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Edited by Filippo Cherubini and Andrea Siniscalco

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The emerging role of CMF designers in sustainable product development: insight from practice

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Abstract

Designers are playing an increasingly crucial role in the transition to more sustainable consumption patterns. This has opened new areas of focus in design, one of which is CMF (Colour, Material, Finish) design. CMF design allows small, low-impact changes to be made to the design of a product without disrupting the production process. Its potential benefits could be even greater if conceptualised and shared as a distinct design trajectory.
The practical and professional nature of CMF design has resulted in a lack of literature on the subject. This research aims to address this gap by exploring the professional backgrounds, training pathways, and sustainability-related perspectives of CMF practitioners.
The study is based on qualitative data gathered through interviews with 14 professionals and academics in the field. These interviews highlighted the skills and knowledge required for CMF practice and its relationship with sustainability. Finally, it was possible to identify tools for integrating CMF design with sustainability actions.
This research translates the particular know-how of a process created from the bottom up by designers into a more tangible and shareable systematisation. The findings encourage academic and professional communities to recognise CMF as a lever for innovation, with the capacity to support sustainability goals.

Keywords: CMF Design, Design Practice, Sustainable CMF.

Introduction

In the current context, the role of designers in sustainability is increasingly strategic. Designers act as mediators between the various stakeholders, becoming coordinators capable of managing the complexity of design processes in all their phases (Antonelli *et al.*, 2008). This horizontal positioning allows designers to integrate environmental and social values from the beginning of the design process, transforming sustainability into an essential design condition.
Therefore, designing with sustainability becomes part of the design process, a *conditio sine qua non*. Designers' sensitivity to sustainability (Kumar and Sarkar, 2018) allows them, through the language of objects, to educate citizens in acting responsibly towards the environment (McDonald and Oates, 2006; Wastling et al., 2018). In this sense, designers have a cultural responsibility: to engage citizens in more conscious behaviour, stimulating a systemic view of daily actions.
The multidisciplinary nature of design allows designers to have the same flexibility in their approach. Colour, Material and Finish (CMF) is an emerging and cross-disciplinary discipline among the many possibilities. Originating in the automotive tradition of the "Colour & Trim" departments, CMF design, as it is known today, began to spread in the 1980s and subsequently gained momentum in the 2000s (Zuo, 2020). By its very nature, CMF design has acquired increasing strategic importance within product development processes. This approach focuses on balancing the artefact's aesthetic and functional aspects, as well as its sensory and emotional elements (Becerra, 2016). CMF design

thus allows for the integration of sensory, cultural, technological, and, more recently, sustainable dimensions.

In the field of sustainability, selecting materials, colours, and finishes becomes part of a process that considers the entire life cycle of an artefact. From this perspective, carefully considered CMF choices can positively contribute to the broader and more complex dynamics of a product's Life Cycle Assessment (LCA).

However, the potential contribution of CMF design goes beyond material selection. This approach allows designing CMF to be easily adapted to different targets. Small changes in the product aesthetic appearance can thus make it possible to change the target while maintaining the production technologies, moulds, and materials already in use (Zuo, 2020). This flexibility opens a range of possibilities that allow companies to update themselves without incurring costs or excessive consumption.

Equally relevant is the emotional dimension that a manufactured product can generate. A product that engages all five senses satisfies the consumer's perceptual needs and emotional expectations (Becerra, 2016). The emotional experience is a fundamental aspect of consumer perception, and it is precisely these emotions, along with the emotional value associated with the perception of quality, that serve as a significant source of competitiveness.

Given its practical nature, CMF design often remains linked to professional fields. Many companies, including Philips, Nokia, and Samsung (Zuo, 2020), have dedicated sections to CMF design within their R&D departments. Despite the potential of this approach, it is still struggling to establish itself, especially in academia, partly due to the absence of a shared vision of the process or dedicated training courses (Liu, 2020). This situation limits its full exploitation, contributing to the perception of CMF as a subordinate activity compared to other established design areas.

