Generative AI in the Design Process

A JOURNEY THROUGH IMAGE GENERATION
FOR CONCEPT IDEATION

Agnese Azzola, Fabio Figoli, Lucia Rampino

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Introduction

This book intends to contribute to the discussion on generative AI in design, particularly for image generation and creative outputs. The aim is to offer insights into future developments by evaluating generative AI's current advantages and challenges in the product design process.

The book is based on the degree thesis of Agnese Azzola, discussed in April 2024 at Politecnico di Milano, Master of Science in Design & Engineering[1]. Lucia Rampino was the thesis supervisor.

Note 1.
Design & Engineering Master's degree program provides an integrated education in the disciplines of product design, mechanical engineering, and materials engineering, with the aim of training professionals who combine design and engineering competencies.

Generative AI has achieved remarkable levels of realism and interpretative capabilities, becoming more accessible to practitioners and enthusiasts by enabling natural language recognition and overcoming the need for programming skills or a deep comprehension of algorithms.

Creativity, which has been considered an exclusively human domain for a long time, is now being questioned at its very core: generative AI requires redefining the human role within creative processes. While these debates currently fire up the art world, we asked ourselves about the impact of this evolving panorama on the product design field. At the intersection of art and science, design presents its specificities, which cannot be assimilated into the ongoing art debate.

Agnese Azzola experimented firsthand with various generative AI tools, focusing on text-to-image tools, such as Midjourney. Her initial curiosity was directed toward how and to what extent these tools will shape design practice, considering the variated panorama of AI tools and the different needs for each phase of the design process. We decided to consider all this from an industrial design perspective[2], which presents its feasibility constraints as opposed to the abstract and imaginative tendency of generative AIs.

We assumed that tools like Midjourney — primarily developed for art creation — could play a relevant role in the early stages of the design process, enhancing concept inspiration by introducing serendipity and acting as a collaborative partner. This would impact the process before the development phase, requiring the designer to refine these initial inspirations for feasibility and coherence.

While confirming the vibrancy of the debate, a literature review on AI in the design process guided us towards a more defined understanding of the phenomenon and the shaping of our research direction.
The book is structured into four sections.

In the first one, we introduce readers to the fundamental concepts of image generation AI tools, with a particular focus on their primary interaction method: prompt engineering.

The second section discusses the outcomes of the comprehensive literature review and lays out the hypotheses that guided the investigative trajectory. Through a critical examination of scholarly works and a reflective assessment of methodological approaches, we defined a path for understanding the nuanced role of AI image generators within the realms of product design. Specifically, we decided to explore the potential alignment — or misalignment — between the artistic intent of these tools and the practical feasibility required in industrial design during the concept development phase. We also propose hypotheses on how AI can be leveraged to enhance the concept generation process.

In the third section, we share our firsthand experience using a selected AI tool (Midjourney) to generate three distinct product concepts. For each concept, we analyze the steps of the generation process and identify the gap between the AI-generated outputs and

Note 2.
We interpret industrial design as a discipline that emphasizes the coordination of product design and industrial engineering, with a focus on technical feasibility, manufacturing constraints, and engineering processes. This contrasts with broader definitions of product de- sign, which often encompass UX, service, and digital design. Throughout the book, each ref- erence to industrial design should be understood in this specific context.

a *manufacturable* product. This analysis enables us to evaluate our initial hypotheses, assess the tool's impact on the design process, and compare various pathways for product generation.

In the fourth and last section, we discuss the research outcomes, comparing the three products' processes. This enables us to trace process considerations that are scalable to other products, as well as guidelines on prompt engineering for industrial product design.

Given the continuous evolution of AI tools, it was necessary to anchor our study at a certain point in time — specifically, January 2024 — and proceed with the resources available at that moment, acknowledging the fluidity of the field.

In the near future, we expect AI tools tailored for design ideation to emerge soon or existing ones to evolve to meet the product designer's needs better.

PART 1

Analysing the State of the Art

1. Generative AI Models for Image Generation, an Overview

1.1 Introduction

When discussing Generative AI Models for image generation, we address a specific category of artificial intelligence algorithms and models designed and trained to create images or visual content based on textual, sketch, or other input forms. These models use complex mathematical and statistical techniques, frequently leveraging deep neural networks as a foundation. The primary objective of Generative AI Models for image generation is to produce visual content that is both visually coherent and semantically relevant to the input provided by users. The result is a new image that either did not exist before or is a transformed version of an existing image, offering significant potential in various fields, including design, art, and media.

Currently, an artist can input a textual prompt into a Discord chat using the Midjourney Bot and receive a visually striking representation of the described concept. Similarly, a designer can sketch a rudimentary product concept, and Vizcom will produce a detailed render following the provided style and guidelines.

As designers, the advent of generative AI for image generation invites us to take a fresh look at our creative processes and consider how our approach to work might evolve. The rise of AI-driven image generation is transforming how we conceptualize, develop, and ultimately bring our design ideas to life. Before exploring the transformative impact of these technologies on the design process, it is crucial to establish an understanding of what this technology involves.

Consequently, this chapter provides a comprehensive overview of the state of the art in generative AI image generation, exploring its underlying mechanisms, existing models, and the diverse range of tools that are reshaping the frontiers of design and visual creativity.

The foundational concepts of using computers to interpret and process visual data arose in the 1950s and 1960s when researchers began experimenting with enabling machines to replicate basic human visual skills, such as identifying shapes and patterns. AI's role in image creation was limited to basic pattern recognition and replication. The turning point came with the development of neural networks. In particular, Convolutional Neural Networks (CNNs), introduced in the late 1980s, revolutionized image processing with their ability to accurately recognize and classify images on a level that mimicked human visual perception. Their subsequent refinement in the 1990s and 2000s facilitated a more nuanced understanding and replication of visual data.

However, it was the advent of Generative Adversarial Networks (GANs) in 2014 that truly transformed AI's capabilities in image generation. Developed by Ian Goodfellow and collaborators, GANs introduced an innovative approach to image generation. These networks consist of two parts: a generator, which creates images, and a discriminator, which evaluates them. The interaction between these two components allows for the production of increasingly sophisticated images. The generator's goal is to create convincing images that are indistinguishable from real ones, while the discriminator continually refines its ability to differentiate between generated and authentic images. This led to significant progress in AI's ability to generate realistic, high-quality images.

Following the transformative development of GANs, generative AI for image generation entered a phase of rapid innovation and expansion. This progression laid the foundation for the emergence of sophisticated tools like DALL-E (in 2021) and Midjourney (in 2022), representing the culmination of years of advancements in AI technology.

One of the most significant milestones was the improvement of training datasets for these AI models. Larger and more diverse datasets enabled AI to process a wider range of styles, subjects, and compositions. This broadened the range of images AI could generate, from photorealistic landscapes to abstract art.

In parallel, there was an increasing focus on user interface and experience, making these tools accessible to a broader audience. The transition from purely research-focused platforms to user-friendly applications facilitated experimentation with AI-generated imagery by artists, designers, and enthusiasts.

In just a few years, the widespread adoption and transformative power of AI) is reshaping various industries, leading some scholars to describe this era as an 'AI revolution,' akin to the industrial and digital revolutions of the past. The potential societal impact is profound, marking a significant shift defining the pre- and post-AI landscape. However, revolutions typically unfold over long periods, so while AI is already deeply embedded in daily life, its full societal effects may not become clear for decades (Makridakis, 2017). This transitional period brings with it a degree of uncertainty about AI's future implications. In the design field, new challenges are emerging, including the practice of crafting effective prompts for AI systems. This topic will be explored in detail in the following chapters of this book.

Currently, there is not a one-size-fits-all AI design tool. Therefore, this book explores a mix of tools and methods to optimize the existing toolkit for the design process, particularly during the concept generation phase, and defines guidelines for developing future tools.

1.2 Image Generation and Manipulation Models

Generative AI in image generation presents a fascinating spectrum of models and technologies, each offering unique interaction methods and creative possibilities. The most prevalent interaction modes are text-to-image generation, image-to-image transformation, drawing-to-image rendering, style transfer, inpainting (editing parts of an image), and outpainting (extending beyond the original image borders). Each method offers distinct approaches to engage with and generate visual content, addressing a wide range of creative needs.

We will examine these methods, exploring their underlying technologies, real-world applications, their impact on creativity, and the innovative tools that make them accessible to a wide range of users.

Over the past year, new tools have emerged in AI-driven image generation, and undoubtedly, many more are on the horizon. This book focuses predominantly on two cutting-edge methodologies: text-to-image generation and sketch-to-image rendering. The former category, featuring powerful tools such as DALL-E and Midjourney, stands out for its capacity to boost creative possibilities, adding serendipity and unpredictability in the concept generation phase. On the other hand, sketch-to-image technologies, exemplified by platforms like Vizcom (offering targeted solutions for designers), show effectiveness in refining and enhancing existing designs. Together, these technologies underscore a dynamic shift in how visual content can be generated and refined.

To complete our exploration, we will also investigate methods for manipulating images, using some famous tools as examples and references.

1.2.1 Text-to-Image Models

Models like OpenAI's DALL-E and Midjourney are pioneers of text-to-image conversion, challenging the traditional boundaries between the written word and visual art and making the creation of complex imagery accessible to individuals without formal artistic training.

These models can handle complex, abstract, or even surreal textual descriptions that users input in a box, translating them into vivid, often coherent visual representations (Figure 1, p. 21). They use diffusion techniques, where noise is gradually introduced into an image during training. The model then learns to reverse this process, refining the image step by step to match the prompt. This method is more effective in creating detailed and coherent images from text descriptions compared to earlier GAN-based approaches. While the exact workings of Midjourney's system remain undisclosed, it is widely believed that it also follows a diffusion-based method similar to other state-of-the-art text-to-image tools. These models are trained on extensive datasets that pair images with corresponding text, enabling them to grasp subtle connections between words and visual elements.

DALL-E, developed by OpenAI, shows an impressive ability to create diverse and complex images from simple text descriptions. It can generate anything from realistic photographs to surreal scenes based on the user's textual input. This model excels in combining different concepts in a single image, making it a powerful tool for creative exploration. It is renowned for delivering outstanding results following prompt instructions, especially in terms of composition and visual coherence.

Midjourney adopts a slightly different approach, standing out for its sophisticated interpretation of textual prompts. It is known for generating images that not just represent the text but also carry a unique artistic essence, often resulting in thought-provoking imagery. This model's strength lies in its ability to capture the mood and essence of the input text, translating it into a visual medium. This can be beneficial during the exploratory design phase, adding an element of serendipity into the concept research stage. The reason for this lies in the immediacy of the interaction: requiring only text as input, they allow quick visualization of ideas that are at a very initial stage, even before any sketches are drawn.

Both DALL-E and Midjourney have seen substantial evolution since their early versions. They are regularly updated to enhance their backend systems through improved datasets and algorithms, as well as their frontend interfaces to provide a better overall user experience. Notably, developers are focusing on enhancing the models' ability to align with user preferences, such as through adjustable parameter settings. This means that the models are becoming increasingly versatile and capable of meeting user needs across a broader range of possibilities.

1.2.2 Image-to-Image Models

Tools like NVIDIA's GauGAN, DeepArt, and most recently, Krea.AI and Vizcom represent a different approach. These models offer a form of interaction where the input is an existing image or a simple sketch, and they use advanced CNNs to transform it into a detailed visual output. Image-to-Image techniques are especially effective when users already have a clear reference to start from, as this direct input enables the model to produce more accurate and detailed results. By starting with a defined image or sketch, the model can better understand the context and specifics of the desired output, leading to enhanced fidelity.

Subcategories of this image generation method are *Drawing-to-Image* and *Style transfer* methods. GauGAN, for instance, can take a simple sketch and transform it into a photorealistic landscape, analyzing the sketch's components (like trees or water) and rendering them life-like. DeepArt, on the other hand, applies artistic styles to an input image, enabling users to reimagine their photos in the styles of famous paintings.

Drawing-to-Image Models

As a subcategory of Image-to-Image, this mode of interaction with AI holds excellent value for design professionals. It can elevate a basic concept sketch into a refined and visually appealing representation, relying on neural networks (Figure 2). In March 2023, the latest version of Vizcom was launched, featuring unprecedented performance. It is a design-specific tool that transforms rough sketches into photorealistic renderings within seconds. Vizcom facilitates group collaboration and inpainting and provides style variations in addition to traditional text prompts. It represents a pioneering effort in developing an AI tool tailored to the design field.

Style Transfer

This intriguing technique allows users to apply artistic styles to their images or photographs, often with the option of replicating the style of a specific artist or genre (Figure 3). Midjourney or DALL-E permits the indication of the desired style in the prompt. Tools like Krea.Ai offer a specific *Stylize* feature that can be applied after image generation, allowing users to modify the image style through an image-to-image approach. However, this style-transfer feature, present in many image generator tools, raises significant ethical and privacy rights considerations.

Figure 1.
Example of Text-to-Image Generation in Midjourney. Above it is displayed the textual prompt followed by the results generated by Midjourney.

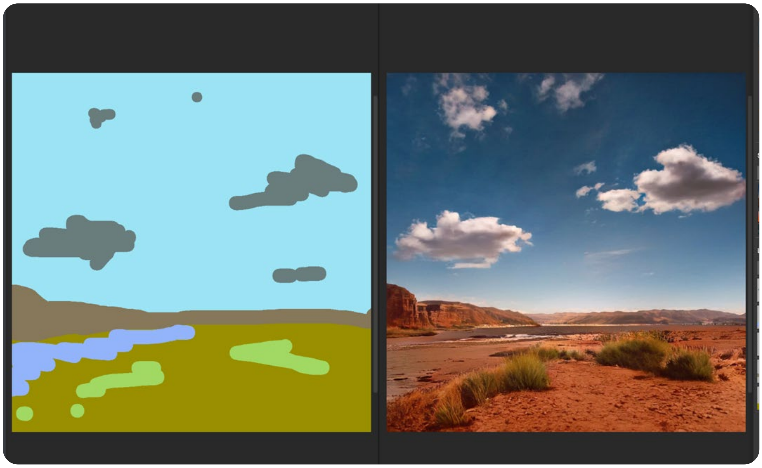


Figure 2.
GauGAN2 canvas: a basic sketch being turned into a realistic landscape picture.

Figure 3.
Image-to-Image style transfer in DeepArt, where the style of *The Scream* by Munch is applied to a cat picture, with the reported result.

1.2.3 Manipulating Results

Neuroscience suggests that how one individual perceives an object In AI image generation, a key aspect beyond initial creation is the ability to manipulate existing images or the outputs from previous AI generations. Companies are progressively trying to integrate these features into their platforms to enhance user creativity and workflow efficiency. This adaptability in altering and enhancing images enables vast possibilities for creative exploration and practical application, making it a turning point in the evolution of AI-assisted design.

Since the generated images often meet expectations only partially, designers and artists frequently wish to change specific elements; however, this is often partially feasible with current tools, necessitating the generation of a new image, which can significantly differ from the original. This challenge highlights the ongoing need for tools that offer greater control and precision in image manipulation.

Inpainting and Outpainting

These techniques focus on editing portions and expanding existing images. Inpainting involves selectively editing or filling in missing or damaged parts of an image seamlessly (Figure 4). This technique is beneficial for image restoration and manipulation, allowing users to modify details, substitute one element with another, or altogether remove unwanted aspects. On the other hand, Ooutpainting extends beyond the boundaries of an original image, creating additional content that seamlessly blends with the existing composition. A tool that has been updated with these features is Adobe Photoshop, which boosts the speed of editing images. Similarly, Midjourney introduced an upscale feature that allows for the extension and enhancement of images, further broadening the scope of creative expression.

Variations

Typically, generative AI image generators provide multiple outcomes for a single prompt, allowing users to select from multiple options. For instance, Midjourney generates four images per prompt. Users can create variations for each image and specify the variation intensity, ranging from robust to subtle variations (Figure 5). This flexibility is crucial when a user finds an image that aligns closely with their vision but requires minor adjustments to achieve perfection. Users can explore similar yet distinct visuals by iterating on a preferred image, each offering a different perspective or emphasis.

These modifications are highly beneficial in design, particularly during the brainstorming phase, as they allow for rapidly generating various concept variations. This iterative process encourages exploration and refinement, allowing designers to swiftly pivot and evolve their ideas based on visual feedback. Moreover, this flexibility enriches the design process by integrating an element of dynamic interaction with AI, fostering a collaborative partnership where humans and machines engage in an iterative exchange of input and output. The ability to fine-tune or alter AI-generated images streamlines the creative process, offering a dynamic and interactive approach to concept development.

