011; Karana, 2012; Baxter, Aurisicchio, and Childs, 2015; Manu T. et al., 2022) rarely situate them within a CMF design framework, resulting in conceptual fragmentation.

As Zuo (2020) highlights, ambiguity persists in both the historical development and definition of CMF, which only entered academic discourse around 2005. Its interdisciplinary nature further complicates theoretical framing (Strappini et al., 2024). Positioned between disciplines yet fully belonging to none, CMF design suffers from theoretical vagueness and methodological dispersion. Moreover, much of its professional knowledge remains tacit or proprietary rather than publicly shared.

CMF also holds untapped potential for sustainability. As a vehicle for sensory and emotional meaning, it supports design for emotional durability and resource efficiency. By eliciting attachment, guiding use, and extending product lifespan, CMF can reduce obsolescence and encourage material consciousness.

This review is part of a broader investigation into the CMF design, sustainability, and behaviour change. It addresses the need for a systematic overview of CMF research to clarify its definitions, lexicon, and theoretical foundations. The central research question is: What is the current state of CMF design research in academia, and how can its insights contribute to more sustainable paradigms? In response to this gap, this review aims to consolidate the core concepts of CMF design by tracing its evolution, analysing current definitions, and highlighting its strategic role in contemporary practice. By bridging theory and practice, it seeks to articulate the design knowledge embedded in CMF approaches and outline directions for future research.

2. Materials and methods

2.1. Research method

The authors adopted a Systematic Literature Review (SLR) to shed light on the current academic and professional landscape regarding CMF design. As expressed by Zuo (2020), several researchers have studied and continue to investigate Colour, Materials, Finishes, and their interrelationships. However, including all studies that examine these elements individually would have led to an overly broad and heterogeneous dataset, inconsistent with this research. Therefore, to maintain focus and coherence, the authors set an initial boundary for their selection criteria, only including works in which CMF design is explicitly addressed as an integrated concept.

As noted by Lame (2019), the primary objective of the SLR approach is to minimise bias and enhance transparency at every stage of the review process. This is achieved through clearly defined, systematic methods for selecting and including studies, appraising their quality, and summarising them objectively (Liberati et al., 2009; Petticrew, 2001). Accordingly, the authors structured their analysis following the main steps of the PRISMA Statement (Nightingale, 2009), beginning with the definition of themes (Aguiar et al., 2022) that could shed light on the various aspects involved in investigating CMF design (Fig. 1).

The process involves several steps. First, the review questions are defined, followed by the inclusion and exclusion criteria (Lame, 2019). In this case, an initial identification phase enabled the establishment of which sources met the requirements (see paragraph 2.2). After removing duplicates, the sources were screened. Those selected and finally included were considered and admitted because they reflected and provided information on the defined topics through coding (Lame, 2019; Aguiar et al., 2022).