In addition, while CMF designers frequently use established tools, these usage patterns are neither standardised nor widely shared. The existence of this ambivalence in practice has resulted in each CMF designer developing their tools, adapting existing ones to their design process. Thus, without common structures, opportunities to create new knowledge and dedicated theoretical and methodological tools are lost.

This study explores the potential of CMF design from a professional point of view. It aims to understand how this approach can effectively promote sustainability. While literature references the selection of colours, materials, and finishes from an LCA perspective, there is limited understanding of how such practices are integrated into professionals' everyday work.

By adopting a qualitative approach, this research pursues a twofold objective. First, the authors aim to bridge the gap between theoretical reflection and applied practice, providing valuable insights for defining an operational framework for sustainable CMF. Second, the study seeks to understand how professionals perceive and address the issue of sustainability in their daily work.

Therefore, the research question is: *how can CMF be a concrete lever for integrating sustainability into design processes, and what opportunities do CMF designers perceive?*

The evidence presented in the following sections offers both academics and practitioners an initial basis for fostering greater critical awareness and advancing the integration of sustainability within CMF practice.

Methodology

This research is part of a broader doctoral project investigating how CMF design can be used as a lever in sustainable design, particularly in conveying sustainable behaviour. For this reason, the study presented here is part of a Grounded Theory framework.

Grounded Theory is a qualitative methodology to social research developed by Glaser and Strauss (1967) to bridge the gap between theory and empirical research. Unlike other approaches, it does not start from predefined hypotheses but constructs theories directly from data collected in the field. This

process involves a continuous alternation between data collection and analysis to bring out concepts and categories consistent with the participants' lived experience. The nature of the topic reinforces the appropriateness of Grounded Theory, which is particularly suited to exploring areas that are understudied or where knowledge is still limited (Payne, 2007).
Within this framework, interviews play a central role. Semi-structured interviews were conducted with CMF design professionals to explore their experiences, meanings, and professional contexts.
Respondents were selected according to the professional profiles identified in Liliana Becerra's CMF model (2016): colour design, colour development, material design, material development, surface design, finish design, CMF strategy, CMF development, trend tracking and forecasting, storytelling, and marketing. The professional profiles were then cross-referenced with various possibilities, such as professional roles and operating contexts, including freelance, studio consulting, company (R&D department), and academia. The interviewees' selection was targeted, starting from publicly available information on personal or company websites, to ensure representativeness concerning the diversity of roles in the contemporary CMF landscape.
The interviews, which lasted approximately 45 minutes, were conducted in person and online, with the assistance of question slides on PowerPoint. The research protocol was approved by the Politecnico di Milano Ethics Committee, and all participants signed an informed consent form, authorising the use of the data collected and its processing per current privacy legislation.
The discussion followed a flexible structure organised around three main themes: training and background, professional practices, and integration of sustainability into design processes. The goal was to obtain meaningful data from the professional field and experiences that will allow the authors to understand design processes and specific knowledge about the vision of sustainability.
All interviews were audio recorded, transcribed, and coded using MAXQDA software. The main tools of Grounded Theory include *coding* - assigning labels to text segments to summarise their meaning - and *memoing* - reflective writing used to record insights and theoretical connections (Saldaña, 2013). Through the coding process, it was possible to obtain 22 code categories. These codes were then compared and aggregated to identify significant recurrences, divergences, and trends within the text corpus. The results, presented in the following section, highlight actions that illuminate the main challenges and opportunities for embedding sustainability in CMF practices.

Results and discussion
The results of the interviews were analysed according to the 22 codes. Specifically, as can be seen from the graph (Fig. 1), the code that received the most responses concerned sustainability strategies, followed by the relation of CMF with sustainability in general.