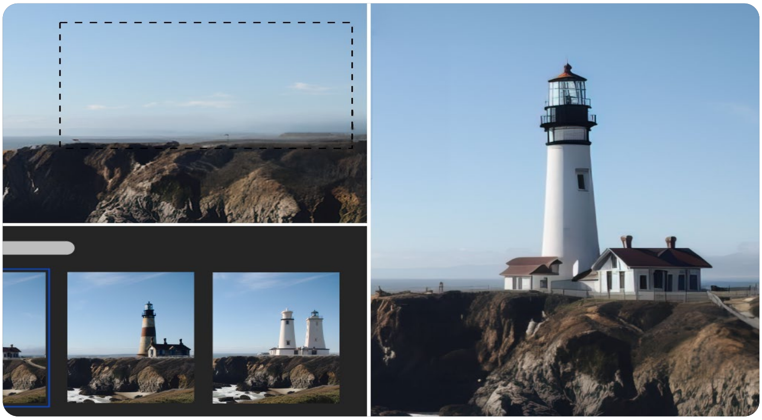


Figure 4. Example of *Generative filling* in Photoshop, where a portion of the picture is filled with a lighthouse given three different options.

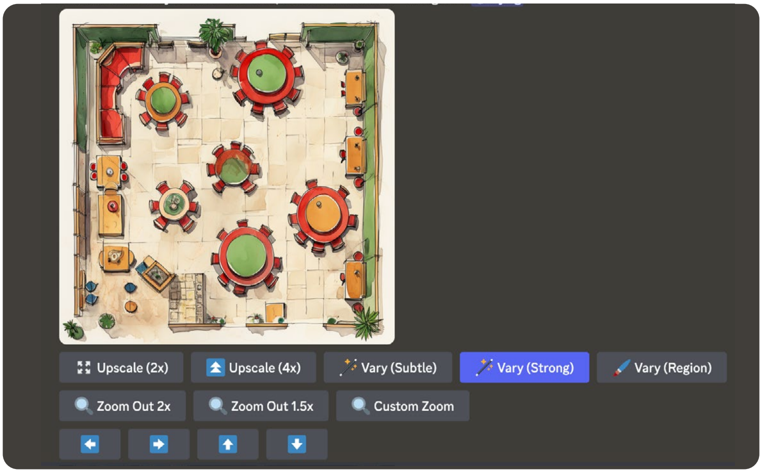


Figure 5. Midjourney Bot's interface for results' variations, showing the modification options for a selected image.

1.3 Text-to-Image as the Core of AI Image Generation

In AI-driven image generation, a common feature defines the latest generation of tools: the inclusion of text prompts. Whether these tools employ image-to-image transformations or include additional features like upscaling and inpainting, they always integrate a text input that allows users to describe their desired outcomes.

The adoption of text input represents a prominent trend in generative AI, as evidenced by the widespread use of chatbots like GPT (text-to-text). The popularity of this trend can be attributed to its inclusive nature, offering accessibility to individuals regardless of their painting skills or proficiency with digital tools. It empowers users to generate images by expressing their creative vision through textual descriptions, expanding the horizons of image generation possibilities.

The democratization of the creative process favors non-experts but comes at a cost for experts. As AI can potentially automate parts of the design workflow, speeding up traditionally tedious stages, the perceived value of the experts' skills and work may diminish. This concern is not new; similar fears arose with past technological innovations, such as the advent of CAD. As the design field adapts to these changes, it is clear that AI could be a major disruptor, underscoring the need for a thorough discussion about its implications. However, instead of delving into discussions about the potential substitution of creative jobs due to this technology, our focus lies in the operational challenges encountered by visual creatives accustomed to translating their ideas into visual representations.

The shift toward using text as an intermediate step can initially appear counterintuitive, demanding an adjustment in their creative process. For individuals well-versed in visual thinking and rapid idea execution, this transition introduces an extra layer of complexity. It requires navigating between two distinct cognitive domains: the visual-spatial and the linguistic. Visual creatives, who are accustomed to the immediacy of visual expression, must engage in a mental process of translating their visual ideas into written words. This involves breaking down intricate visual details, compositions, and emotions into coherent textual descriptions.

Balancing the convenience of text-based input with the creative immediacy of visual expression remains an ongoing consideration in integrating AI tools into the creative workflow.

The practice of crafting the textual prompt also goes under the name of prompt engineering. Prompt engineering involves the construction of text prompts to elicit specific responses from AI models. It plays a crucial role in AI-driven image generation, allowing users to refine and optimize their interactions with these powerful tools. By mastering the art of prompt engineering, creatives can expand the boundaries of what is achievable with AI-generated visual content. We will explore this topic in chapter 2.

1.4 Digital Tools or Co-Designers?

There is a substantial difference between all the cited AI tools and other digital tools for design, like Adobe Creative Suite or CAD, which both shaped our profession and changed how we design. Unlike these tools, AI-driven platforms introduce an element of serendipity. This is not just a challenge; it is a feature that transforms the design process into a dynamic dialogue between the designer and the machine. Designers learn to communicate with AI, but the responses they receive are always unpredictable. This resembles much the process of co-designing, of having a collaborator more than a tool. As Norman said in an interview for the Interaction Design Foundation:

> **It's a collaboration because we think of the idea and then we have to judge what it produces to say whether that's at all what we thought of. And sometimes and this is a great thing about collaboration, sometimes it will produce something that's so weird and strange, and we sit and look at it and say, oh wow, I would never have thought of that. (Norman, 2023)**

This aspect of AI fundamentally changes the role of digital tools in the design process. No longer are they just instruments or extensions of our manual skills; they are now active participants in the creative process, offering unexpected directions and possibilities that can enhance the design journey. This shift is encapsulated by the concept of *Mixed-Initiative Co-creativity*, which describes the collaboration between human and non-human agents as both showing initiative and proactivity (Yannakakis *et al.*, 2014).

When we input a detailed description into the prompt, it is with a clear vision in mind. However, AI might not precisely replicate that vision, which can be empowering and restrictive at the same time. The art of prompt engineering has evolved to guide AI creations as closely as possible, yet it cannot fully tame the inherent unpredictability of AI. Viewing this unpredictability solely as a limitation overlooks its potential. This uncontrollability mirrors collaborating with another human creative, whose imagination is equally beyond our control.

In this transformative landscape, generative AI catalyzes creativity, enhancing the designer's intuition and expertise with fresh perspectives and ideas. It does not replace human creativity but amplifies and augments it. The interaction between designer and AI becomes dynamic, with each contributing their unique strengths (Wilson & Daugherty, 2018). Designers bring their deep understanding of aesthetics, cultural nuances, and emotional and conceptual depth; AI adds computational expertise, the ability to process vast datasets, and a propensity for exploring uncharted territories.

As we navigate this transformative landscape, we must acknowledge the potential and responsibility of this new creative power. Ethical considerations surrounding AI-driven design take center stage. Questions about authorship, intellectual property, and the impact of AI on the creative industry require thoughtful exploration. Nevertheless, AI has the potential to become an indispensable co-designer, reshaping how we think, create, and innovate in the design world.

This overview of generative AI for image generation sets the foundation for understanding its role in the creative process. In the following chapters, we will delve deeper into the practical applications of these technologies in design and development. Exploring these AI tools will shed light on their potential to facilitate and inspire new forms of creativity. The capabilities of tools like Midjourney and DALL-E, complemented by additional functionalities like inpainting and images blending, open new horizons for designers and creatives. They streamline the creative process and push the boundaries of what can be imagined and created, introducing a new era of digital art and design innovation.

2. The Practice of Prompt Engineering

2.1 Introduction

As said, generative AI relies on text-based interaction, and the effective use of text-to-image tools requires mastery of prompt engineering. Understanding which aspects of this practice are helpful and which are problematic in defining future tools' development is essential.

An extensive literature review was conducted, focusing on publications related to generative AI tools, their use in the design process and in related fields, including the specifics of prompt engineering. The following paragraphs encapsulate the findings from this review. They encompass a range of topics, from defining prompt engineering to offering guidelines for effective prompting practices. Additionally, they address the current challenges in this field, explore principal research directions, and discuss how prompt engineering is reshaping our understanding of creativity in the digital era.

Prompt Engineering can be defined as «the formal search for prompts that retrieve desired outcome from the Language Model (Liu, 2023) or the iterative practice of applying prompt modifiers to input prompts» (Oppenlaender, 2022). These two definitions accurately represent the practice's formal and iterative nature. It is formal because it focuses on shaping the most efficient sentence and iterative because, as we will see, it requires going through the same prompts until the desired outcome is achieved.

This practice is not merely about formulating sentences but requires a deep understanding of the AI model's capabilities. It is akin to speaking a specific language: a language that the AI understands and can unlock its creative potential.

A fundamental aspect of prompt engineering is precision. The selection of words, context, and structure of the prompt must align precisely with the user's vision. Achieving this precision involves an iterative process, where designers refine their prompts based on the AI's responses, gradually approaching the desired outcome.

However, prompt engineering goes beyond mere technicality. It introduces an element into the process itself. Designers and creators must envision how their textual descriptions translate into visual or textual creations. This creative insight is a unique element of the practice, as it simultaneously requires thinking from both the human and AI perspectives.

2.2 Prompting Guidelines

The algorithms are trained to produce an image with a specified style and subject, and they cross-reference every word used with the corresponding images present in their dataset. Therefore, the choice of words and the structure of the prompt influences how the AI interprets and generates images. Some words or phrases may carry more significance or relevance in determining the final image output, and the AI model may assign different weights to them based on the prompt's formulation.

Many prompting guidelines have been created by practitioners and enthusiasts who, via a vibrant online community, have developed a shared understanding of the most effective techniques for each AI model. These guidelines were later categorized and analyzed by researchers.

Hereafter, we synthesize the main prompting guidelines encountered in our literature review.

2.2.1 [Subject] in the style of [Style] Prompts

Practitioners have found that initiating prompts specifying the subject and style and incorporating additional compositional and stylistic elements enhances the AI's performance. This might be because the structure aligns well with the AI models' training methods on vast datasets featuring millions of images paired with textual descriptions. The models learn to associate specific visual styles, techniques, and subjects with their corresponding textual descriptors. A structured prompt, such as *subject in the style of*, aligns well with how the AI has been trained to understand and correlate images with text.

Furthermore, the AI model processes a prompt by breaking it into components it can understand and process. In the *subject in the style of* format, the model can quickly decompose the prompt into two main parts: the subject (what to depict) and the style (how to depict it). This decomposition helps the AI focus on accurately rendering the subject while applying the specified style. In summary, a structured prompt helps the AI to navigate the complexities of the generation by clearly outlining the elements that need to be combined.

Researchers (Liu & Chilton, 2022) have found that as long as the subject and style are specified, the connecting words (i.e., function words, punctuation, and words for ordering) do not contribute meaningful differences in generation quality. If, for example, we want to produce an image of a cat in the Japanese Ukiyo-e style, prompting *cat ukiyo-e* (SUBJECT STYLE), *cat in the style of ukiyo-e* (SUBJECT in the style of STYLE), or *cat with ukiyo-e art style* (SUBJECT with a STYLE style), would not produce significantly different results (Figure 1, p. 35).

This suggests that users should prioritize specifying the key attributes rather than the construction of the sentence. However, this principle is not applicable in all cases of prompting. As discussed in the following sections, the prompt's syntax could become more pertinent for more complex tasks that demand extensive specifications and attributes.

The algorithm's need for a defined subject and style arises from the primarily artistic objectives of these tools. In product design, the results we might want to produce would have distinct output requirements: aspects like artistic medium or style would be indifferent as the focus is usually on creating a render or a 3D model, and the style should be applied to the product itself and not the image. These specific considerations and their relevance in product design will be thoroughly examined in the third part of this book.

2.2.2 Modifiers

Modifiers are a category of words or codes that act on the style of the image. The attribute STYLE cited before is already a modifier, but usually, more modifiers are used to obtain desired outcomes. We can specify a particular artist from a specified art period or mix a photographic technique with a brand style (Figure 2, p. 33).

To further personalize the output, creators can also manipulate light and shadow through modifiers, adding depth and mood to the visual narrative. The most common categories of style modifiers include Art Styles (such as *Art Nouveau*, *Manga*, and *Minimalism*), Historical Periods (like *Victorian Age* or *Contemporary*), Photography Techniques (including *Long-exposure photography* and *Panoramic Photography*), and Miscellaneous Styles (such as *Synthwave*, *Low Poly*, *Pixel Art*, or *Vector Illustration*). Additionally, specific Artists (like *Hayao Miyazaki* or *Francisco Goya*) and Designers/Brands/Architects (such as *Dieter Rams* or *Yves Saint Laurent*) can also serve as style modifiers, each bringing their aesthetic influence on the visual output.

Another category of modifiers, identified as *magic terms* by Oppenlaender (2023), introduces elements of unpredictability and surprise, of ten aimed at increasing variation in the output. Magic terms might encompass concepts that are semantically distant from the main subject of the prompt or refer to non-visual qualities, such as sensory perceptions, including touch, hearing, smell, and taste. An example cited by Oppenlaender involves a Twitter user, *@jd_pressman*, who incorporated the magic term *control the soul* into the prompt *orchestra conductor leading a chorus of sound wave audio waveforms swirling around him on the orchestral stage*. This addition was intended to evoke *more magic, more wizard-like imagery* in the resulting image (Figure 3,p. 34). This invites an imaginative use of language, underscoring Midjourney's sensitivity to even the subtlest nuances and encouraging a deeper exploration of the creative potential of words.

2.2.3 Repetition and Solidifiers Hierarchical Prompting (Placement and Weights)

Using different phrasing and synonyms will cause the text-to-image system to activate regions more reliably in the neural network's latent space associated with the subject terms (Oppenlaender, 2023). For this reason, a prompt like *warrior cat. a cat that is a warrior* will likely produce better results than using each term independently (Figure 4, p. 34). This is because repetition and clarification help the AI to focus on the desired concept, reducing ambiguity and enhancing the specificity of the generated image. In the same research, Oppenlaender also affirms that the prompt *a very very very very very beautiful landscape* will, for instance, likely produce a better image than a prompt without repeating terms. This technique of repetition emphasizes the importance of specific attributes to guide the AI effectively.
Quality boosters can be added to a prompt to increase aesthetic qualities and image detail. Examples of this modifier are terms like *trending on artstation*, *award-winning*, *masterpiece*, *highly detailed*, *awesome*, *#wow*, *epic*, *8k*. These modifiers act as keywords that trigger the AI's recognition of high-quality benchmarks, aligning the output more closely with professional standards in various art communities. They bridge the creator's vision and the AI's execution, ensuring the nuances of what is considered *high-quality* or *trending* are accurately interpreted and rendered. By using terms associated with training data with specific outcomes, creators can subtly steer the generative process toward producing visually enhanced works. By leveraging the AI's training on diverse datasets, these boosters help fine-tune prompts and produce visually enhanced works.

2.2.4 Hierarchical Prompting (Placement and Weights)

Many AI tools give more emphasis to the initial part of a long prompt, so strategically organizing sentences by their importance can be effective. Additionally, several tools offer the option to assign weights to specific prompt sections. This weighting system is akin to adjusting the focus lens on a camera, where certain scene elements are brought into sharper relief based on the user's input. For instance, Midjourney's syntax allows users to use *::* followed by a number to indicate weights. This nuanced control mechanism allows for a customized emphasis, enabling users to sculpt the AI's attention toward specific themes or elements within a prompt. By default, all words carry a weight of 1. Adding a number, like *::2* or *::10*, increases emphasis on the section preceding the *::*. It is also possible to use negative weights, such as *::-1*, to de-emphasize or indicate elements the AI should avoid. *–no* can be used as a substitution for negative values (Figure 5, p. 35). This level of specificity in command syntax enriches the interaction, turning prompt engineering into a more deliberate process.

2.2.5 Midjourney's Controls

Knowing the specific syntax of a tool can significantly enhance clarity. For Midjourney, two key parameters to note are chaos and stylize.

The *–chaos* or *–c* parameter influences how varied the initial image grids are. Adjusting the *–chaos* parameter allows users to experiment with the balance between coherence and novelty, offering a tailored approach to creativity. High *-chaos* values will produce more unusual results and compositions. Lower *–chaos* values have more reliable, repeatable results (Figure 6, p. 35). It goes from 0 to 100, and it is written, for example, *–chaos 60*.

The Midjourney Bot has been trained to produce images that favor artistic color, composition, and forms. The *–stylize* or *–s* parameter influences how strongly this training is applied, modifying how the final output adheres to or diverges from conventional artistic expressions. Low stylization values produce images that closely match the prompt but match less Midjourney's artistic training style. High stylization values create images that are very artistic but less connected to the prompt (Figure 7, p. 36). *--stylize* default value is 100 and accepts integer values 0–1000.