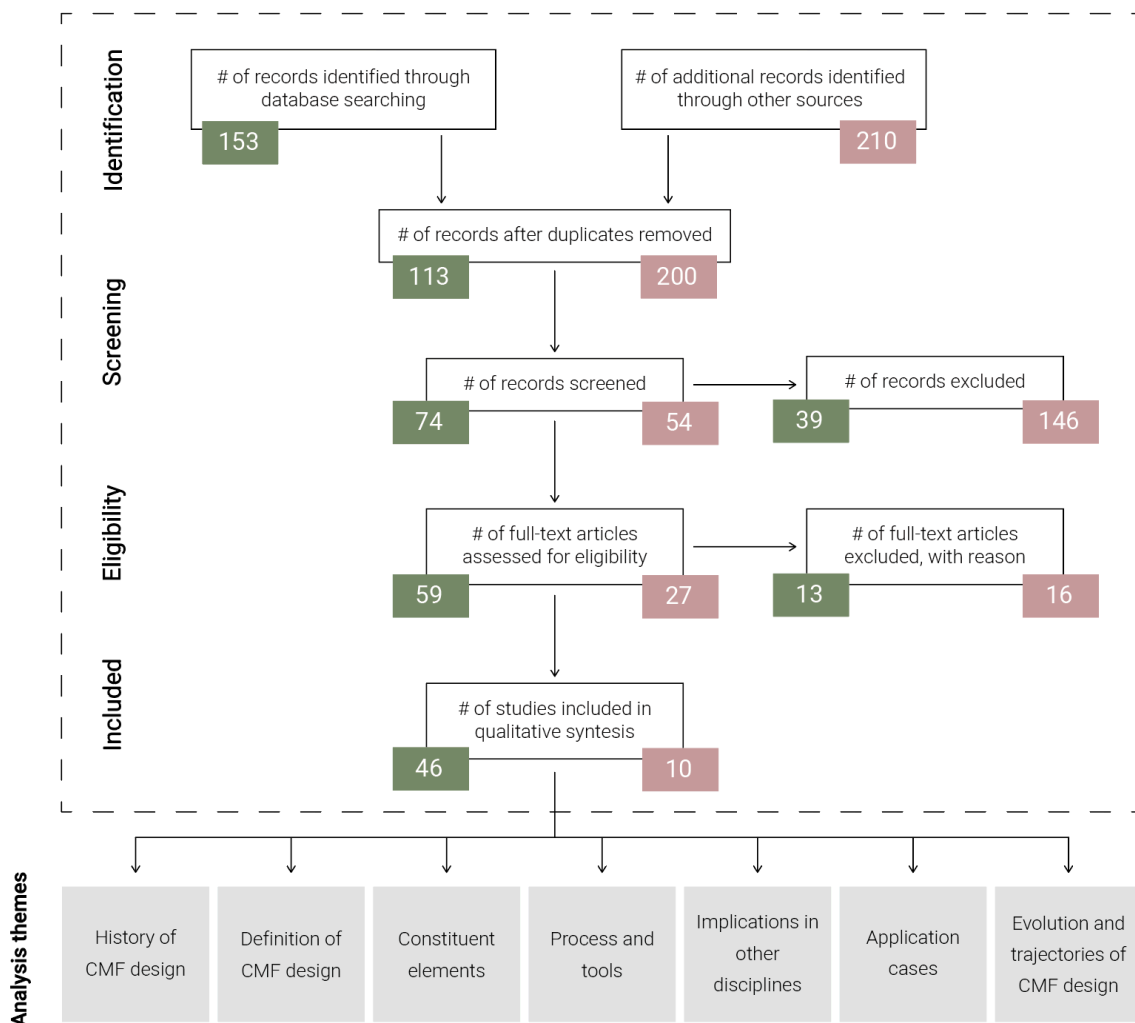


Figure 1: The steps of the Systematic Literature Review (Image by the author).

2.2. Data collection

The literature search was conducted using academic databases and engines such as Scopus, WoS, and Google Scholar, as well as the digital catalogue of Politecnico di Milano. The search queries used included: 'cmf AND design', 'cmf AND design AND surface', 'surface* AND design AND colour* AND material* AND finish*'. As mentioned above, one of the significant challenges in this process was the limited availability of literature on the subject, aside from the fact that the CMF acronym frequently appeared in unrelated contexts. Indeed, CMF stands for several unrelated terms, such as *Common-mode filter*, *compute-and-forward*, *common mode failure*, *composite metal foam*, *Crew Module Fairing*, *craniomaxillofacial*, and others, including names of chemicals and technical engineering concepts.

To ensure relevance, the first sorting was conducted by excluding publications written in languages not spoken by the authors — specifically, those not in English, Italian, or Spanish. Additionally, studies from fields unrelated to the

research focus, such as medicine, health professions, veterinary science, energy engineering, and physics, were discarded. Furthermore, articles that were inaccessible or unavailable were also excluded by default.

This initial process yielded 153 articles, which were then reduced to 113 after removing duplicates. The results confirmed the limited volume of scientific literature available directly related to CMF design. Given this scarcity and the practical, industry-driven nature of CMF, the authors extended their search to include a grey literature search. Using Google, they searched for relevant professional and industry-based sources using “*CMF design*” as a keyword. Ultimately, 27 sources were selected for inclusion in the analysis.

2.3. Data analysis

The 113 articles, identified in the literature, were systematically reviewed. The first stage involved reading the abstracts and eliminating the off-topic articles (74 articles were left). A second filtering followed, in which full texts were read, and additional articles were excluded for

lacking substantive relevance to the research objective (59 articles and 27 sources from the grey literature remained).