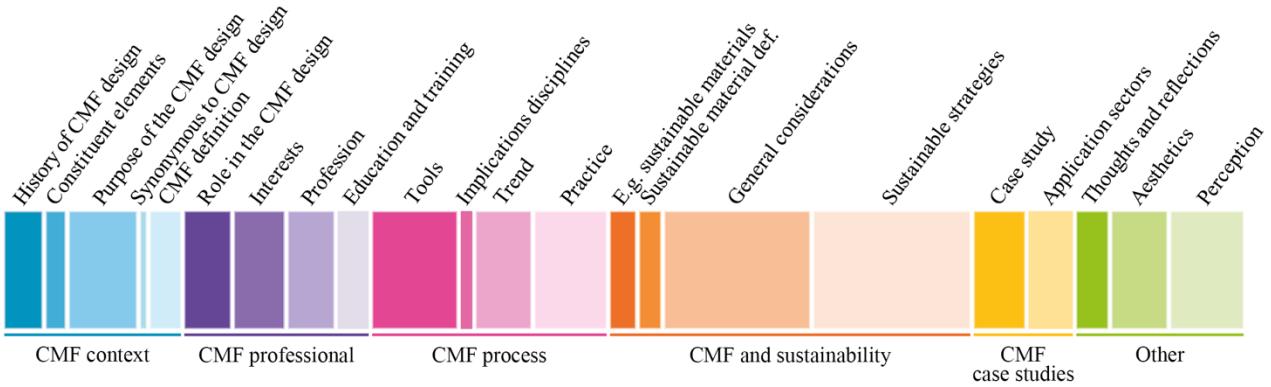

Fig. 1 - Graph showing the codes identified and analysed, divided into categories. The width of each rectangle is proportional to the number of elements selected for that code. Image by the authors.

Moreover, thanks to the interviews, it was possible to clarify points regarding the CMF process, according to the most recurring group of codes. They further revealed significant insights regarding

the tools used, different perspectives on trends, and some measures implemented in practice. Third and fourth place were occupied by information about professionals and the context of CMF design. The authors decided to keep track of considerations regarding aesthetics and perception for broadening the leading doctoral research.
Starting from the characteristics of the interviewees, the figure of the CMF designer has a background linked above all to design and architecture. The interviewees' training is mainly related to product or graphic design, with a few exceptions in architecture. This is primarily linked to the relatively recent emergence of Product Design courses, which have led to greater specificity in training.
The interviewees' profiles are mostly professional, with only five interviewees working exclusively in academic research. However, seven combined professional practice with teaching activities within university courses. As Table 1 shows, the respondents identified themselves in multiple roles (Becerra, 2016), completing almost the entire matrix.

CMF role specialisations	Freelance	Studio consulting	Company (R&D)	Academic
Colour design	X	X	X	X
Colour development	X	X	X	X
Material Design	X	X		X
Material Development	X	X		X
Surface Design		X	X	X
Finish Design	X	X	X	X
CMF Strategy	X	X	X	X
CMF Development	X	X	X	X
Trend tracking and forecasting	X	X	X	X
Storytelling and Marketing	X	X	X	X

Tab. 1 - Matrix showing the roles and professions with which respondents identify themselves.

Although Liliana Becerra's book (2016) was intended to systematise CMF, not all professionals always agreed upon this proposed division of roles. Given the fluid and permeable nature of CMF design, many found it challenging to identify with the different categories, mainly because they did not see them as separate/separable entities.
The interviews also revealed different ways of defining or labelling CMF design. CMF is also spelled CFM. Other terms in use include surface design and soft design. Despite this terminological diversity, almost all respondents agreed that the CMF aims to design the experience as intangible and linked to emotional identity. In this sense, both functional and emotional attributes contribute to identity, making CMF akin to *"dressing the object"* – understood as an artefact of different natures – by defining its skin and outermost layer. CMF design thus becomes a "bridge" between the designer's conceptualisations and the intended message for the user. The three components of colours, materials, and finishes are not separable; they have elements in common and influence each other. In this context, CMF design becomes an area of application that makes colour practical, moving towards a more concrete relationship with materiality. The product is seen metaphorically as "grey clay", with the CMF design completing the functional and aesthetic aspects. Professionals see aesthetics as the external appearance, the way an artefact presents itself. Consequently, since aesthetics is linked to external appearance and the latter is closely connected to identity, CMF design allows for identity design, and aesthetics are closely related.