Lastly, one parameter is handy for the design use of Midjourney: the *–style raw* parameter. It uses an alternative model that gives more control over the images. This option is akin to selecting a 'manual mode' in digital art creation, giving the artist more control over the AI's interpretation and execution. Images made with *–style raw* have less

Figure 1.
The outcomes of two prompts in Midjourney, first using the SUBJECT STYLE structure (*cat ukiyo-e*) and then the SUBJECT with a STYLE format (*cat in the style of ukiyo-e*), show comparable results.

Figure 2.
Other results from two different prompts, first using the secondary style modifier *hyperrealistic* (*cat ukiyo-e with hyperrealistic style)* and then *manga (cat ukiyo-e with manga style*), show overall differences in style.

Figure 3.
An attempt to add the magic word '*control the soul*' into the previous *cat ukiyo-e* prompt shows a variation in the overall mood of the resuts. The images are more dramatic, showing more movement in the composition and a mystic atmosphere, coherently with the example reported by Oppenlaender. The two results have been realised with different stylisation values, but both reflect to a certain extent how Midjourney is sensitive to the tone of the prompt and to nuances of words.

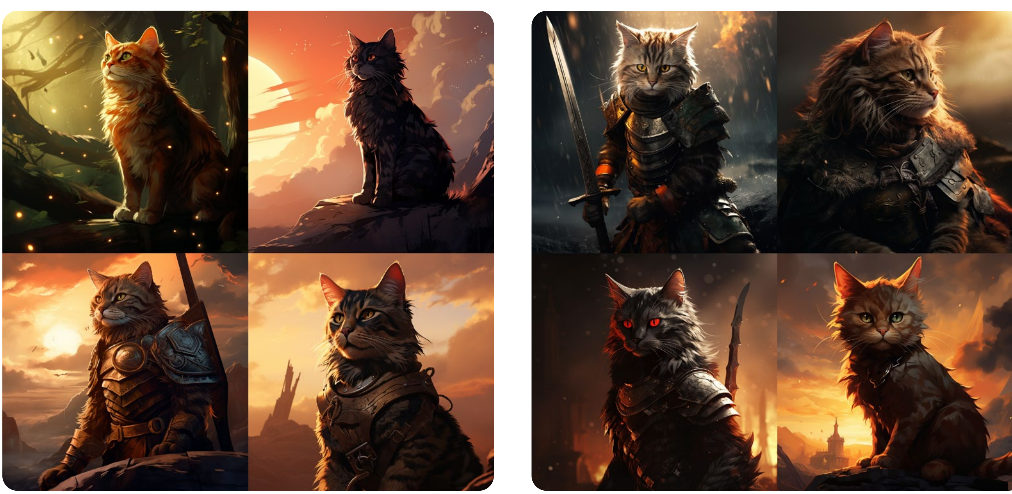


Figure 4.
In the comparison, two image sets are generated: the first from the prompt *warrior cat* and the second from *warrior cat. A cat that is a warrior.* It's observable that in the first set, two images lack clear references to the cat being a warrior. In contrast,the second set consistently aligns all images with the intended theme, demonstrating a more accurate reflection of the prompt's message.

Figure 5.
Results of *cat ukiyo-e, flowers::2* prompt on the left: following the order of input the subject *cat ukiyo-e* still maintains significance in the image, but given the *::2* weight on the second term flowers, flowers results in a notable increase in their presence, making a dominant element one that otherwise might be secondary. On the right, the outcomes of *cat ukiyo-e, --no flowers* clearly demonstrate how flowers are eliminated from the scenes.

Figure 6.
The first batch of images was generated using the prompt *cat ukiyo-e --c 10*, while the second set originated from *cat ukiyo-e --c 70*. Notably, as the chaos value increases, the algorithm progressively diverges from the specified user descriptions, introducing a greater element of unpredictability or *chaos* into the results.

Figure 7.
In the first group of images, the results were generated using *cat ukiyo-e –stylize 50*, In the second set, the prompt *cat ukiyo-e –stylize 750* was used. Prompting any other subject with a stylize value of 750 would produce aesthetically similar results, since they all would reflect Midjourney's style.

Figure 8.
Results of the prompt *kettle design*, first with standard style, and then with the - *style raw* with parameter.

automatic beautification applied, which can result in a more accurate match when prompting for specific styles (Figure 8, p. 36). It is similar to applying a low–stylized value but can be set initially, avoiding constantparameter adjustments.

2.2 Current Challenges

Researchers pointed out several problems in the current practice of structuring prompts in text-to-image generation. In particular, structured prompts are still a trial-and-error process (Liu, 2023). Prompt engineering is indeed an iterative practice where the practitioner does not know at first which prompt structure will be effective. They must experiment with various word combinations until the desired result is achieved. This process can be time-consuming and sometimes leads to frustration.

There is no universal standard or formula for prompt engineering. What works for one model, or one type of task might not work for another. This means practitioners often have to start from scratch with each new model or task type. Furthermore, AI models can produce different outputs when prompted, even with the same input. This variability necessitates a trial-and-error approach to understand the range of possible responses, refine prompts, and find the desired type of answer.

> **The sense of indirectness [...] over the results, together with the lack of control of them in order to replicate what they had in mind is rooted into the blackbox nature of Artificial Intelligence models. Generative AI tools will have to find ways to properly open up their inner models and allow users to properly direct them if they want to succeed in becoming the next companion of digital creators. (Turchi *et al.*, 2023, p. 48)**

The indirect nature of interaction with these AI tools can leave users feeling disconnected from the creative process. They input prompts and receive results, but the lack of transparent controls makes it difficult to understand why specific outputs are generated and how to alter them effectively.

Moreover, creatives encounter the need to translate visual concepts into a structured sentence (Liu, 2023), changing semantic space. This transition from a visual to a linguistic medium poses significant challenges. Visual thinkers who rely on non-verbal cues to conceptualize ideas must adapt to a predominantly verbal and textual interface. This shift alters their creative process and may hinder the full expression of their artistic vision. Also, language's inherent ambiguity and subjective nature can lead to unpredictable and often unsatisfactory outcomes.

Bridging this gap asks for the development of more intuitive interfaces that can better accommodate the natural inclinations of visual artists, enabling a more seamless translation of their visual thoughts into the digital creations they envision.

2.3 Research Directions

Generative AI relies on text-based interaction, but the future is not limited to prompt engineering (Lin, 2023). Currently, the most advanced tools in image quality and extensive training datasets are Midjourney and Dall-E. However, these platforms mainly utilize prompt engineering to steer the creative process. While their primary focus is on producing artistic images, which is beneficial for graphic design and illustration, their applicability in product design is limited, as they are not explicitly trained for this purpose.

Numerous researchers have emphasized the potential of multimodal interactions (image-to-image, sketching, directly manipulating results) as the key to making the technology more accessible and adaptable, particularly in design practices.

The findings from Liu (2023) underscore the importance of multimodal interactions — combining text with visual elements like images and sketches — in making generative AI more approachable and functional for design practices. This approach enables a more nuanced and direct translation of a designer's vision into AI-generated outputs, facilitating a co-creative process that is both intuitive and efficient. Moreover, Liu's work suggests that future tools should enhance these multimodal capabilities, offering guidelines that advocate for deeper integration of visual and textual prompts. Such advancements promise to unlock new possibilities in product design and beyond, ensuring that AI can better serve the diverse needs of the design community.

Emerging tools like Vizcom and Krea.AI are moving in this direction. They offer varied ways to modify generated outcomes and feature user-friendly interfaces (Figures 9-10-11, pp. 40-41).

Vizcom allows designers to input a sketch of their concept with a descriptive text prompt and generates a render following the combination of those inputs. Its intuitive menu offers precise parameter adjustments, allowing users to define render style, reference images, and weight given to both the sketch and the reference images. It is possible to choose between render mode and refine mode, where users can sketch the resulting render. It also allows designers to work with layers, similar to software like Photoshop or Procreate, to modify the images agilely. With such an interface, prompt engineering becomes significantly more intuitive. Also, the possibility of rendering from a sketch and adding a reference image offers significant control over the results.

Similarly, Krea.AI turns basic drawings into impressively detailed artworks. While Vizcom requires a detailed sketch, Krea can generate images from simple geometric shapes and a text prompt. It features visually enhanced parameter adjustments, with a clear explanation of the meaning of each parameter, a smooth and efficient user experience. The parameters perform similar functions to what in Midjourney would require familiarity with codes like *–chaos*, *–stylize* and *::-1*. In Krea, the user can move the slider or check some settings.

The primary distinction between the two multimodal tools lies in Vizcom being tailored explicitly for design, while Krea focuses on artistic generation. Their interfaces reflect what researchers have been advocating for in human-AI interaction.

Dang *et al.* (2023) introduce the concept of hierarchical prompting, which involves using layered prompts — allowing users to create a hierarchy in the sentence — and spatial prompting — allowing users to arrange prompts in the image spatially. They created *WorldSmith* «a multimodal tool that enables users to iteratively design and refine complex fictional worlds using layered editing and hierarchical compositions with a prompt- based model that uses text, sketches,

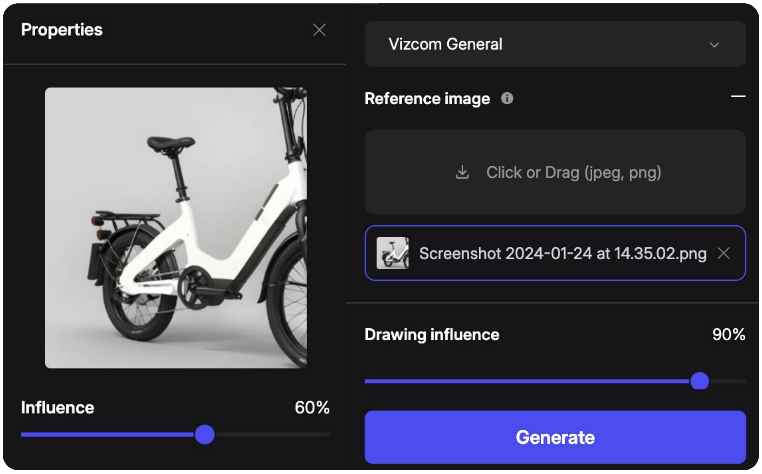


Figure 9.
Details of Vizcom interface, displaying the influence parameters. On the contrary of Midjourney, where the interaction is all based on text, here we observe a more agile interface.

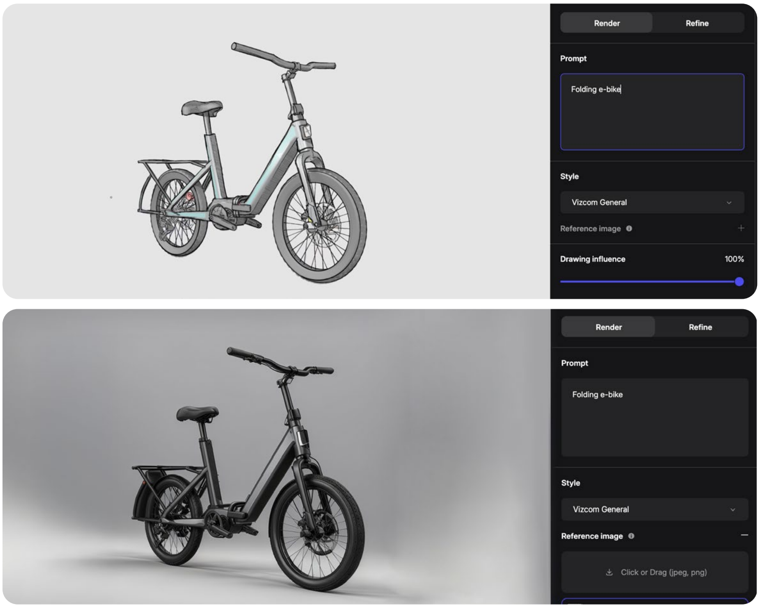


Figure 10.
Vizcom interface, displaying an input sketch and the following generated render.

Figure 11.
Krea.AI interface By writing the prompt *A blue frog and a pink flower* and positioning two geometric shapes of the mentioned colors, Krea renders a realistic image following the basic elements placement.

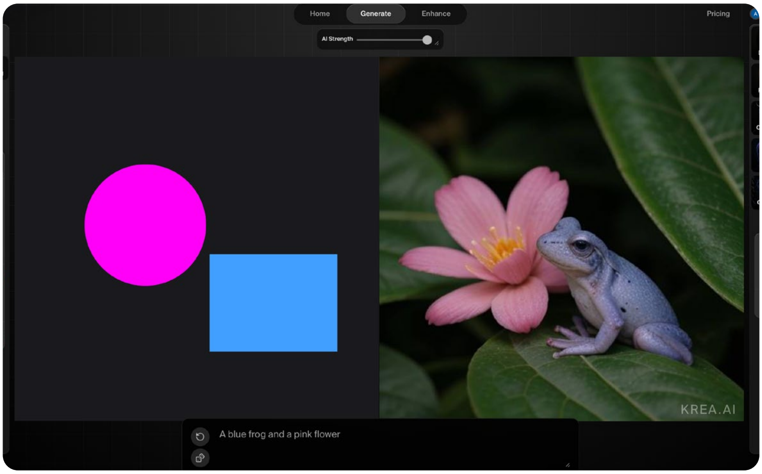


Figure 12.
Figure from WorldSmith depicts the Global Tile View, where tiles with segments of the scene have previously been created. The tool panel on the left-hand side facilitates the control over space between individual tiles and allows for a description of how the tiles should be blended.

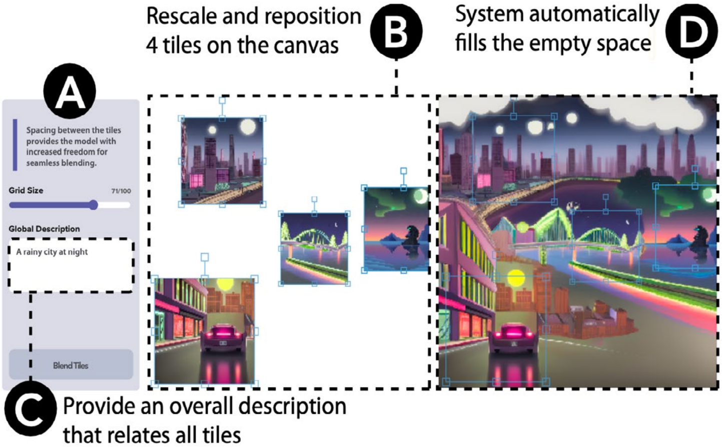
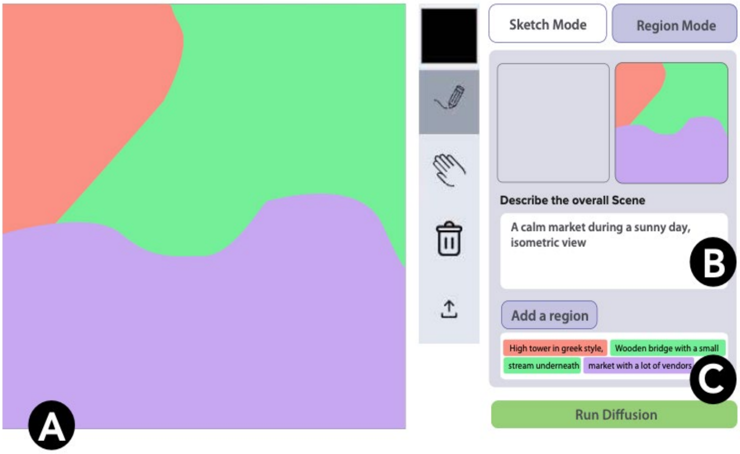


Figure 13.
An example of a region segmentation from WorldSmith with the corresponding scene and region description in the prompt editor. The regions and corresponding text segments are shown with the same color.



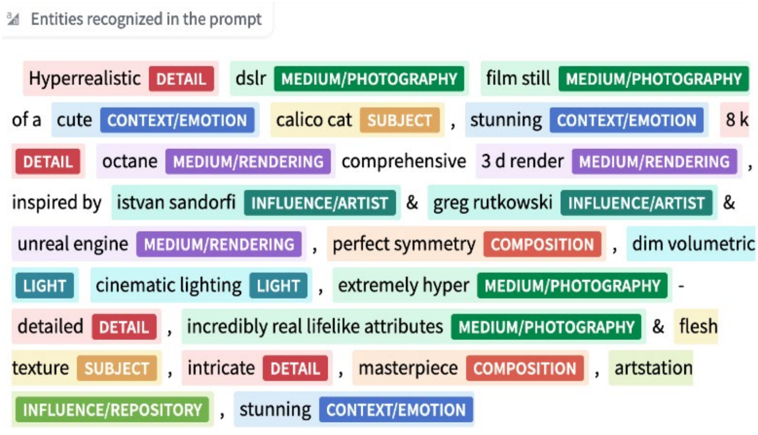


Figure 14.
Example of word prediction from the *en_ner_prompting* model on a real user prompt. Each word is categorized (e.g., medium, composition, subject), helping users in visualizing any missing elements.