Once the core set of text was established, the authors proceeded to code the articles based on thematic relevance, grouping them into the following categories:

- History of CMF design
- Definition of CMF design
- Constituent elements
- Processes and tools
- Cross-disciplinary implications and systemic impacts
- Case applications
- Evolution and trajectories of CMF design (links with behaviour and sustainability)

For this initial framing review, which is intended to serve as a foundation for deeper investigation in future research, the analysis focused on the first four categories. These offer the clearest insights into the conceptual and operational dimensions of CMF design, while laying the groundwork for exploring its broader implications.

3. Results

3.1. History and State of the Art of CMF Design

The origin of the acronym CMF is often attributed to Italian designer Clino Trini Castelli, who is believed to have coined the term in the 1980s during the design of an office chair for Herman Miller (Bosoni, 2016). Another version credits Herman Miller itself, which opened its first CMF-focused showroom in 1996 (Xu, Wang and Xu, 2023). Regardless of its precise origin, the consumer goods boom of the 1970s and 1980s increased product complexity, making it necessary to separate and specify individual choices of colours, materials, and finishes (Perryman, 2021a).

CMF design gained professional prominence in the early 2000s. Companies such as Samsung Electronics, Motorola, and Nokia conducted early research into the integration of colour, material, and finish (Zuo, 2020). Nokia was among the first to align CMF design principles with consumer trends and technological developments (Perryman, 2021a), while Motorola established a dedicated CMF team in early 2006.

Before the term became widespread, CMF-related practices were already established in the automotive sector. The complexity of car interior design required the careful integration of colours, materials, and finishes to create balanced environments. Ford was among the first

to allow users to customise colours and finishes (Perryman, 2021a). The responsible department, known as Colour & Trim, has been replaced by CMF in many companies (Zuo, 2020). Thus, while CMF design principles predate the 1980s, they were not unified under a shared terminology and were often treated as part of colour design.

In academic and experimental contexts, developments in Italy differ from the wider international scene. In Italy, the 1970s marked a growing interest in multisensory design approaches involving colours, material perception, and the perceived object qualities. CMF design can be viewed as an evolution of expressive experimentation by designers such as Ettore Sottsass, Andrea Branzi and Clino Trini Castelli (Squarrito and Ferrara, 2023). Castelli introduced "Design Primario" (Castelli, 1999; Castelli and Petrillo, 1983), referring to the 'soft' characteristics of objects related to perceptual sensitivity — including colour, light, sound, smell, touch, and material finishing. This approach was featured in collaborations with institutions such as the Montefibre Design Centre and brands like ABET Laminates and Louis Vuitton (Bosoni, 2016).

Outside Italy, the term CMF was popularised in 2005 during the Berlin conference, *The Art of Plastic Design* (Xu, Wang and Xu, 2023; Zuo, 2020), where Tina Rippon presented the keynote 'Finish Trends - Getting the CMF (Colour, Material and Finish) Right' (Zuo, 2020). Earlier research into the interplay of colour, material and finish dates back to the 1980s in Japan, where Hiroki Aoki and Mai Suzuki explored the sensory properties of materials under different environmental conditions. Institutions including the University of Cambridge, the Royal College of Art, Kingston University, Delft University of Technology, and Politecnico di Milano also conducted related research without explicitly using the CMF acronym (Zuo, 2020). In 2016, Colombian designer Liliana Becerra (2016) published *The Fundamental Principles of CMF Design*, one of the first attempts to define CMF design outside academia.

Today, CMF is widely recognised in professional practice. Companies such as Volkswagen, Samsung, and Philips have established dedicated CMF teams (Liu and Kim, 2023), and specialised online platforms have emerged, including *Colour Material Design*, *The Colour Authority*, and *Colour of Saying*. Material libraries, such as *Material District* (Material District, no date) and *Material Connexion* (Material-minded Design | Material Connexion, no date), also provide CMF insights. Additionally, studios like Chris Lefteri Design conduct extensive research on CMF design trends (Chris Lefteri Design, no date).

Despite its widespread professional use, CMF remains underrepresented in academic research. Many scholars

do not explicitly use the term, complicating efforts to consolidate related studies. Its cross-disciplinary nature also challenges researchers working within rigid academic structures.