The broader purpose of CMF design is to create a visual language that conveys messages. These messages can be of various kinds, from the more practical ones related to the function and affordance of a product (e.g., texture/grip) to brand communication. The latter, closely related to marketing, helps companies strengthen their brand identity and customer loyalty. It connects the user and the artefact, creating desirability and added value through experience and emotion. Importantly, the messages communicated are also linked to sustainability.

The interviews revealed several considerations regarding the relationship between CMF and sustainability. Initially, within the evolution of sustainability as a megatrend and design driver, there was a period in which CMF was exclusively a trend. Sustainability was not a prerequisite but rather an alternative proposition. Today, however, it has become fundamental and enters the process right from the brief. From the interviews, several visions have emerged that allow us to create a list of seven actions CMF design can take to assert its role in sustainable design:

1. CMF to communicate sustainability
2. CMF to cultivate a sustainable culture
3. CMF to ensure visual sustainability
4. CMF to last over time
5. CMF to build inclusive languages
6. CMF to create synaesthetic harmonies
7. CMF to reduce impact

CMF to communicate sustainability. CMF can lead to building the perception of the sustainability of artefacts differently, working on the more aesthetic aspects. The most intuitive approach is to use a transparent material language, thus making the eco-credentials behind an artefact visible. This is linked to specific material, colour, and finish characteristics with irregularities and visible inclusions, thereby promoting new aesthetics for products made from innovative materials. When employed effectively, this kind of language facilitates the identification of the components or the life cycle of the artefact itself as sustainable.

However, this is not always possible. Sometimes, characteristics are deliberately concealed due to aesthetic incompatibility or conceptual ideals. In such cases, the sustainability communication can be achieved using labels or certifications that elucidate the underlying choices.

A more critical issue concerns using “fakes” – such as fake wood or fake marble. Two distinct positions emerged. Some interviewees are against using these materials, as faithful imitation of colours and textures can mislead the end user. This happens not only when the product is discarded, but also from a more sensory point of view. Thus, there is no correspondence between the perception of the different senses: when touched, a table resembling wood reveals its true nature as plastic. On the other hand, supporters of fakes say that if you focus on perception, it doesn't matter if the material is wood or not, because you're working on emotion. Consequently, this could lead to environmental benefits, especially when considering using certain types of wood or stone.

Mediating between these visions is the prospect of developing new aesthetics, building on less impactful choices, even without an agreed-upon aesthetic. Thus, it is possible to work on abstract concepts to propose new possibilities that may connect with tradition while pointing toward the future.

CMF to cultivate a sustainable culture. Linked to the materials language, new materials have established dynamics whereby imperfection, irregularity, and inclusions are sustainability indicators. Although these aspects are becoming increasingly popular and evolving into new, more synaesthetic models, some people are not yet ready to accept imperfection.

Imperfection is not always stable due to irregularities, but it can also be linked to the evolution of the material over time. Therefore, it is essential to leverage that this is not a “malfunction” but a *plus* that creates uniqueness. It is thus a question of consciously informing the consumer so that transformation

also becomes added value, something unique. Accepting irregularities, pastel colours, etc., is also part of a cultural process of receiving this new aesthetics. Processes are needed to educate new consumers to make choices that go beyond the pursuit of perfection and to accept the language change that is taking place.

CMF to ensure visual sustainability. A deeper analysis of the purpose of CMF design reveals that it is not only about designing the artefact as a stand-alone entity, but also about its relationship with other objects, integrating seamlessly into different contexts. Therefore, designers start by considering the environment, which must be less chromatically polluted, so it does not overload the user's perception. Moreover, fitting artefacts into existing environments allows designers to work on the project's identity. The main objectives become adaptability and timelessness, allowing the product to function in many different contexts. So, the sustainability paradigm is changing. Previously, the search was for objects with an iconic character; now, adaptable artefacts are needed, with a lengthy visual life span equal to their physical one. Linked to this aspect is the request for timeless colour. It is necessary to focus on colour schemes consisting of a few colours that can be easily adapted.