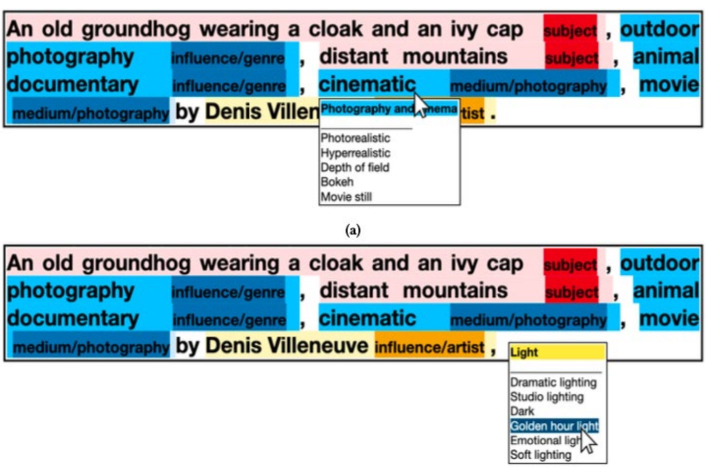


Figure 15.
Illustration of prompting assistance through the suggestion of prompt specifier alternatives (a) and continuation with new types of specifiers (b) in Sanchez's research.

and region masks as inputs». By marking the area of the image, they want to interact with, users can generate images that do not modify the entire scene but just the portion they desire (Figure 12, p. 41), as well as move elements inside the scene and make the AI fill the gaps (Figure 13, p. 41). This process anticipates inpainting and outpainting, making them not after the image generation but the core of the image generation process itself. Dang *et al.* research illustrates how future AI image generator tools could function, helping creatives control prompts' spatial and conceptual order.

Sanchez (2023) suggests that an interactive system could either indicate alternatives for typed specifiers or missing categories of prompts. A similar solution would help in the process of term retrieval for prompt structuring, and it would be an easy feature to implement as it is an AI operation already present in other kinds of apps and services. Sanchez's research required the development of a machine learning model (en_ner_prompting) that can parse prompts and identify specifiers according to the classes from the taxonomy (Figure 16). The system would label the category to which the word refers (subject, style, composition) and suggest possible inputs (Figure 15).

2.4 AI Reshaping Creativity

Oppenlaeder (2022) claims that the current product-centered definitions of creativity are not sufficient to assess the creativity of a product designed in collaboration with generative AI:

> **The human creativity in text-to-image synthesis lies not in the end product (i.e., the digital image), but arises from the interaction of humans with the AI and the resulting practices that evolve from this interaction (e.g., prompt engineering). (p. 193) ing the next companion of digital creators. (Turchi *et al.*, 2023, p. 48)**

With generative AI, creativity becomes a collaborative process between humans and machines. While the creativity of the final product can indeed be assessed, it often cannot be attributed solely to the human participant. What can be credited to the human is their curatorial role – their capacity to steer the machine and find creative ways to leverage its potential.

Indeed, when we talk about human-AI collaboration, there is an emerging trend of emphasizing curatorial practices both at the image and portfolio levels. Expert practitioners can control the text-to-image translation process and show expertise to replicate a unique style, thus creating a cohesive portfolio. Achieving a consistent style across separate works presents a significant challenge due to the previously discussed difficulties in controlling the various parameters. It requires creative thinking to elicit specific outcomes from the machine, predict how certain inputs will produce specific outputs, or leverage the unpredictability of the machine creatively.

In the art world, numerous artists have recognized and embraced the potential of utilizing AI's unpredictability in their creative processes. A prime example is Mario Klingemann's work in *The Hyperdimensional Attractions* series, which delves into the unforeseen by applying the three-body problem to latent spaces. This results in a triptych of images that morph based on the *orbital* movements of the feature vectors they represent. Viewers are presented with a tri-partite piece where familiar images perpetually transform into bizarre shapes and combinations. This approach indicates a broader trend within the artistic community, where the unpredictability of outcomes is leveraged to explore new creative horizons.

Moreover, Oppenlaender's research delineates the multifaceted nature of creativity in text-to-image synthesis, stressing that the traditional product-centric view of creativity inadequately captures the complexities of generating art with AI. He advocates for a broader understanding that encompasses not just the final artwork but also the creative process, the individual's role, and the influence of the digital environment. This holistic view is vital for evaluating the creativity of art produced in collaboration with generative AI.

While AI can produce work that mimics the superficial aspects of creativity, true innovation requires a depth of understanding and context that AI currently lacks. It is crucial to emphasize the relevance of such technology not as a replacement for human creativity but as a tool that can augment and extend the creative capabilities of humans. Integrating AI in creative processes is a collaboration where AI's ability to process and generate based on vast datasets complements human intuition and emotional depth.

Furthermore, ethical considerations are increasingly becoming a focal point in discussions about AI-generated art. Questions about originality, ownership, and the value of AI-generated art compared to human-created art are raised. These discussions highlight the need for a new framework to understand and evaluate creativity in the age of AI, one that recognizes the contribution of both humans and machines to the creative process.

As we move forward, we continue to refine our understanding of creativity in the age of artificial intelligence. In our view, the potentialities of creativity in AI generations might foster a symbiotic relationship between humans and machines, where each complements the other's strengths. This involves not only advancing the technological capabilities of AI but also critically examining the ethical, social, and cultural implications of its integration into the creative process.

By embracing a collaborative model that respects and amplifies the strengths of humans and AI, we can pave the way for a future where technology and creativity converge to expand the boundaries of what is possible.

PART 2

Setting the Research Focus

3. Use of Image Generators for Creativity Support in Design

3.1 Literature Review

A comprehensive literature review was undertaken to assess the impact of AI image generation on the design process. However, as we delved into the literature, we realized that it focused primarily on image generation and the broader creative applications of AI technology, which were not always directly related to the design discipline.

The analysis of the considered corpus of publications revealed three research insights. Firstly, there was a discernible trend in several publications toward exploring the nuances of prompt engineering, aimed at developing practical guidelines, which we will explore in detail in Chapter 2. Similarly, the second insight encompassed broader reflections on text-to-image practices, including potential future developments and the role of creativity within these processes, also elaborated in Chapter 2. The third and central outcome of the literature review was identifying potential applications of AI image generators within the design process. This aspect underscored a scarcity of scholarly work on the subject, with most relevant studies being

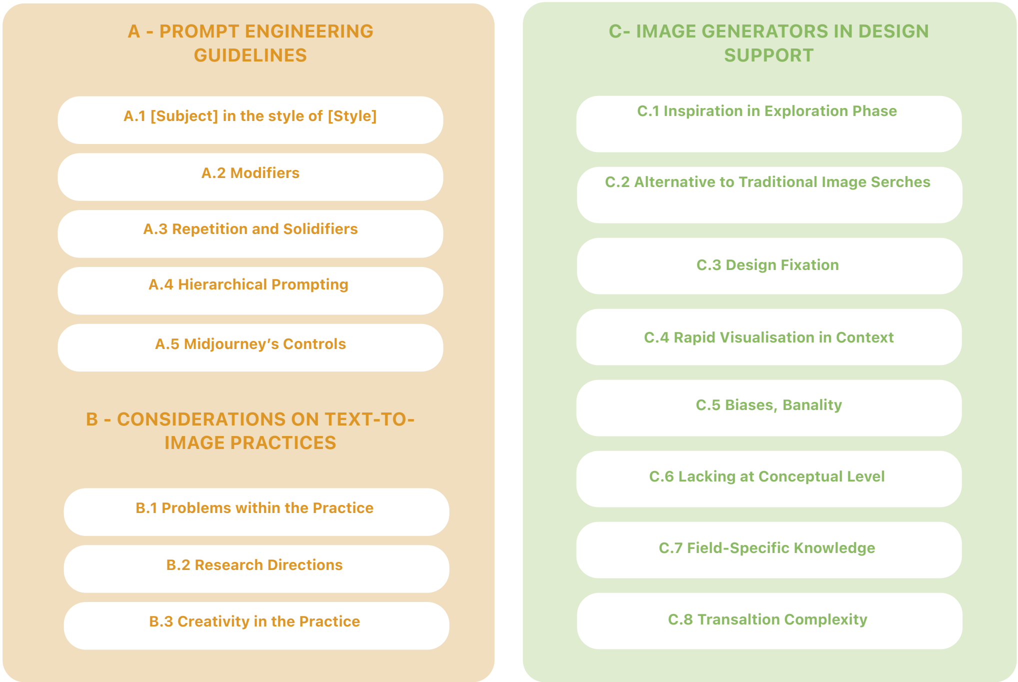


Figure 1.
Topics Covered by the Literature Review.

published between 2021 and 2023, thereby highlighting the emerging debate in the field. Among these, only 15 papers directly addressed the integration of AI in the design process, indicating that, despite some exploratory and experimental studies assessing the utility of these tools in design, the research remains nascent. This suggests an area for future exploration and highlights the importance of delving deeper into how AI can be harnessed to foster creativity and redefine the landscape of design practices in the digital age.

The three insights can be organized into two main clusters, shown in Figure 1. The first focuses on topics related to AI image generators on a theoretical level, which forms this book's foundational knowledge. The second addresses topics concerning the integration of these tools into the design process. This section will cover the latter group specifically.

Scholars have primarily explored the integration of AI-generated images into design processes through firsthand experimentation with the tools. To evaluate the specific AI image generators, researchers conducted two types of studies:

- Studies in which researchers observe designers as they experiment with and utilize AI tools in their design activities to assess their effectiveness. These AI tools may be developed specifically for the study or could be pre-existing ones. These studies usually rely on quantitative research methods, centering on collecting quantifiable data that holds statistical significance, and tracing comparisons between different users' experiences. For instance, Liu *et al.* (2023) introduced an AI tool tested by 13 participants with design and engineering backgrounds to evaluate its usefulness in aiding 3D development.
- Studies in which researchers use the tools themselves and document their observations through an autoethnography process. This approach favors qualitative research methods, which provide a deeper dive into the creative journey, emphasizing the individual experience and the intricate relationship between designers and AI. As an example, Hoggenmueller *et al.*'s (2023) exploration of AI tools in designing new robot concepts was conducted by the three authors themselves, using generative text-to-image models to ideate and visualize robotic artifacts.

Each approach offers unique insights and perspectives on integrating AI in design. In our research, we employed the second approach, which involves experimenting firsthand with an AI tool and formulating observations on the process, as it was considered more apt in terms of time and resources.

In this second section, we present the outcomes of the comprehensive literature review and lay out the hypotheses that guided the investigative trajectory to understand the nuanced role of AI image generators within industrial design.

3.2 Perks and Pitfalls of AI in Design Support

Scholars generally agree that state-of-the-art AI image generators primarily benefit the initial stages of the design process for inspiration and idea generation (Cai, 2023; Tholander & Jonsson, 2023; Zhang *et al.*, 2023). This is mainly due to the algorithms' focus on visual elements, lacking depth in understanding conceptual and functional dimensions. Without the designer's lead, these tools fall short in conceptualizing ideas or assessing feasibility and other critical practical design considerations, as Zhang and colleagues point out by noticing that AI image generators improve the variety of new ideas but challenge some aspects of creativity and might end in fixation (Zang *et al*. 2023, p. 256). However, their capacity to merge styles and translate words and moods into visual representations is valuable for inspiring creative work.

In their study Tholander and Jonsson (2023) highlight Generative AI's effectiveness in divergent phases rather than in convergent ones:

> **AI system was perceived as being very fast resulted in a view that the system was more useful for going wide when exploring a design space, rather than going deep. (p. 1939)**

This makes AI systems valuable collaborators and co-designers in stages where high variation but less useful for idea refinement is needed.

Several studies highlight using AI image generators as an alternative to traditional image searches through platforms like Pinterest and Behance, a well-known tedious and iterative activity for designers. Rather than gathering images of existing products online for inspiration, AI image generators can create a new set of images. These can serve as conceptual inspiration and as a mood board, providing fresh, innovative visual inputs that stimulate the design process (Cai *et al*., 2023).

Another recurring theme is the deployment of these tools to mitigate design fixation or even, as Cai and colleagues venture, to prevent it (Cai *et al*., 2023). When designers become overly attached to a single idea, AI can introduce unexpected variability, breaking the fixation cycle by introducing serendipity. Tholander and Jonsson (2023) suggest that providing users with outcomes different from their initial request — an occurrence often encountered during prompting — can foster creativity. This happens by *introducing a form of creative friction that encourages reflection in action* (p. 1938), effectively leveraging unpredictability to enhance the creative process.

Not only does the ability of these algorithms to apply different styles to a subject and to create a variation on a theme increase idea diversity, but the unwanted AI misunderstanding or imperfect adherence to prompts becomes a positive element in fostering creativity. This illustrates AI's role as a collaborative partner in the design process. Hong *et al.* (2023) emphasized that these situations allow «promising opportunities to augment human creativity in real-world professional practice» (p. 1).

Lastly, a study by Hoggenmueller *et al.* (2023) highlights an intriguing application of AI, showcasing its ability to rapidly visualize concepts in «various contexts, scenarios, and situations at a stage of the design process where the artifact does not yet exist in reality» (p. 8). This functionality underscores AI's potential to significantly enhance the conceptualization phase, allowing for a more dynamic exploration of design possibilities before physical realization.

Creative AI support also has its drawbacks. Primarily, the capability of these tools to generate a vast number of images quickly, while advantageous, can also become overwhelming (Zhang *et al*., 2023). In the search for conceptual inspiration, one might find themselves stuck in a cycle of continuously generating new, qualitatively similar ideas, leading to a sense of being lost and overwhelmed by the options. In other words, AI's serendipity can sometimes aid in overcoming design fixation and sometimes paradoxically induce it. Designers may encounter appealing visuals that are far from practical or conceptually relevant. However, they might find themselves stuck trying to achieve that same aesthetic imagery quickly generated by the AI, diverting focus from feasibility evaluations and conceptual relevance. This bias is significant to consider, as the shift from the quick response of the AI program – together with the impression of time-saving – to prolonged fixation might occur gradually and almost unconsciously. As a result, to rearrange the AI-suggested image, the designer might spend the same amount of time, or even more, than would have been requested to generate it autonomously. This entails the need for a more refined knowledge and utilization of these tools.

Another frequently debated aspect is the potential for AI-generated content to be biased, culturally selective, and, in the context of design, lacking in novelty or innovation. This issue stems from the fact that algorithms are developed and trained by humans who may have their own biases and utilize data created by humans with additional biases. Consequently, this can result in AI producing inherently non-inclusive outputs, such as adopting a Eurocentric perspective on design if trained with Euro-centric data. Similarly, AI might also perpetuate stereotypical or unoriginal design concepts due to the nature of its training data. Hoggenmueller *et al.* (2023) highlight this problem through their experience seeking inspiration for robot concepts, where they observed that the AI frequently reverted to stereotypical views of robots, illustrating the challenges in achieving innovative design ideas due to the limitations of the training data:

> **Many existing assumptions and robot stereotypes were reinforced through the generated images with outcomes that were neither *novel* nor *surprising*. For robot appearance and embodiment, this was in particular true when not further specifying the characteristics of the robot within the prompt (e.g., simply using the term *robot* or *social robot*) and if the situated context was rather neutral (e.g., *at work*), thus not evoking a strong specificity that would influence the appearance of the robotic artefact or its embedding. For example, this would lead to image generation in which the robotic artefact would be depicted as blue- and white-colored, confirming the predominant racialization of AI as White (p. 45).**

This study emphasizes the importance of human intervention in achieving both *novel* and *surprising* outcomes, steering clear of clichés and the triviality of ideas. The researcher stresses the need for *further specifying the characteristics*, highlighting that detailed guidance is essential in avoiding generic results and fostering originality in AI-generated designs.