A notable exception is China, where CMF design has become a significant trend and the source of most related academic publications (Xu, Wang and Xu, 2023). The China Household Electrical Appliances Research Institute Innovation Design Centre has researched CMF design in electrical appliances (Zuo, 2020), while Covestro has collaborated with Tsinghua University on CMF design projects using recycled materials (Covestro AG, no date). In 2017, China launched the CMF Design Award to promote value and innovation (CMF Design Award, no date). The 2024 Design Shanghai exhibition, which hosted a CMF design and aesthetics conference, underscored the growing theoretical and aesthetic interest (Design Shanghai CMF conference schedule, no date). In Asia, CMF goes beyond practice to a deeper theoretical inquiry. Scholars such as Liu (2020) and Zhang (2020) have called for a greater understanding of CMF design, echoing Zuo's (2020) appeal for more scholarly attention. However, many of these studies remain accessible only in Chinese.

Finally, CMF design is slowly entering academia through dedicated programmes such as the Master in *Sensorial Surface Design* at POLI.Design, Italy; the *Colour, Material and Finish Design* online short course at Central Saint Martins, UK; the *Colour and Materials Design* MFA and MA at the College for Creative Studies in Detroit, US.

3.2. CMF Design definition

As with the ambiguity surrounding its origins and use, the definition of CMF design remains imprecise. As Zuo (2020) notes, there has never been a universally accepted definition of this term. Even among scholars, there is no consensus on the proper designation of the term, which is often used with different meanings within the same article, for example, as an *approach-strategy* (Kato, Botella-Carrubi and Ribeiro-Navarrete, 2023); *approach-discipline* (Valan and Paglierani, 2024), or a set of *methods-technology* (Wang and Wang, 2021).

CMF design has been described as a method (Xu, Wang and Xu, 2023; Liu, 2020), process (Zhang, 2020), design field (Gaetani, Brevi and Balloni, 2021), discipline (Salvoni, 2021; He and Zhang, 2023; Valan and Paglierani, 2024; Ugale, Bisoyi and Loudon, 2022; Ugale and Thakur, 2021; Becerra, 2016), theoretical framework (Kato, Botella-Carrubi and Ribeiro-Navarrete, 2023), meta-design approach (Squatrito and Ferrara, 2023), research direction (Liu and Kim, 2023), technology or set of methods (Wang and Wang, 2021) and more simply, as an approach (Zuo,

2020; Zuo and Peng, 2021; Kato, Botella-Carrubi and Ribeiro-Navarrete, 2023; Valan and Paglierani, 2024).

Among these interpretations, Zuo and Peng offer one of the few explicit definitions for both CMF and CMF design (Zuo and Peng, 2021):

- **CMF:** “the integration and optimisation of colour, materials, and processes (particularly the process of surface finishing) towards the most appropriate apparent form, function, and quality of the designed object” (Zuo, 2020).
- **CMF design:** “the identification of the solution for the colour, materials, and processes (particularly the process of surface finishing) for the designed object to balance aesthetics and function and offer the optimal user experience” (Zuo, 2020).

Although the authors do not explicitly define CMF design as a field or discipline, they consistently refer to it as an *approach*. The New Oxford American Dictionary defines “approach” as “a way of dealing with something”, and the Cambridge Dictionary as “a way of considering or doing something”. Accordingly, CMF design can be considered an *approach* — a way of doing design that focuses on colours, materials and finishes and on designing their relationship to enhance the product's attributes (Spence and Wan, 2015).

CMF design is integrated throughout the design process, from initial research to final production (Kato, Botella-Carrubi, and Ribeiro-Navarrete, 2023). It is primarily applied in product and interior design (Valan and Paglierani, 2024) across various industries, including furniture, apparel, cosmetics, home appliances, and automotive (Kato, Botella-Carrubi, and Ribeiro-Navarrete, 2023). At its core, CMF design concerns the interrelation between the product, the user, and the company.

For the product, defined by its colours, materials and finishes, CMF design shapes visual language and identity (Liu and Kim, 2023; Piselli et al., 2018), playing a key role in defining style (He and Zhang, 2023). Influencing elements that directly interact with the user it creates a strong visual and sensory impact (Liu and Kim, 2023). CMF design balances aesthetic and functional attributes (Zuo and Peng, 2021), achieving harmony between visual appeal and usability (He and Zhang, 2023; Salvoni, 2021; Ugale, Bisoyi and Loudon, 2022). By shaping aesthetic perception, it enhances the product's value and perceived quality (Zhang, 2020; He and Zhang, 2023; Kato, 2022b; Kato, Botella-Carrubi and Ribeiro-Navarrete, 2023), a key aspect of a good design (Kato, 2022a) that influences emotional engagement, brand loyalty, and product longevity, namely, the desire to take care of a product and

thus extending its life cycle (Kato, Botella-Carrubi and Ribeiro-Navarrete, 2023; Zhang 2020).