CMF to last over time. From the previous action, the thought expands to become "durability over time". This gives rise to the theme of lasting identity from all points of view. It is not just a matter of responding to an ideal or integrating visually into the context; it becomes an increasingly objective and universal language. This is where the most functional part of CMF design comes in, balancing aesthetics to find its dimension. Selecting and defining colours, materials, and finishes that consider the product's life cycle leads to an evolution in interaction. Users may then accept gradual changes in appearance or interaction as natural. This objective is realised in the design of new materials, which must still be capable of guaranteeing the performance, aesthetic colour, and finish of traditional materials to be accepted. The theme of timelessness, emphasised by university professionals, is increasingly becoming a guiding trajectory, even among younger designers.

CMF to build inclusive languages. CMF is also responsible for fostering inclusivity, considering diverse sensory and perceptual needs. For designers, this means carefully evaluating their choices from a social point of view, opting for colours, materials, and processes that do not involve forms of exploitation and that promote accessibility. Inclusive language can translate, for example, into design solutions for children and older people or people with colour blindness, facilitating their interaction; or into systems that elevate CMF to a proper communication tool for blind people or those with severe medical conditions. Conversely, fake materials may mislead users who rely on touch, suggesting a surface is natural when it is not. More broadly, with a view to social sustainability and the involvement of all stakeholders, there is an opportunity to integrate inclusion as a guiding principle in co-design processes, especially in larger-scale projects.

CMF to create synaesthetic harmonies. CMF design can become a key tool for creating new synaesthetic harmonies with a view to sustainability. Working on innovative finishes allows us to modify the perception of colours and broaden the spectrum of interaction, giving rise to new visual effects, such as colours that change with light or appear different from different perspectives. Design synesthesia engages multiple senses simultaneously: textures that evoke sounds, surfaces that stimulate touch, and colours that generate emotions. Such strategies compensate for limitations of new sustainable materials, integrating them with solutions that arouse curiosity and offer familiarity, strengthening the link with already known sensory experiences. This aesthetic-sensory research not only innovates the product's visual and tactile language but also contributes to a more empathetic and lasting relationship between the user and the object, promoting more conscious and responsible consumption.

CMF to reduce impact. The concept of reduction in CMF design can be addressed on several levels. Starting with the most immediate aspect, it is possible to intervene in the quantity of material used, choosing lightweight solutions with a good balance between strength and weight, thus reducing the impact of transport. During production, waste can be minimised by adopting processing and finishing

technologies that optimise the use of resources. A further reduction can be achieved in the colour palette: more essential colour charts allow for less waste, avoid overproduction, and keep customisation as a targeted exception. From a more systemic perspective, finishes and textures can offer aesthetic variations without significantly impacting costs or the environment. On a larger scale, reduction can also be achieved by choosing materials with a low ecological footprint or sourced locally, thereby enhancing local resources. Finally, designing with flexible and upgradeable systems in mind allows for easy adaptation to new scenarios, textures, and targets, extending the product life cycle.

Tools and Approaches for Sustainable CMF Design.

CMF design can be guided sustainably using conceptual and practical approaches.

Starting with the conceptual tools, storytelling plays a key role. Storytelling makes the project's value easier to communicate by showing the sustainability principles that underpin it. As shown above, communicating a project's sustainability is a fundamental step. Reflection can focus on cultural and emotional elements linked to the analysis of perceived value. In this way, targeted storytelling opens a communication channel between companies, designers, and users.

Participatory and exploratory methodologies represent another potential source of inspiration. Among these, fictional design and future scenarios enable preparation for tomorrow’s contexts, anticipating sustainable and innovative solutions.