Another crucial limitation of AI in the design field is at a conceptual level; while it excels at stylizing concepts, it struggles to grasp and interpret the functional and conceptual aspects of a project. For example, suppose the input is a *compact air fryer*. In that case, the AI might generate images of dimensionally smaller air fryers, but it cannot envision how a design could innovatively achieve compactness. This issue is inherent to platforms like Midjourney, which are designed to produce two-dimensional images and, therefore, cannot employ the third dimension. Additionally, its inability to assess feasibility further limits its effectiveness in design contexts. This is highlighted in the study by Zhang *et al.* (2023), where 11 participants with backgrounds in architecture and design were invited to use the AI tool DreamStudio to inspire initial sketches of a *hotel near the sea* concept:

> **AI generates surreal images that are not suitable for architectural purposes. It was common that the AI would result in images that were unrealistic or impossible to construct (p. 256).**

A further limitation identified in this and other studies is that existing tools lack field-specific knowledge. As mentioned in the introduction, current generative AI tools (such as Midjourney and DALL-E) are predominantly developed for artistic outcomes. Design encompasses a specific vocabulary and set of rules, and different design fields have distinct needs; for example, the process in fashion design varies significantly from that in interior or industrial design. As Zhang *et al.* (2023) report:

> **AI does not understand design domain knowledge. Three participants (P4, P6, P9) mentioned wanting the AI to better interpret domain-specific terms for architecture. P6 specified in the prompt that they needed that building to be *with tectonics facade*.**
> **This term would be known and understood by an architectural designer, but the participant did not get the expected outcome with AI as the tectonics structure was not on the facade, but placed elsewhere on the form (p. 256).**

This concept is underscored by the research conducted by Tholander and Jonsson (2023), which examined the use of ChatGPT for text-to-text generation in early prototyping. Their study was organized as a half-day workshop involving eight participants: five professional designers (two industrial designers, two organizational designers, and one user experience designer) and three researchers in interaction design and HCI. Their findings are also pertinent to text-to-image generation, given the similarities between the underlying algorithms.

They highlighted two main issues:

> **1) the system's lack of understanding about the context of the design problem being worked on, and 2) the system's lack of memory of the unfolding interaction and emerging design concept (p. 1934).**

The accessible and most-used current tools do not learn from ongoing interactions; each generation is entirely new and independent from what was previously conceived. It is up to the user to skillfully combine the results.

The last point, which has already been introduced in section 2.3, regards the cognitively tricky task of translating designers' visual concepts into text expressions, a problem related to the practice of prompt engineering. While the image-to-text function of the AI has been extensively inquired about (Liu *et al*., 2023), the rebound effect of reinterpreting the generated image in textual outcomes, allowing proper product creation, has not yet been adequately addressed. Users need to articulate their intended meanings clearly and remember specific ontologies, which diverges from the typical design practice that is predominantly visual-centered. Designers usually find inspiration, visualize an idea, and sketch, visually representing the concept without structuring a sentence or searching for specific terms. While this may seem trivial, AI assistance can be more cumbersome than helpful. For example, as observed in our experiments, when dealing with products that are neither stereotypical nor well-established, making the AI comprehend the requirements might necessitate defining the product and experimenting with various descriptions and terms to prompt effectively. This could become a lengthy process.

3.3 Five Roles for Designers in Human-AI Collaboration

As many people speculate on the future of generative AI and its potential to replace certain activities, it is essential to consider its implications specifically within the design field. Currently, the state of generative AI tools reveals significant limitations. Managing outputs remains complex, and the results only sometimes meet expectations. The design process involves steps from metaproject formulation to concept generation and product development. Image generation tools can inspire during the concept phase, as observed. However, no generative AI tools currently offer 3D capabilities, nor can they perform feasibility evaluations or operate at a conceptual level to guide the metaproject. However, the rapid evolution of these tools is undeniable. Generative AI for 3D and design-specific tools like Vizcom are emerging, demonstrating significant advancements in simplifying prompting, allowing result manipulation, increasing output control, and providing field-specific training. This evolution raises questions about the future role of designers, with researchers suggesting a shift towards more curatorial responsibilities, emphasizing meta-project oversight and the strategic direction of implementations. In this context, the designer's role when using AI for concept generation should evolve in these five specific areas:

Analytical Role

The designer's analytical capabilities are essential in setting the project's problems and objectives. This involves a deep understanding of the project's scope, user needs, and market context, ensuring that AI-generated concepts are aligned with strategic goals. By setting clear parameters, designers can leverage AI tools effectively to explore potential solutions, maintaining a critical eye on the relevance and applicability of generated ideas.

Instructional Role

Structuring the prompt, or *engineering the interaction*, requires a nuanced understanding of how AI interprets input. Designers must become adept at crafting prompts that guide the AI toward desired outcomes, balancing specificity with openness to encourage creative solutions. This role involves a detailed knowledge of the AI capabilities and limitations, enabling designers to formulate prompts that maximize the tool's potential for innovation.

Evaluative Role

Selecting and evaluating the results generated by AI involves a discerning judgment that synthesizes aesthetic, functional, and strategic considerations. Designers must assess AI-generated concepts' viability, originality, and alignment with the project's vision. This evaluative process is crucial in filtering out impractical or misaligned ideas.

Synthetic Role
Selecting and evaluating the results generated by AI involves a discerning judgment that synthesizes aesthetic, functional, and strategic considerations. Designers must assess AI-generated concepts' viability, originality, and alignment with the project's vision. This evaluative process is crucial in filtering out impractical or misaligned ideas.

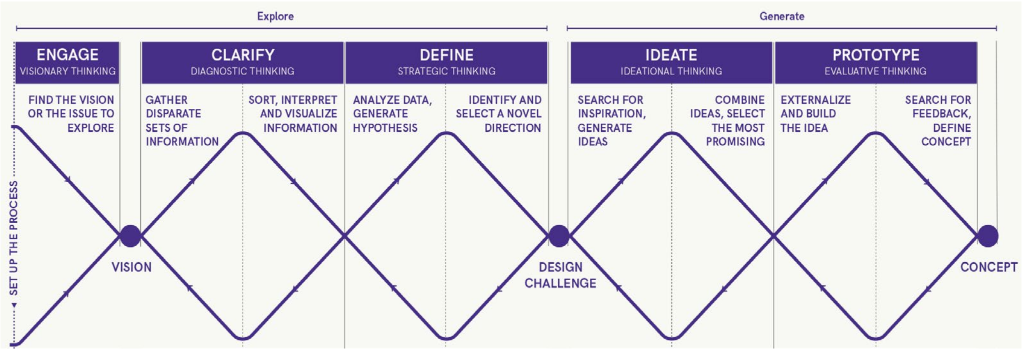
Curatorial Role
Creating coherence through generations and styling portfolios emphasizes the designer's ability to weave together disparate AI-generated concepts into a cohesive narrative. This role extends beyond individual projects, requiring an overarching vision integrating various concepts into a unified brand language or design ethos. The designer curates AI-generated outputs, ensuring consistency and coherence across all touchpoints and enhancing the brand's identity and narrative.

These five roles underscore the evolving nature of design in the age of AI, where designers are called to integrate their creative and strategic expertise with AI's generative capabilities. Far from making the designer's role obsolete, AI augments the design process, empowering designers to navigate complex problem spaces more efficiently and creatively. In these human-AI collaboration roles, as applied to design practices, there is consistently a guiding role from the designer's side: even though the unpredictability of the machine can serve as a source of inspiration, there is a need to maintain a certain level of coherence and practical utility in the outputs.

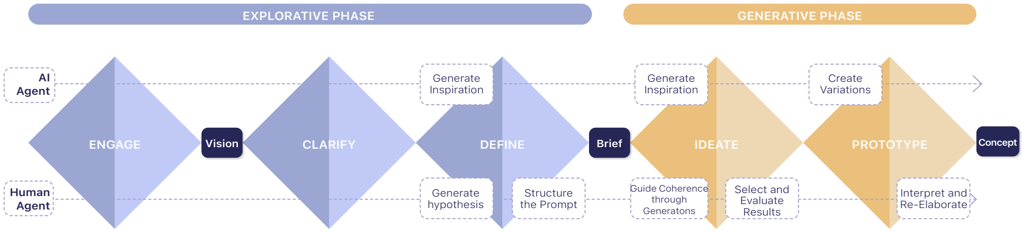
Translating these roles into practice to delineate the specific actions of human designers within each stage of the design process, we referenced the foundational structure of Bruno's (2022) Creativity 4.0 Framework, which delineates the stages and activities of the Creative Design Process as illustrated in Figure 2. Bruno's model is segmented into the Exploration and Generation Phase, each divided into sub-stages that follow the structure of a double diamond diagram, each phase encompassing a divergent and a convergent stage. Also, Bruno identifies five distinct roles of the designer:

- *Engage (Visionary Thinking)*: This initial stage involves Visionary Thinking, where the designer sets up the process. The activity here is to *Find the Vision or the Issue to Explore*, which is about understanding the broader context and identifying the core problem or opportunity the design process will address.
- *Clarify (Diagnostic Thinking)*: The Clarify stage involves sorting, interpreting, and visualizing this information to make sense of it and to diagnose the problem more clearly.
- *Define (Strategic Thinking)*: Here, the critical designer's activity is to *Analyze Data, Generate Hypothesis*, and then *Identify and Select a Novel Direction*. This involves taking the insights gathered in the previous stages and shaping them into a strategic direction for the design.
- *Ideate (Ideational Thinking)*: The designer engages in *Searching for Inspiration, Generate Ideas*. It is a divergent phase where numerous ideas are created, from which the designer will 'Combine Ideas and Select the Most Promising' ones to take forward.
- *Prototype (Evaluative Thinking)*: Here, the designer's task is to *Externalize and Build the Idea*, creating tangible representations of the selected ideas. It also involves *Searching for Feedback, Define Concept*, which is about testing the prototypes, getting feedback, and refining the concept towards a final solution.

Figure 2. Carmen Bruno's Creativity 4.0 Framework basic structure, representing the Creative Design Process stages and activities.



As AI tools become increasingly sophisticated, the designer will focus on guiding, evaluating, and curating the creative process, ensuring that AI is a powerful ally in pursuing relevant design solutions. This shift towards a more integrated human-AI collaboration in design suggests a future where AI acts as a co-creator, requiring the designer's presence to fulfill the previously cited critical roles (see Graph 1).



Graph 1.
Preliminary subdivision of AI and Human Roles in the Design Concept Generation Process. Using Carmen Bruno's Creativity 4.0 Framework as a reference structure, the main actions have been highlighted.

Human-AI collaboration is currently an extensively debated topic among scholars. The five roles identified aim to encompass all possible roles of humans in this collaboration, drawing on various theories (both more-than-human and human-centered). This comprehensive view echoes Wakkary's (2021) advocacy for a collaborative partnership The AI agent consistently participates during the divergent phases of the design process. This is due to its ability to *going wide [...] rather than going deep* (Tholander and Jonsson, 2023). It provides initial inspiration in the Definition phase to generate hypotheses. In the brief definition phase, the designer could leverage the serendipity of AI for brainstorming and generating hypotheses they might not have considered. Later, in the Ideation phase, AI provides rapid and abundant idea generation and faster creation of variations on promising ideas, compared to traditional methods.

Conversely, the human agent predominantly engages during convergent phases, synthesizing the AI's work. The Analytical Role of setting problems and objectives is relevant throughout the Exploration Phase. In the convergent phase that succeeds the AI's divergent hypothesis generation, the human agent undertakes the Instructional Role of engineering the interaction. The human then adopts a Curatorial Role to ensure coherence throughout the divergent phase of AI's concept generation and variation. Subsequently, humans re-enter a convergent phase with the Evaluative Role — selecting and assessing the results produced by AI. Finally, the Synthetic Role of interpreting and reworking AI-generated results occurs in a subsequent divergent phase, associated with generative rather than selective activities.

This interplay between human and AI roles within the design process framework highlights a dynamic collaboration. AI agents are best utilized for their strength in expanding the horizon of possibilities, while human designers are called to distill and refine these possibilities into concrete, viable concepts. This complementarity leverages the wide-reaching generative abilities of AI with the deep analytical and evaluative capabilities of humans, ensuring a balanced and innovative design process. between humans and AI, suggesting that such a relationship can lead to innovative and meaningful design outcomes. Simultaneously, it acknowledges the principles of Shneiderman's (2022) Human-Centered AI, recognizing the importance of human guidance, ethical considerations, and the augmentation of human creativity and decision-making through AI.

For instance, Wakkary sees the interaction between humans and intelligent systems as a collaborative creation process that extends beyond traditional human-centered approaches. He underscores the potential for AI to participate not just as a tool but as an active agent in the creative process, challenging us to reimagine the dynamics of creation and innovation, navigating through a landscape where AI contributes as a co-creator. This paradigm aligns particularly with the final three roles (evaluative, synthetic, and curatorial), highlighting the necessity for designers to navigate, integrate, and refine AI-generated outputs within the broader context of their projects.

Moreover, Shneiderman (2022) emphasizes designing AI systems that support human needs and enhance human capabilities. This approach stresses the importance of ethical considerations, user control, and the augmentation of human skills rather than their replacement. Shneiderman's theory is particularly relevant to highlight designers' instructional and analytical roles. By crafting precise prompts and setting clear project objectives and parameters, designers ensure that AI tools are effectively harnessed to explore potential solutions aligned with human values and strategic goals, recognizing the importance of human guidance, ethical considerations, and the augmentation of human creativity and decision-making through AI. The debate about AI is mainly between Collaboration vs. Augmentation: Wakkary's emphasis on more-than-human collaboration suggests a future where AI's role transcends that of a mere tool, becoming an integral part of the creative process. While recognizing AI's potential to enhance human capabilities, Shneiderman maintains a human-centric approach, focusing on AI as an augmentative force. The five designer's roles presented encompass all these views, assessing generative AI in the design process both as a collaborator (co-designer) in its inspirational role, through its unpredictable outputs, and as a tool that cannot lead to results without the designer's guidance.

4. Uncovering the Research Gap: Industrial Design Specificities

4.1 AI Image Generation across Different Design Fields

Drawing has always preceded any construction activity in the design process. The act of drawing constitutes a moment of organizing ideas, managing resources and forecasting results, which is made possible by using dedicated tools. The introduction of the computer as a drawing tool has brought about an epochal change: in addition to contracting execution time and increasing the accuracy of the sign, the computer allows drawing in a practical simulated three-dimensional space, enabling the expression of more articulated forms.

4.1.1 Concept Inspiration

Initially used as a functional *digital drafting table*, differing little, from a conceptual point of view, from the traditional modes with ruler and square, the use of the computer has progressively conditioned the design process so much, that today it's difficult to separate it from design practice. With the new millennium, economic and cultural changes have accelerated the advent of a digital and globalized society. Increased computer literacy has involved designers, leading them to investigate the processes underlying the operation of daily-used digital tools. The conscious use of the computer stimulated a new type of modelling based on information-processing logic and freed the designer from the traditional CAD software constraints.

4.1.2 Moodboard Inspiration

This increased mastery has enabled a growing group of researchers and designers to develop their own drawing applications adapted to their specific individual design and research experiences. The form is now studied and generated by drafting algorithms, systematic procedures based on a succession of uniquely interpretable instructions that lead the computer to achieve a given goal. The discipline of drawing has thus evolved from iconic representation to the formalization of relationships and processes.

4.2 The Lack of Research on Generative AI for Industrial Design

In this new paradigm, different design instances can be articulated in emergent relational structures that require new theoretical analysis tools and understanding, capable of maintaining a high level of design coherence. It is necessary to manage the interaction among multiple parameters through diagrams capable of articulating programmatic interactions that operate as reactive systems in domains where real and virtual are increasingly overlapping. The etymon of the term virtual, from Latin *virtus*, meaning strength but also capacity or faculty, leads back to the concept of possibility, that is, of unexpressed potential far from opposing the real, representing a different mode

4.2.1 Limitations in Feasibility Evaluation

Though product language is critical and must be crafted carefully, a product's usability and feasibility are also important. These considerations must be factored in even during the early stages of concept development and when defining the product language. The intriguing power of AI often stems from its lack of human cultural evaluation capabilities, leading to the production of absurd or paradoxical image combinations. These unexpected juxtapositions can boost curiosity and inspire novel ideas. Such hints might significantly enhance creativity and imagination in art or illustration. However, in industrial design, absurd concepts often pose feasibility-related challenges, making it crucial to balance innovation with practicality. This challenge means that visually compelling AI-generated images may not always translate into real-world applications, feasibly manufactured and functional as intended. Without the ability to assess the practical implications of a design, AI-generated images might lead designers down a path of exploring concepts that, while innovative, are ultimately unviable.

4.2.2 Risk of Fixation on Unrealistic Renders

Connected to the previous point, there is another challenge presented by the AI's capability to produce highly realistic and appealing renders. Designers might become fixated on these detailed visualizations without fully considering their practicality. This fixation on visually appealing but unfeasible designs can divert valuable resources and time from exploring more viable solutions. The risk here is not just the potential for wasted effort but also the possibility of overlooking simpler, more practical designs in favor of those that are more visually striking but less functional.

4.2.3 Tendency to overfocus on Aesthetic Aspects

While AI demonstrates remarkable skill in creating stylistic variations and blending existing styles to create new ones, its ability to generate genuinely original concepts is less assured. This is particularly problematic in industrial design, where innovation often involves rethinking how a product functions or is used rather than only its appearance (Rampino, 2011). Hoggenmueller's study (2023) underscores this issue, showing that AI might reinforce conventional ideas rather than challenge them or propose novel solutions. In a domain where breaking away from the conventional to find innovative solutions in terms of mode of use and technology is crucial, AI's tendency towards aesthetic innovation over functional originality can be a significant limitation.