CMF design creates opportunity for meaningful experiences through innovative combinations of aesthetic and functional attributes (Kim, Lee and Suk, 2023). These experiences address users' emotional and unconscious needs (He and Zhang, 2023; Huang and Cui, 2021; Zhang, 2020), integrating design and psychology to meet product requirements (Zhang and Yuan, 2021). By aligning user needs with tailored aesthetic strategies, CMF design provides a specific and empathetic approach to product development.

From the company's perspective, effective CMF design strengthens brand differentiation (Zhang, 2020), thereby increasing product recognizability and competitiveness (Kato, Botella-Carrubi, and Ribeiro-Navarrete, 2023; Kato, 2022b; Liu and Kim, 2023; Huang and Cui, 2021). By conveying positive experiences and high quality, it enables consumer loyalty and reduces the risk of product failure. Through target analysis and style revision via minor adaptations, CMF design also allows companies to reach new consumers and enter emerging markets (Salvoni, 2021).

3.3. CMF elements: Colour, Material and Finishing

As previously discussed, colour, material and finish have been extensively studied across various fields. This section analyses each element individually in relation to its role within CMF design.

3.3.1. Colour

Colour is the first element perceived when interacting with an object and the most extensively studied of the three, particularly from a perceptual perspective, as it strongly influences cognition, emotion, and behaviour (Kato 2022a).

Artists and scientists have long explored the nature of colour. Technically, it is defined through hue, saturation, and lightness. Over the centuries, philosophers and researchers have developed systems to organise colours and their relationships (Boeri, 2010), including the works of Albert Henry Munsell, Lars Sivik, Anders Hard, and Shigenobu Kobayashi.

Designers must consider how light reflections affect colour perception (Kato, 2022b), as manufacturing processes and surface properties can alter appearance (Kato, 2022c). While technical accuracy and function are essential, the aesthetic, symbolic, and emotional value of colour remains central (Kato, Botella-Carrubi and Ribeiro-Navarrete, 2023).

Studies on colour psychology reveal how colours can evoke emotions and influence behaviour (Perryman, 2021b; Gupta and Sharma, 2018). Hemphill and Wexter investigated emotional responses to individual colours (Na and Suk, 2014), leading to models linking colours and emotional states (Liu, Zhao and Zuo, 2015). Darker

colours make forms appear slimmer than lighter tones, while neutral tones suggest calmness and austerity, and bright colours evoke liveness (Becerra, 2016).

Understanding both the semantics of individual colours and the effect of combinations is essential to communicate effectively with users (Salvoni, 2021). Colour perception and meaning vary widely across cultural contexts and personal experiences, influenced by factors such as environment, recognition ability, and background (He and Zhang, 2023). Thus, analysing audience and context is crucial in CMF design (Valan and Paglierani, 2024).

Given its emotional power and immediate impact, colour plays a key role in consumer choices and brand perception (Kato, 2022b; Kato, 2022c; Kato, Botella-Carrubi, and Ribeiro-Navarrete, 2023). Light and bright colours convey confidence, while white conveys honesty, red stimulates, darker colours convey luxury and elegance, blue represents ability, and black represents refinement, and brown communicates sturdiness (Kato, Botella-Carrubi, and Ribeiro-Navarrete, 2023). Understanding these psychological effects allows designers to shape brand values and consumer experience strategically. Colour is thus a fundamental element of CMF design to be deeply integrated with design thinking.

3.3.2. Material

Material is the essence of any object and the medium through which we experience the world. Its central role in human evolution is clear, with historical eras being named after materials: the Stone Age, the Copper Age, the Bronze Age and the Iron Age. Human progress has always been linked to material discoveries and technological advancement (Zhang and Yuan, 2021).

With advances in technology, materials have become crucial to design (Ashby and Johnson, 2003). Their exponential diversification has made selection increasingly complex: over 160,000 distinct materials have been identified in the past two decades (Papile, Del Curto and Coccia, 2021), contributing to what Manzini (1989) termed 'the hyperchoice'. Designers must therefore develop strong selection skills.