Turning to more practical tools, moodboards are indispensable in CMF design. A moodboard translates the designer's vision into something more tangible, with design directions that capture the sensibilities of both the end user and the company. The next step is the creation of maps that allow colours and materials to be designed and organised by hue, lightness, saturation, or according to geographical, sensory, and sustainability parameters. Diagrams and charts visualise the proportions and quantities of colours, materials, and finishes, while the material box or material-board offers concrete samples for tactile and aesthetic evaluation. Through the materials panel, designers can give concrete form to innovation, communicating and allowing people to experience new possibilities. This can lead to more inspirational proposals, such as those related to new materials and more technical ones related to specific processes, such as powder or water-based paints.

Finally, a tool currently viewed by professionals as somewhat controversial is the trend. Trends are defined as changes in society or specific groups, ranging from profound transformations to ephemeral phenomena. In sustainable design, trend research and forecasting help identify new aesthetics, innovative materials, and solutions that might not otherwise be considered, facilitating positive environmental impact and market adoption. However, the global trend system is often unbalanced: trends emerge in specific contexts (mainly Europe and the United States) and spread elsewhere, with little attention to local values. Furthermore, their original goal – to reconnect with people and intercept their needs and emotions – has been partly lost, replaced by marketing logic that pushes for rapid consumption. This leads people to follow trends for no real reason, intoxicated by their appeal, without fully understanding their real needs. Nevertheless, trends still hold potential. Used ethically and inclusively, they can foster the creation of lasting products. This could mean trends that do not create addiction but encourage dialogue and culture, visualising tools and opportunities for interaction that raise user awareness.

Despite the wide range of possibilities CMF design offers regarding sustainability, several difficulties remain that slow down its effectiveness. For designers, keeping up with sustainable criteria means constantly monitoring the entire production process. Still, there is a lack of standardised tools and shared control systems. The absence of a shared vision frequently results in the inability of companies to network. Better coordination would facilitate knowledge sharing and improve new materials' performance and aesthetic results, allowing for more informed choices. Other significant obstacles

are related to the risk of greenwashing and the high costs of new materials or technologies. In this context, the path towards truly sustainable CMF design requires innovation, collaboration, transparency, and economic strategies that ensure financial viability.

Conclusion

By gathering different approaches, this study reveals recurring themes, key tools, and mindset elements that characterise CMF design when it aims to contribute to sustainability.

The role of the CMF designer, given its multidisciplinary nature, is particularly relevant in transition contexts. However, designers must step outside their comfort zone (Manzini, 2009). They must learn to work under conditions of uncertainty, acquire new skills, explore different disciplinary languages, and engage in dialogue with experts from various fields (Micheli et al., 2017). This ability to cross boundaries and connect knowledge is essential to drive profound change. Designers are no longer simply creators of objects, but facilitators, connectors between disciplines, social actors, and interpreters of complex scenarios. CMF designers also fit into this context, not only by having a vision of the supply chain, but also by designing the various interactions from above. For this reason, design can only make a concrete contribution to the ecological transition if it can operate at multiple levels.

In addition to guiding aesthetic and functionality, CMF offers concrete possibilities for sustainable innovation: from the selection of low environmental impact materials to designing for durability and creating finishes and colours that reduce waste and promote reuse and disassembly.

The future trajectories for CMF design certainly open the possibility of exploring the ethical dimension in greater depth. In this sense, adopting synesthetic approaches and inclusive languages allows the development of products accessible to a broader audience, enhancing the sensory experience. Furthermore, integration of digital and physical strategies has the potential to yield additional scenarios, facilitating exploration of novel interactions between physical materials and digital experiences. This, in turn, optimises resources and expands the possibilities for customisation without generating waste. In this context, CMF becomes a strategic tool that guides informed choices and transforms design into a fundamental driver of change, where aesthetics, functionality, and ethics intertwine to build sustainable and innovative products and systems.

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