Given AI's current difficulties in understanding function, its application in industrial product design might initially seem constrained. However, when we reframe our perspective on AI's role within the design process, its value becomes evident, particularly in the early and explorative phases. When referring to current AI Image Generators, the key is to employ AI as a tool for inspiration rather than final solution generation, using its capacity for style variation and visual synthesis to enrich the creative process before the critical stage of feasibility assessment begins. The generated ideas can serve as a springboard for further development, where designers apply their expertise to refine these concepts into viable solutions. The dynamic interplay between AI's imaginative proposals and human expertise is where true innovation is born.

The integration of AI in this manner can speed up the concept generation phase, allowing human agents to invest more time in product development and refinements. This approach maximizes the potential of AI as a design tool, enabling the exploration of new design languages and the expansion of the creative palette while maintaining sight of the end goal: creating innovative products that are functional and manufacturable.

4.3 The Potential of Generative AI for Industrial Design

Considering all aspects previously discussed, three main uses of AI Image Generators have been identified for industrial design processes, all aiming at supporting concept generation.

4.3.1 Brainstorming

Referring to Graph 1, Generative AI can play a valuable role in the Definition Phase by aiding in identifying a novel direction. AI-generated images can help shape the design brief. At this stage, prompts are likely to be very general, which may lead to outcomes that are either quite obvious or nonsensical; however, such prompts, lacking specifications that constrain the results, may result in unexpected or unconventional AI generations. The serendipity of these outcomes could spark inspiration for the overall design direction. While these generations may not provide a final concept inspiration, they may serve to refine and guide the design direction. From Vision to Design Brief, designers aim to identify a precise design challenge with a clear brief to guide the concept generation. This chaotic and fuzzy phase is where designers seek inspiration, and it is crucial to avoid design fixation. Introducing diverse ideas is important, and even within a group, there is a risk of fixation on a solution that is difficult to find. Adding AI to the brainstorming process introduces a unique perspective governed by different rules, such as biases different from our own. In this context, the AI's lack of conceptual depth and functional interpretation becomes advantageous, potentially generating ideas beyond our typical thought processes. This diversity can challenge conventional thinking and inspire innovative design solutions, making AI a valuable partner in navigating the initial stages of a product design process.

4.3.2 Concept Definition

This application is specific to the Ideation Phase, a stage where we aim to start generating concept ideas. In contrast to the earlier stages, this phase is focused on seeking genuine Concept Inspiration. It follows the Design Brief Definition and the delineation of benchmarks and requirements. Consequently, the prompts at this stage will be more targeted, thoroughly researched, and thoughtfully constructed, supported by an expanded set of references. This deliberate approach ensures that the ideas generated are aligned with the defined objectives and constraints of the project. In this stage, the typical serendipity of AI, though still beneficial, is less crucial than in the brainstorming stage as the focus shifts towards realistic and meaningful cre- ations. In shaping a specific solution, we must constrain the inputs to yield outputs that define our product.

Consequently, AI collaboration's essence here assumes a convergent rather than divergent goal and becomes more complex.
A key objective of our research is to evaluate whether such results can consistently be achieved and, if so, with what likelihood. Indeed, observing the art realm and based on our research on prompt engineering, achieving precisely what is expected from AI is quite tricky; artists often leverage these aspects and embrace unpredictability.

However, this might not always be the case in design: we cannot deviate too much from the design brief. Despite all these considerations, we still think that AI can significantly contribute to Concept Definition, as some brands are starting to test this option and launch AI-designed products.

4.3.3 Language Definition

AI-generated images may only sometimes be relevant conceptually, but they can inspire aspects of product language. Indeed, there are instances where these images can serve as elements within a moodboard. An image created during the search for concept inspiration may possess moodboard value, either serendipitously or because the user aims to generate a moodboard intentionally. This flexibility allows designers to derive aesthetic inspiration from AI-generated images, even if they are not directly applicable to the developed concept.

Indeed, tools like Midjourney are known for focusing on the aesthetic appeal of images. It is relatively frequent that the AI will produce aesthetically captivating images by only using some Modifiers and Magic Words (see Chapter 2). This aspect of text-to-image AI applications presents a relatively straightforward process for deriving product language inspiration, as it leverages the core capabilities of these algorithms.

In conclusion, using text-to-image AI technologies for brainstorming and language definition leverages their constituent aspects, exploiting their unpredictability for divergent thinking and their proficiency in stylistic rendering for style inspiration. On the contrary, when these technologies are applied to concept definition, the focus shifts towards the ability to control the AI to produce feasible and realistic outputs.

In the following chapter, we will formalize these methods of AI usage, defining research goals and tools to investigate the use of a specific AI image generator, Midjourney, in the concept generation phase. This exploration aims to provide a structured approach to understanding how AI can enhance the creative process of product designers, focusing on identifying effective strategies and practices. By doing so, we aim to uncover insights into AI image generators' potential benefits and limitations, offering guidance on their application in industrial design.

5. Midjourney-aided Concept Generation

5.1 Introduction to Midjourney Prompts Options

Alongside the literature review, while asking ourselves about the implications of this technology, we started experimenting with Midjourney. In 2023, there were significant improvements in various AI tools, particularly regarding image quality and prompt coherence. Initially, we focused on studying prompts to understand how to get the best outcomes, primarily trying to get images with artistic value. However, after a while, we asked ourselves about the potential relevance of this tool to our field of study. We started generating images whose subject was design products, aiming to assess if those images could be relevant to design project development.

Getting used to the software took time, as it required learning not only its grammar (illustrated in Chapter 2) but also its core operational principles, understanding how its algorithms function, and predicting the outputs for specific inputs. Before illustrating our experiments, it is necessary to illustrate the different ways of prompting and the main functions in Midjourney. Those functions will be central in concept generation and shape how we set the process.

The first method, and the most common, is to use text prompts. This is where all the tuning parameters outlined in Chapter 2 come into play, such as chaos level, stylization, and the use of seeds. Here, the mastery of prompt engineering becomes crucial. Text prompts are handy for controlling the output image in terms of subject and composition. However, managing the stylistic outcome can be more challenging. Specifically, replicating an inspiring image with precision using only text prompts is nearly impossible. The strength of this input method is that it can lead to unexpected results while maintaining a certain degree of realism.

The second approach involves enhancing text prompts with a reference image. This method presents all the advantages of pure text prompting but adds the ability to direct the AI towards a specific style. The limitation here is that Midjourney might prioritize the text or the image over the other, and often, the mix results in a nonsense production. This can also result in the image being too distant in subject from the text, leading the AI to produce a weird synthesis.

The third method is the blend function. It allows us to create a serendipitous synthesis of two or more images, which can be good when we have inspirational images and want to transfer one's style over another. Yet, as we have seen, there is no direct control over the results, which can require many iterations. This method is particularly suited when we seek moodboard inspiration rather than a realistic concept. The advantages and disadvantages of the blend function tool are thoroughly explored in this chapter.

The last function that is important to mention is the description. This function is not a prompt modality but helps the formulation of prompts.

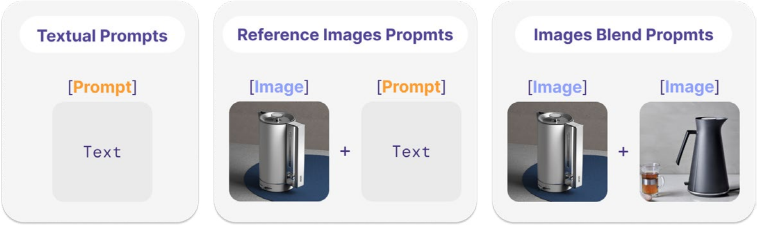


Figure 1. Midjourney Prompt Options.

[Prompt]

3d rendered design of a chair made of light orange and light amber plastic, biomorphic forms, hyper-realistic, playful body manipulations, chair design, clear and crisp, panfuturism, gradients.

Figure 2.
Example of prompts and results.

[Prompt]

A chair sitting on a pink background, in the style of gelatinous forms, rendered in cinema4d, some transparent and some translucent medium parts, playful design, rounded shapes, sublime typography, multi-layered figures.

Figure 3.
Example of prompts and results.

[Prompt]

```
A plastic chair on a green background, in the style of
cubist sculptures, rounded shapes, organic forms, muted
tones, bright sculptures, rendered in cinema4d, playful
abstracts, orange and blue.
```

Figure 4.
Example of prompts and results.

It enables the input of an image, in response to which the AI generates four descriptions. These descriptions can serve as a source of inspiration when aiming to recreate a similar image, facilitating the process by offering insights into possible interpretations and details that might not be immediately evident. Furthermore, this function is beneficial for term retrieval and style definition, providing a clearer understanding of the visual elements and stylistic nuances present in the image.

Understanding and leveraging these diverse input methods is critical to harnessing Midjourney's full potential for applications in design. Our research aimed to identify which function is most effective for specific outcomes or stages of the process.

5.2 Initial Generation Attempts

We started exploring product design generations by prompting well-established categories of products that offer many stylistic possibilities. For this goal, the seating category was well indicated.

We were immediately impressed by the quality of the images generated, yet we quickly identified some shortcomings. As shown in Figure 4, p.79, not all the instructions provided in the prompt were followed by Midjourney. For instance, when we requested a chair *in the style of cubist sculpture*, the resulting image did not embody that style. However, the AI accurately interpreted other instructions, such as emulating a specific renderer-like style (e.g. *rendered in cinema 4d*), color indications, and scene setups. We must acknowledge that in those initial attempts, we included many stylistic attributes in the prompt, which may have led Midjourney to prioritize some over others. With brief prompts, the AI consistently delivered exciting, potentially inspiring outcomes.

On the other hand, when submitting longer and more unconventional prompts, the results were more unexpected, perhaps less realistic, but indeed very inspiring in a way akin to a moodboard. We noticed that the more details, conceptual aspects, and *magic words* we provided, the more the designs became abstract. On the contrary, keeping the prompt short led Midjourney to generate more realistic renders. After experimenting with seating (Figure 5), we wanted to test the

Figure 5

[Prompt]

Modern eccentric chair, toysh features, minimal, soft, pastel colours, high quality image.

[Results]

software in other design domains. Aware that these technologies often fall short of accurately generating letters, numbers, and text-related elements, we were intrigued by the potential outcomes of designing user interfaces. In this experiment (Figure 6, p. 76), we did not provide detailed design instructions. By prompting *Figma-designed UI*, our goal was to receive a UI prototype — a series of mock-ups similar to those typically created using tools like Figma, without picturing the related product. Midjourney well understood the brief. As predicted, the text within the image turned out meaningless, and similarly, the symbols and icons lacked meaningful representation. However, the generated visuals offer valuable inspiration for layout and color schemes.

These first experiments underscore the importance of clear and strategic prompting when leveraging AI for design, considering the balance between providing enough detail to guide the AI and leaving space for creative interpretation.

Following these two first experiments, we wanted to test the Blend feature. This tool allows users to request the AI to synthesize two existing images, incorporating images previously generated by Midjourney and imported images from external sources. This experiment investigated the feasibility of using images instead of text prompts to specify *subject in the style of*. Specifically, we intended to provide one image depicting the desired subject and another showcasing the style we wanted to apply. This approach aimed to bypass the limitations of textual descriptions. As illustrated in the first section, one of the main pitfalls of AI for creativity support is that designers need to

[Prompt]

Figma-designed UI

[Results]

Figure 6

[Blend Images]

[Subject] [Style]

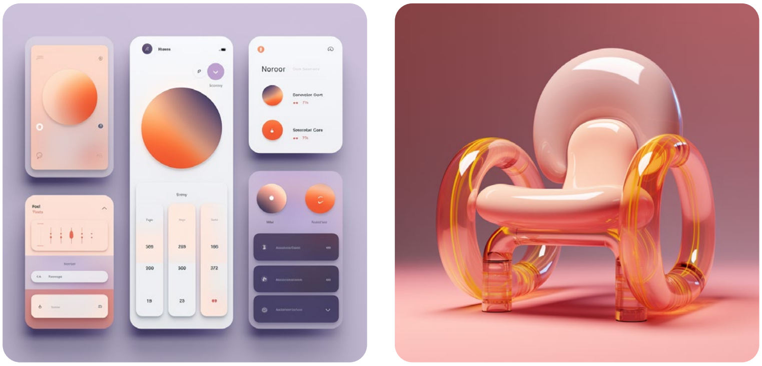


Figure 7

translate visual ideas into detailed text descriptions. The experiment was intended to assess whether such a method could offer a more intuitive means of communicating design intentions to the AI.
The experiment was conducted on a user interface (subject) that incorporates 3D elements (style), emulating the aesthetic of one of the chairs we had previously designed (Figure 7).

The outcomes generated by the AI were quite intriguing (Figure 8). The subject of the images leaned towards abstraction, diverging from a conventional UI design. However, these images held inspirational potential, functioning once again as a moodboard. In terms of style, the AI demonstrated the ability to assimilate and reflect the aesthetic characteristics of the chair. The fusion of style from the chair into the UI images validated not only the AI's understanding of design aesthetics but also its potential to bridge different design domains creatively.

Post-production was undertaken to refine the abstract images into visuals resembling an actual concept. During this phase, elements that did not make sense were removed, and some details were corrected to enhance the overall coherence of the images. Additionally, authentic UI elements were incorporated, drawing inspiration from an iOS interface. Curiously, a part of this post-production work utilized

Figure 8

[Selected Iterations] [After Post Production]

Figure 9

Photoshop's latest generative AI features, remarkably speeding up the process and showcasing the potential synergy between different AI technologies.

Given the moodboard-like quality observed in most outcomes, we were curious to see if moodboards could be intentionally created (Figure 9). We began by carefully crafting text prompts, soon realizing we held a specific vision on 'moodboards' not immediately grasped by the AI. Therefore, we specified a product design moodboard composed of abstract elements, listing desired colors, shapes, textures, and compositions while explicitly stating what we wished to avoid. In all these initial generations, many iterations of different prompt structures were needed. After some attempts, we obtained fascinating outcomes. These were still far from being final moodboards, mainly since some were excessively abstract, and others included unwanted elements, such as flowers. It was curious to see how the AI continued inserting flowers even when we explicitly stated not to. Motivated by the challenge of accurately manipulating the text input for desired outcomes, we experimented with the blend function (Figure 10). We selected a moodboard result that we were satisfied with and combined it with a chair design previously generated. The aim was to obtain a chair moodboard that reached the perfect balance between being recognizably related to chairs without being overly literal or leaning towards abstraction. While the blend function does not allow for precise guidance in this regard, contrary to text prompts, it offered a more direct method to provide Midjourney with some references of the desired results.

The final outcomes (Figure 11) were quite fulfilling, embodying the desired characteristics: abstract and not literal forms that reveal the intended product alongside a consistent style. Nevertheless, the results still lacked in meaningfully referencing seating, with the obtained forms being rather abstract. Although only some of these outcomes could be considered final, they were valuable, offering

Figure 10

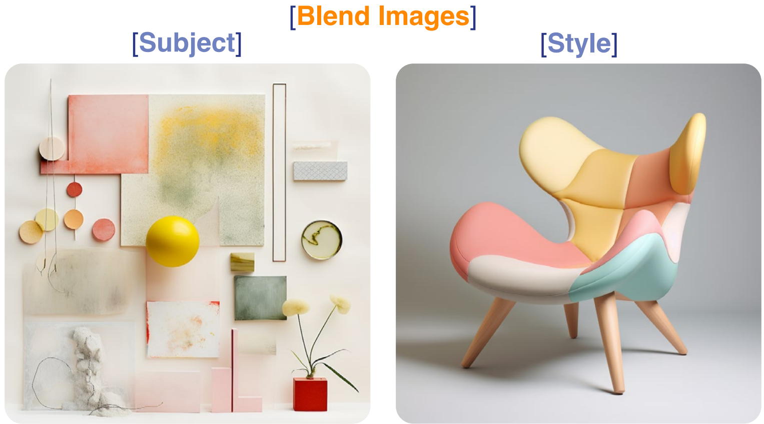


Figure 11

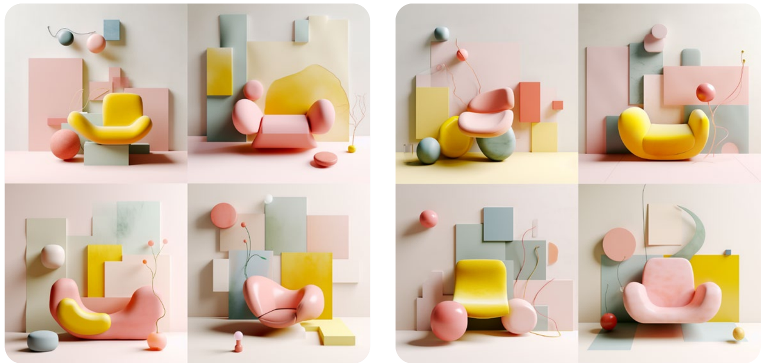


Figure 12

a promising direction for further exploration and underscoring the potential for innovative design exploration.