Digitalisation has led to online material libraries and tools that support this process (Del Curto and Dantas 2009; Ramalhete, Senos and Aguiar, 2010; Papile and Del Curto 2021). CMF design refines not only the choice of materials but also their combination within a product, bridging functional attributes (technical and performance aspects) with aesthetic ones (perceptual and emotional value) (Piselli et al., 2018).

Users initially assess whether an artefact meets physical and sensory requirements before considering style, cost, and broader social factors, such as sustainability (Zhang

and Yuan, 2021). The growing focus on sustainability has transformed material selection. Consumers increasingly seek ethical and ecological options; however, reliable data, such as Life Cycle Assessments (LCAs), are often missing, which enables greenwashing practices (Lefteri in Van Vliet, 2023). Designers must therefore link technical performance with transparent communication and user dialogue. Designers also elevate material value by embracing imperfections as desirable features. They must anticipate and meaningfully integrate potential changes due to light, heat or humidity (Ziarsolo, 2023).

CMF design gives materials a “voice”, as they not only realise products but also carry meaning. Through sensory interaction, materials evoke emotions and connect to unconscious desires (He and Zhang, 2023; Squatrito and Ferrara, 2023). Enhanced by colour and finish, CMF design can materialise sustainability and foster more responsible consumption.

Beyond physical essence, one expressive medium emerges: the surface.

3.3.3. Finishing

While colour and material have defined boundaries, finish acts as the *trait d'union* between them, both shaping and being shaped by each. Closely linked to sight and touch, it defines the initial interaction between the user and the product, and plays a central role in aesthetics (Morozzo Della Rocca and Zappia, 2022).

Finish acts on the product's ‘skin’ (Del Curto, Fiorani and Passaro, 2010), requiring specialised expertise, complex problem-solving, and processing time. Each material offers distinct finishing possibilities, producing varied tactile and visual effects. Technological advancements have expanded these options, enabling similar effects across various substrates (He and Zhang, 2023), thereby giving designers greater expressive freedom.

A carefully crafted finish enhances perceived quality and value (Niculescu et al., 2023), thereby enriching the consumer experience (Kato, Botella-Carrubi, and Ribeiro-Navarrete, 2023). It becomes a decisive factor in how a product is understood, used, and remembered.

3.4. CMF design process

As discussed, CMF design has yet to be systematised or standardised, resulting in varied and nuanced approaches. Its professional nature adds complexity, as most designers develop *ad hoc* processes rarely documented in academic literature.

Across different approaches, CMF design consistently combines rational and inspirational methods and tools (Zhang, 2020; Xu, Wang and Xu, 2023; Zuo and Peng, 2021). These range from quantitative techniques — such as perceptual testing, statistical user analysis, and measurement of physical colour, material, and texture

properties — to qualitative ones, including brainstorming, focus groups, and user profiling.

By analysing existing literature and professional communication channels, the authors have mapped the main CMF design stages (see Table 2). While their explanation varies depending on the designer's perspective, the process can generally be broken down into increasing levels of detail.

Most models identify three macro phases: analysis (exploration), operational (experimentation), and application (definition) (Valan and Paglierani, 2024; Zuo and Peng, 2021). Within these, specific steps detail these methods and tools employed.

Laura Perryman (2021b) identifies five main steps:

1. Defining the problem or brief
2. Collecting information
3. Brainstorming and Analysing
4. Developing and creating
5. Presentation and feedback

These correspond to a research phase, where designers gain insights into consumers and trends, leading to a visual storyline and moodboard for presentation and design development.

Liliana Becerra (2016) offers a six-step model, also cited by Ugale, Bisoyi and Loudon (2022):

1. Information gathering: understanding consumers, their habits and preferences, identifying relevant colours, shapes, and materials for them, defining the brief to identify the main relevant information about the target audience, budget, and timeframe. It also involves analysing the market and competitors.
2. Narrative building: developing storytelling, the message to communicate with the audience. Designers may create personas, identify market trends, and use moodboards to visualise desired emotions and sensations.
3. CMF strategy: analysing user-product interaction to determine key functional and emotional attributes.
4. Component analysis: examining each product element from production to finishing perspectives.
5. CMF palette development: curating materials and colours to express the desired design direction.
6. CMF development: applying finishes, working with suppliers and overseeing production.

This six-step framework remains the most referenced, though other variations exist. Salvoni (2021), for instance, expands it into ten steps — brief, company and competitor analysis, target and trend analysis, moodboard, message definition, CMF palettes, colour scheme, and application — adding details to the earlier model.

<p>Analysis phase <i>Explore</i></p>	<p>Defining the problem or brief Collect information Brainstorm and Analyse</p>	<p>Information gathering Establish a narrative Creating a CMF strategy</p>	<p>Brief Company analysis Competitor analysis Target analysis Trend analysis</p>
<p>Operational phase <i>Experiment</i></p>	<p>Develop and create</p>	<p>Understanding part break up Creating CMF palettes</p>	<p>Moodboard Definition of the message CMF palettes Colour scheme</p>
<p>Application phase <i>Define</i></p>	<p>Presentation & Feedback</p>	<p>CMF Development</p>	<p>Application and colour variants</p>

Table 2. The structure of the CMF process is not always the same. The diagram illustrates how the CMF process, in general, can be broken down into three main phases. However, within it, one can find different views on the more specific steps (Image by the author).

Additional activities may be integrated depending on the project, such as surveys (Ugale and Thakur, 2021), brainstorming sessions (Zuo and Peng, 2021), testing (Piselli et al., 2018; Huang and Cui, 2021; Zuo and Peng, 2021) or colour and tactile experiments (Zhang, 2020). Zuo and Peng (2021) also highlight the inclusion of Participatory Design, where collaboration with end users provides valuable insights for refining outcomes.

In the final phase, designers move from colour scheme definition to detailed CMF documentation, presented through renderings or prototypes (Zhang and Yuan, 2021; Mango Design, 2024).

The process described above represents the most comprehensive CMF design model. However, it remains flexible: as seen from Table 2, depending on project goals, some stages, such as colour analysis or material selection, may receive greater emphasis. Each CMF element encompasses a complex background of technical and experiential knowledge that shapes the overall design process.

Complementary research activities often support CMF design, including User Research, Market Research and Trend Research (Zhang, 2020; Huang and Cui, 2021; Yin and Krotova, 2023).

- User Research explores audience characteristics and behaviour and can evolve into dedicated consultancy projects (Becerra, 2016).

- Market Research analyses competitors' products, costs, usage, colours, and material strategies (Becerra, 2016).
- Trend Research tracks social evolution to anticipate design directions and scenarios, as well as emerging user desires (Piselli et al., 2018; Dragt, 2023; Yin and Krotova, 2023).

4. Conclusion

This review has explored the theoretical and practical foundations of CMF design, highlighting its growing relevance and largely unexploited potential within academic research. From its historical evolution to the analysis of its core components, CMF design emerges as a contemporary, adaptive, and strategic design approach. Its multidisciplinary nature makes it especially suited to today's complex challenges, where intersections between engineering, psychology, marketing, and sustainability generate innovative outcomes.

As discussed, CMF design offers a wide array of tools, dynamics and application steps adaptable to different contexts and needs. Each phase can be deepened to focus on specific aspects such as colour analysis, material research, or trend exploration. This flexibility positions CMF design as a key driver of innovation (Huang and Cui, 2021). Its impacts go beyond aesthetics: by intentionally designing colour, material, and finish, CMF design shapes perception, fosters emotional connections, and enhances user experience.

Studies have shown that emotions drive consumer decision-making and that 60% of these emotions are influenced by design (Na and Suk, 2014). CMF design, therefore, plays a crucial role in creating emotional bonds with consumers, becoming a strategic element for driving sales and enhancing customer satisfaction.

By integrating functional and aesthetic dimensions, CMF design also holds promise as a catalyst for more sustainable behaviour, from extending product lifespans to reducing waste. The material selection process is crucial to addressing environmental challenges. By enhancing the visual and tactile qualities of a product, CMF designers counter the perception that sustainable products are less appealing. Exploring textures, finishes, and culturally embedded materials opens opportunities to promote sustainability without compromising design quality or engagement.

Finally, CMF design can act as a medium for cultural storytelling and value communication. Integrating local materials, traditional techniques, or symbolic colour codes reinforces identity and community while promoting environmentally conscious behaviours aligned with users' cultural values. Taken together, these dimensions position CMF design as a strategic lever for developing meaningful, innovative, and responsible products. Moving forward, it will be essential to deepen both academic and practical exploration. As a bridge between functionality, aesthetics and sustainability, CMF design has the potential to transform how we conceive, design, produce and interact with everyday objects.

5. Conflict of interest declaration

The authors declare that there is no conflict of interest regarding the publication of this paper.

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