In our final experiment, we tasked the AI to create a visualization for a chair presentation (Figure 12), including text and visual elements that mimic a presentation slide. Like the UI experiment, while the generated text was nonsensical, the provided layout was inspiring, further highlighting AI's potential to generate innovative visual layouts. Despite the textual content not directly contributing to the design's utility, the test showed the value of AI as a tool for enhancing visual communication strategies.

5.3 The Product + Language Paradigm

All the experiments so far revealed a typical pattern: many generations applied different product languages to a given product, with none focusing exclusively on conceptual directions without explicit

Figure 13.
Experiment with bag concepts utilizing the Blend feature, showcasing its versatility across applications in various design domains.

product language definitions. This pattern emerged for a twofold reason. First, as mentioned earlier, our initial attempts lacked a specific design brief. Second, and more crucially, we found ourselves unconsciously aligning with the operational logic of the AI tool. Given that the algorithm synthesizes images based on the input words, particularly for image generators designed to depict a [SUBJECT] in a specified [STYLE] (Liu & Chilton, 2022), we inadvertently mirrored this process in our design explorations.

This led to a direct translation of the [SUBJECT] in the style of [STYLE] framework into a design vocabulary: [PRODUCT] in the language of [LANGUAGE]. This adaptation reflects the inherent constraints and capabilities of the AI tool and underscores the influence of its underlying mechanisms on the creative process, shaping the way we approach design generations within this AI-assisted framework. We then experimented with a phone cover, a simple product whose primary design focus is aesthetic appeal. We aimed to apply a texture to it, giving it a 3D appearance, by using an abstract image with a pronounced texture as a guiding reference (Graph 2). Initially, we utilized the Blend Function, which, as mentioned, does not allow for specific instructions on how the blending should occur.

"SUBJECT in the style of STYLE" --------> **"PRODUCT in the language of LANGUAGE"**

The result was a successful blend of styles in terms of shapes and color, yet it failed to capture the desired fabric texture.

We augmented the process by incorporating a text prompt alongside the reference images. However, the results still did not accurately reflect the desired style, mainly because the fabric texture was lacking. Interestingly, we noticed that the color palette of the first image provided in the prompt was emphasized more, confirming that Midjourney gives decreasing weight to prompts based on their order.

Since we could not achieve satisfying results through blending or pairing a text prompt with an image reference, we started iterating with the resulting images. We still aimed to guide the generation process using text prompts. Although the outcomes were visually appealing, they still did not align with the desired texture. However, they did offer an interesting mix of the initial images' shapes and colors, demonstrating a unique fusion that, while not entirely meeting our expectations, provided a fresh perspective on possible design directions.

As highlighted in the first chapter, prompt engineering is an iterative practice: numerous alternatives were explored to gain deeper insight into the AI's responsiveness, and many attempts failed to produce the desired results. The images in Fgure 14 resulted from continued variations and blending of the variations. Eventually, since we could not achieve the fabric texture through images, we experimented with purely text-based prompts (Figure 15). Initially, our descriptions did not produce what we imagined. So, we went for the describe tool, and Midjourney provided many useful terms. Combining our instructions with Midjourney's suggestions finally led to the realization of the fabric texture. Although excessively detailed, it was closer to our intended outcome than any attempts using reference images. In its simplicity, this experiment provided more profound insights into the tool's capabilities and which functions are best suited for specific tasks.

Graph 2.
Procedural Scheme of the generative steps conducted for the experiment.

[Selected Iterations] [Variations]

Figure 14

While not delivering the expected results, the blend function introduced an inspiring element of serendipity. It became evident how different prompting modalities prioritize various design aspects, offering valuable lessons on the tool's versatility and application in design exploration.

Figure 15

[**Prompt**]
An iphone cover front view, in the style of 3D organic forms and patterns, light violet and light pink tactile wool textures, fabrc moquette texture, wool texture, light magenta and dark blue bold color blobs, poolcore, comfycore, mottled, white background.

5.4 Trying different (sketch-to-image) Models

We wanted to test other AI models to determine their potential as valuable additions to the process. Vizcom was particularly promising because it is the first generative AI tool tailored explicitly for design outcomes. It holds a significant advantage over Midjourney in that its final outputs are already visualized in a designerly way (photorealistic renders, with or without an inserted setting). A key distinction is that the render is generated from an initial sketch, with the option to include a text prompt. We opted to test it with sketches from two previous Design & Engineering Degree Course projects: a folding e-bike and a table lamp. The objective was to see whether this tool could have assisted the team in achieving a better or distinct outcome, starting from the initial sketches.

5.4.1 Test 1: Folding e-bike

Figure 16

Figure 17

Before submitting the sketches, I tested Vizcom's ability to produce outcomes based solely on text input, similar to Midjourney. The results of this initial test were rather disappointing. The representation of the bike was nonsensical and disproportionately structured, and it included elements that lacked any purpose or significance. This suggests that this tool might be helpful only when some sketches have already been produced by the design team. Therefore, after the first text-only prompt, we submitted a sketch generated by a student in a stage where the design team had already defined some core aspects of the project, like buy-components choice and placement, but they were struggling to design custom parts and define a product language.

For the first generation, we maintained a very straightforward text prompt (*Folding e-bike design concept*), without adjusting the Drawing Influence parameter (keeping it at 100%). Vizcom produced an extremely literal render that offered an idea of how the bike would have looked, so it would be helpful for evaluating the design's

Figure 18

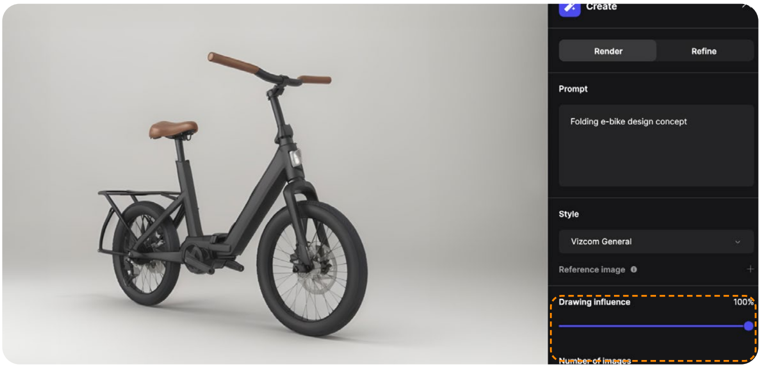
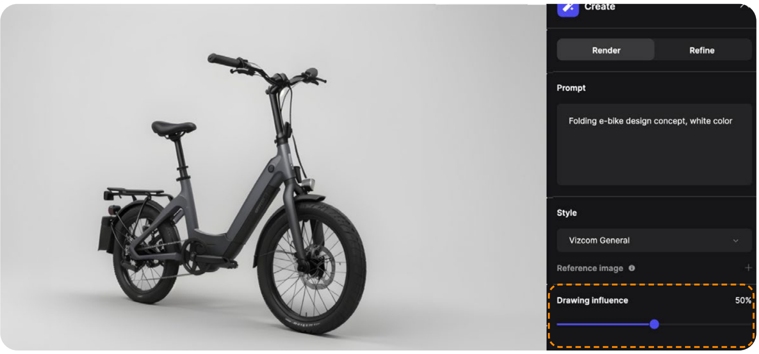


Figure 19



strengths and weaknesses without the need for 3D modeling and rendering. This approach could significantly save time in the design evaluation process.

In our second generation, we changed the Drawing Influence to 50% and specified in the text prompt that we wanted the main color to be white. The render was more inspiring, maintaining coherence with the sketch but significantly interpreting the shapes and details, suggesting a stronger product language. However, it did not follow the color indications.

Lastly, to get the desired color, we used another software function that allows sketching over the render to indicate desired changes. Lacking an iPad or a graphic tablet, we were unable to sketch with precision, leading to a render that was similarly imprecise.

This first experiment with Vizcom highlighted its utility in the design process once some concept sketches are available. Specifically, at 100% Drawing Influence, Vizcom offers a faithful visual representation of the sketches, aiding in evaluating the design's viability without

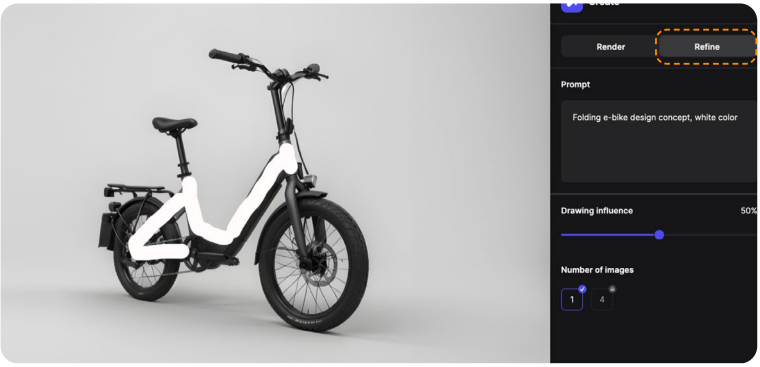


Figure 20

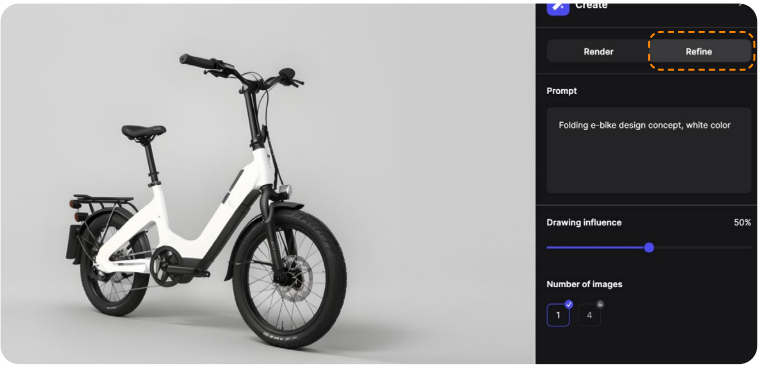


Figure 21

extensive 3D modeling. This feature can significantly streamline the evaluation phase, allowing designers to identify and address design strengths and weaknesses quickly. Conversely, reducing the Drawing Influence introduces a degree of creativity, transforming the tool from a mere visualizer to a design collaborator. This flexibility encourages the exploration of alternative design aesthetics and product languages.

5.4.2 Test 2: Table lamp

Figure 22

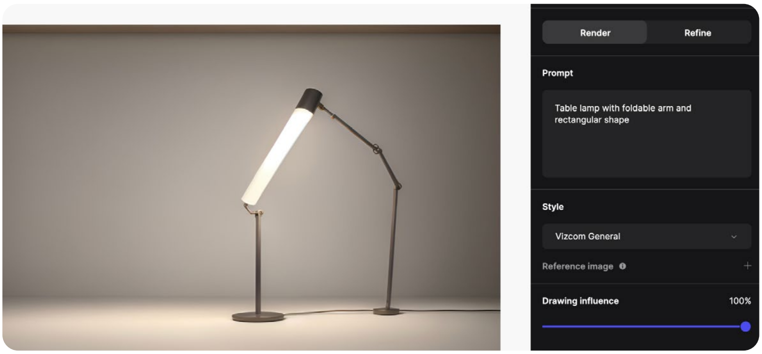


Figure 23

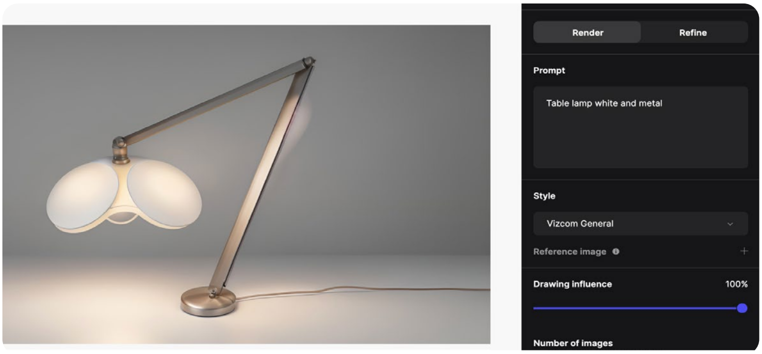
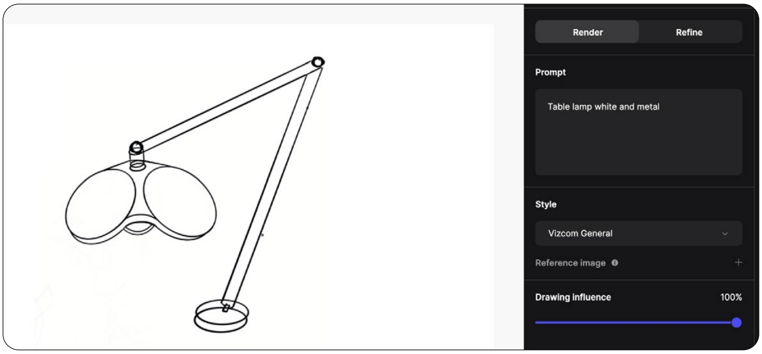


Figure 24



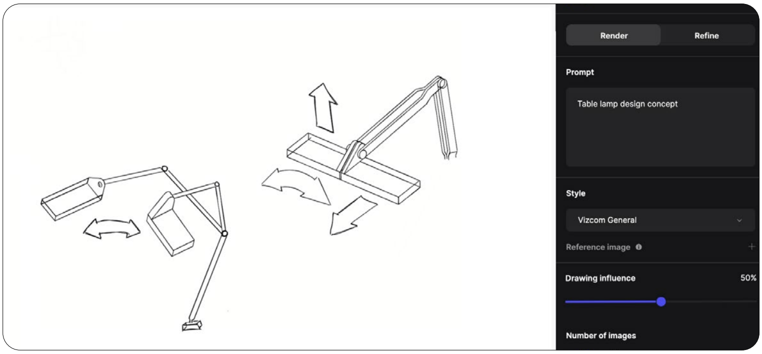


Figure 25

Figure 26

We tested the tool on a second project to gain more evidence of its utility for our research. This time, the focus was on designing a technical table lamp tailored for watch repairers, providing adequate light and avoiding shadows on the table. The brief was quite specific, but most crucially, the drawings were made at an initial stage of the process, and there were no group members particularly good at sketching, so they were conceptual and schematic.

An initial attempt was made using a text-only prompt in which we specified some early design directions (*Table lamp with foldable arm and rectangular shape*). Once again, the result was nonsensical without an input sketch.

The results after submitting two different sketches for the two concepts were quite disappointing, demonstrating the significant impact of the realism and detail of the sketches on the quality of the generated render. The AI showed a lack of interpretation of the schematic drawings, leading to nonsensical and unrealistic results. Even reducing the Drawing Influence value did not produce good results.

5.4.3 Findings

The study revealed several findings regarding the use of Vizcom in the concept creation phase:

Vizcom only produces good results from highly detailed and realistic sketches. This suggests the tool is better suited for stages in the design process where the concept has been thoroughly thought out and articulated visually. Additionally, the utility of this tool is constrained for users who lack proficiency in drawing, necessitating additional effort to produce sketches of an acceptable quality to be processed by the machine.

Once a concept has been clearly defined and detailed sketches are available, Vizcom proves invaluable in bringing these ideas to life through realistic renders. This capability allows designers to see their concepts in a more tangible form, facilitating discussions around practicality, aesthetics, and further refinement. The transition from sketch to realistic render can significantly enhance the conceptualization and iteration processes.

The level of Drawing Influence is a critical parameter in Vizcom, allowing designers to control how closely the render follows the original sketch. Adjusting this parameter can help evaluate the feasibility and effectiveness of the current design or generate new, innovative suggestions. This flexibility makes Vizcom a versatile tool for both refinement and ideation within the design process.

Vizcom's ability to produce variations of renders from a single input sketch offers designers a flexible tool for exploring multiple design directions quickly. This feature supports creative exploration and decision-making, enabling designers to compare different aesthetic or functional aspects of a design without requiring extensive manual adjustments. Vizcom's limitations become evident in the early conceptual stages of design, particularly for generating initial inspiration through text-to-image processes. Its reliance on detailed sketches means it is less effective when used with broad textual descriptions or when brainstorming novel concepts from scratch. This highlights the tool's role as a developmental and refinement aid rather than a source of initial ideation.

Given our research goal of evaluating AI Image Generators' role in inspiring concept generation, it becomes evident that Vizcom is most beneficial in the later stages of the ideation process, particularly once sketches have evolved beyond the conceptual phase and have become more detailed and refined. This underscores the tool's utility in translating well-developed ideas into realistic renders rather than serving as a primary source of inspiration during brainstorming.

Referencing Carmen Bruno's Creative Design Process stages scheme, we can point to Midjourney as a crucial tool during the divergent stage of the ideational phase. This stage thrives on expanding possibilities, making Midjourney's capacity to produce varied and unexpected results particularly valuable. Its ability to rapidly generate diverse visual content supports the creative process by providing a broad array of visual stimuli, which can spark new ideas and directions in a project's early stages.

Conversely, Vizcom is better suited for the convergent phase of the design process, where the goal shifts towards refining ideas or, during the prototyping phase, to more precisely define the concept. In these later stages, the emphasis is on narrowing options, making detailed decisions, and moving toward a finalized design. Vizcom's strength in producing high-quality renders from detailed sketches aligns well with these objectives, offering designers a tool to visualize and refine their concepts. Its application can also prepare for creating prototypes, providing a clear and realistic representation of the intended outcome.

PART 3

Conducting the Experimentation

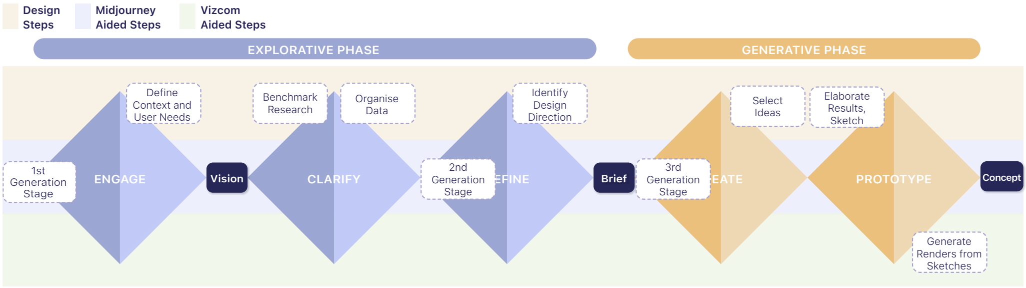
6. Three Concepts' Study

6.1 Concept Generation Process Hypothesis

Considering the distinct capabilities and utilities of generative AI tools, we aimed to investigate the effectiveness of image-generator AI tools in facilitating concept generation within the design process. Recognizing that each software possesses its unique operational mechanics and grammar that users must learn, selecting specific tools for examination became relevant.

Midjourney was chosen as the primary tool, focusing on leveraging its text-to-image and multimodal interaction capabilities for image generation. Before initiating the experimentation to assess the tools' contribution to concept generation, we formulated a process hypothesis (Graph 3). We also planned to incorporate Vizcom into the study to a limited extent.

The process hypothesis was inspired by Carmen Bruno's scheme, which outlines the stages of the creative design process. To it, we added the actions typically performed by human agents, also intro-



Graph 3.
AI-aided Concept
Generation Hypothesis.

ducing a layer for Midjourney and a layer for Vizcom actions. This way, we delineated how each tool could potentially augment the traditional design process, providing a structured framework to explore the interplay between human creativity and AI-assisted design.

Graph 3 delineates the conventional design steps in the first row, highlighted in light orange. We added four primary points of interaction with AI: three involving Midjourney and one with Vizcom. Midjourney is engaged during the divergent phases, while Vizcom is utilized in the convergent phases.

The following chapters will explore and verify these process steps and their efficacy.

Midjourney-Aided Steps

- The initial interaction with Midjourney occurs before defining the vision, aiming to test the AI's understanding of the topic. This step is crucial, as Midjourney's training across different product categories varies, and clarity in the product category can influence the effectiveness of the outcomes.
- Midjourney's second engagement is just before establishing the design brief. At this point, prompts become more specific, inspiring the design brief by suggesting previously unconsidered directions or solutions.
- The final application of Midjourney follows the formulation of the design brief, facilitating the creation of structured prompts for actual idea generation. This phase demands numerous iterations and variations to refine concepts.

Vizcom-aided Steps
Vizcom is introduced during the last convergent phase, preceding the concept definition. At this point, the most promising ideas from Midjourney's generations are selected, reworked, and transformed into concept sketches. Vizcom offers guidance toward finalizing the concept, providing a pivotal hint for concept crystallization.

6.2 Research Objectives

Our design experimentation was guided by various questions that fall into two primary areas of inquiry:
Process-Related Inquiry: These questions explore the implications of integrating the chosen AI tools into the design process, examining their utility and potential limitations. The focus here is on understanding the broader impact of AI tools on the traditional design workflow and identifying areas where they enhance or complicate the creative process. Specifically, the goals are:

- To evaluate the utility of current image generators in enhancing industrial design processes, considering the feasibility-centered nature of this field against the unpredictability and fantasy offered by AI.
- To assess which aspects of the design process these tools may enhance.
- To identify the steps in which image generators could be integrated into the design process, determining whether there is an optimal pattern for their use or if they are more effectively employed intuitively.
- To determine whether using these tools consistently accelerates the design process and to identify scenarios where attempting to achieve the desired result from AI could lead to fixation.

Tool-Specific Inquiry: This aspect of the research focuses on the specific AI tools selected for the experiment. Given the significant differences among AI tools, the choice of software alters the overall process and interactions. The aim is to uncover best practices for leveraging Midjourney's capabilities in generating design concepts and to evaluate how Vizcom can be utilized to refine these concepts into more polished designs, precisely:

- To establish specific guidelines for the effective use of Midjourney in industrial product design, understanding how to leverage the algorithm's characteristics for such purposes.
- To develop a guide for prompt engineering tailored for industrial design, examining if there is a preferred prompt option (text, multimodal, blend) or combination that is most effective in Midjourney for industrial design contexts. Additionally, identify which settings and parameters give the best results.
- To assess Vizcom's potential for concept inspiration, defining the stage of the process where the tool is most effective and determining whether it is valuable for this research.In summary, this structured inquiry aimed to highlight the practical applications of these AI tools in the design process within the ever-evolving landscape we are navigating. The goal is to provide insights into this technology's operational strengths and weaknesses in its current state of the art. As a result, this exploration may showcase existing gaps and inform future developments of AI tools for design.

6.3 Three Products, Three Perspectives

Initially, we needed to determine whether to develop one concept in detail with feasibility evaluations and final models or to concentrate on the initial idea generation. This would involve producing several concepts, focusing on comparing the generation phases without emphasizing their implementation. We concluded that — although implementation and development are central to our field of study — they are not crucial for determining the usefulness of these tools in concept generation. Therefore, we decided to develop three concepts, followed by a brief feasibility analysis and predictions of possible development. This enabled us to explore different nuances of industrial design projects and to assess the chosen AI tool's performance across various tasks, specifically:

A Desk Organizer

- Low engineering complexity: With its straightforward design requirements, a desk organizer is an ideal candidate for assessing how well AI can handle simpler, more defined tasks.
- Language exploration possibilities: It offers an opportunity to explore how variations in design language and aesthetics can be generated and evaluated through AI, highlighting the tool's capacity for creative exploration within constrained parameters.

An Electric Kettle

Medium engineering complexity: It introduces a higher level of complexity, incorporating engineering constraints that test the AI's ability to generate concepts within more stringent functional requirements. This serves as a good example of the challenges presented by products that necessitate a balance between aesthetic appeal and technical functionality.

A Smart Thermostat

UX/UI aspects: Including a smart thermostat allows for comparing AI's efficacy in generating concepts that integrate product design and user interface (UI) elements. This dual focus provides a comprehensive view of how AI tools can support the development of products that are physically tangible and interactively complex, considering Midjourney's current inability to correctly generate letters, numbers, and text with meaning.

7. Concept 1: Desk Organizer

7.1 Explorative Phase

In workspace management, desk organizers are pivotal in transforming cluttered desks into models of efficiency and order.
These tools are defined by their functionality: they are crafted to provide a designated space for multiple or specific office supplies. The evolution of desk organizers has mirrored the changing landscape of the workplace. As office work has become more dynamic, with an increasing number of gadgets and accessories accompanying traditional stationery, the desk organizer has evolved to accommodate these new needs. Today, they often incorporate features like charging ports, device stands, and modular components.

In this phase, our study was dual-focused: on the one hand, an exploration of the product category, examining existing products, current trends, and various design solutions; on the other, we tested Midjourney's capability of capturing the nuances of these elements.

We initiated this process with *Preliminary Generations*, fine-tuning the prompts to better communicate with the tool. Subsequently, we undertook product research, assessing potential scenarios and exploring viable design directions. The selected design direction was then tested and narrowed through a second round of Generations, which ultimately guided us in formulating a precise design brief.

7.1.1 Preliminary Generations (1st Stage)

Willing to explore the generative capabilities of the software using basic, generic prompts, we initially set out with a prompt that specified only the [Subject] – or [Product] category without further specifications.

As depicted in Figure 1, Midjourney generated fantastical and non-sensical images, aligning with its artistic intent. This led us to guess that the algorithm might have yet to accurately identify the product category, contrary to previous tests conducted on other products, where it immediately generated quite realistic images.

[Prompt]
`A desk organizer.`

Figure 1

We then tried to specify the [Language] category, starting with a simple *modern design* specification (Figure 2). This minor tweak better captured the product's essence, showing that a hint of product language could significantly refine the results. However, the images remained unrealistic, predominantly featuring a simplistic, three-component pen holder design.

[Prompt]
`A desk organizer,` **`modern design.`**

Figure 2

Further specifying the material after the style attribute gave slightly more intriguing results (Figure 3). With each additional specification, the generated designs became more detailed and lifelike, although they did not strictly adhere to the provided guidelines. The more detailed the description we provided, the more thoughtful the designs became, yet being interpreted independently of our explicit prompt.

Figure 3

[**Prompt**]
`A desk organizer,` **`modern design trends, polymeric material.`**

Another crucial aspect we wanted to test was the ability of Midjourney to recognize and apply famous designers or design styles to a given product. Images in Figure 4 showcase the results when we instructed the AI to design a desk organizer in the style of Dieter Rams. The software exhibited an awareness of the designer's style. However, it could not reinterpret it into the desk organizer product category. The result was a product reminiscent of a radio, with pens and other items stored in it. The algorithm blended a generic notion of a desk organizer with Dieter Rams' iconic creations.

Figure 4

[**Prompt**]
`A desk organizer in the` **`style of Dieter Rams.`**

Finally, we went for a more structured prompt. Since we started exploring the product category, we were intrigued with the idea of a modular system. Therefore, we specified this solution with color, shape, and stylistic details, such as rounded edges. We also specified that we wanted a render-like visualization of the product on a desk (Figure 5 , p. 104). The outputs were more interesting than the previous ones, following many of our requests, even though some were

[**Prompt**]

A **modular** desk organizer, lamp included, modern design, **minimalistic design,** polymeric material, **red color, squared shapes with rounded angles, stackable,** photorealistic render photoinserted in a picture of a desk.

Figure 5

interpreted less satisfactorily than others. For instance, we specified it to be situated on a desk, and indeed, we observe it resting on a surface reminiscent of a desk, though it is not distinctly identifiable. Additionally, the modular aspect was not pronounced.

The final text prompt generations were conducted with a very long and detailed prompt. As the images in Figure 6 show, these outputs were undeniably the most realistic. However, the design lacked innovation. After numerous trials, our hypothesis evolved to suggest a necessary trade-off between abstract or nonsensical images, which could inspire innovation but need a deep reinterpretation, and realistic images, which may appear banal and need the designer to add some interest.

To define the design language more precisely (moving beyond the simple descriptors of *modern* and minimalist), we incorporated a broader range of adjectives, specifying additional design directions like *compact* and that it *fits seamlessly on a desk without occupying too much space*. Interestingly, these instructions led Midjourney

[**Prompt**]

Design a desktop organizer that is **sleek, stylish, and minimalist.** Consider the following design elements: Clean and Minimalist Form. Create a simple and streamlined form for the desktop storage box, with clean lines and a **minimal number of elements.** Opt for a **compact size** that fits seamlessly on a desk without occupying excessive space. Use **acrylic materials.** Add visual interest. Modular Functional Compartments: Design the storage box with **only 4 compartments** or dividers to help organize different items, such as pens, notepads, paperclips, or small office accessories [...]. Ensure the compartments are easily accessible and efficiently utilize the available space. **Minimalist Color Palette:** Choose a **bold color** palette of **two or three colors.** Consider **rounded edges, smooth surfaces,** and user-friendly features that enhance usability. **--style raw**

Figure 6

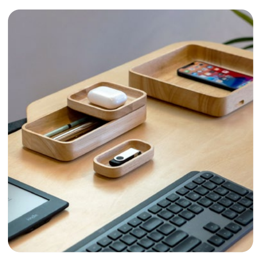
to place the desk organizer on an actual desk. We clarified that we wanted a *minimal number of elements* and *only 4 compartments* to counteract the AI's tendency to create overly complex designs.

Furthermore, we specified the material as *acrylic material*, which was accurately depicted by the AI. However, our request for a *bold color palette of two or three colors* was not fully realized, potentially because sentences are given progressively less weight when placed toward the end of a lengthy prompt.

Employing the *-style raw* parameter was pivotal in obtaining images that adhered more closely to the prompt and were less driven by the AI's imaginative extrapolations.

Lastly, we selected some modular tray organizers found online and the 621 Table by Dieter Rams as references. In the prompt, we further specified that we were looking for delicate forms with rounded edges

Figure 7

[Prompt]	+[Product]	+[Language]
A **modular** desk oganizer **in the style of 621 Table by Dieter Rams, sackable pieces, rounded edges,** polymeric material, white color, minimal design.		

and pieces that could be stacked. The results demonstrated Midjourney's capability to synthesize elements from both reference images, with recognizable features present in the results. However, the style interpretation was not as effective, as it primarily adopted the color scheme from the second image (Dieter Rams' table) without fully capturing the essence of the design language. Shapes still resemble the desk organizer image, featuring soft curves only with a more intricate composition. Similarly, some functional specifications, like *stackable pieces*, were not accurately understood.

7.1.2 Product Research

The outputs of the First Generations showed that Midjourney was confused about the *Desk Organizer* product category, leading to weird results. Recognizing the pivotal role of words in text-based interactions, we revisited the fundamental step of term retrieval, as discussed in Chapters 1 and 2.

Text-to-image AI requires designers to translate visions into words and engage in a term retrieval process, given the significant impact nuances in wording can have on the generated image. For this reason, before diving into the usual research on existing products, it was necessary to start with the basics, searching for product definitions. While this might seem trivial and certainly adds an extra step to the standard design process, it was crucial for refining our text prompts. Additionally, considering Midjourney's optimal performance in English, this step becomes even more critical for non-native English speakers. The product *Desk Organizer* was defined as a storage accessory designed for organizing and holding various items commonly found on a desk (stationery items, office supplies, documents, electronic devices, cables). This definition helped clarify whether the product was intended for a specific category or multiple categories, and if so, which ones. It could also be described as a tool that enhances workspace efficiency and productivity. It provides structured spaces, like compartments or sections, for the orderly arrangement of items. This interpretation underscored the importance of specifying *structured spaces* in the prompt, detailing the envisioned solution. What was most helpful was categorising desk organizers into two types: 1) multi-items storage and 2) specific items storage, such as file organizers, pen holders, and drawer organizers. This distinction is far from trivial, as a search for *desk organizer* often yields results for pen holders or specific items organizers, reflecting a potential bias in the AI's understanding of the term while we were referring to multi-storage.

7.1.3 Benchmark

Researching existing products, we found many interesting designs and identified several categories, each offering unique solutions to different design challenges.

The first challenge is saving desk space. Some solutions include designs that develop vertically rather than horizontally, like multi-tiered or wall-mounted ones. Additionally, some designs can be attached to various surfaces, enhancing their versatility.

Another challenge revolves around portability: some desk organizers are designed to store more DIY-style tools and thus require easy mobility. A solution to this is the toolbox-style design, exemplified by the famous MELT 505 Caddy from Vitra.

Lastly, there is an everyday request for customizable design, which can vary depending on necessity. This is addressed by modular tray designs — families of trays in different sizes that can be combined in various ways. We found this last category particularly inspiring.

7.1.4 Defining Design Direction (2nd Stage)

In seeking to define a design direction, we focused on customizability and adaptability. The idea of using interchangeable modules caught our interest, and to further explore this, we conducted a second test in Midjourney (Figure 8, p. 108). Our text prompts were crafted to express a desire for *interchangeable modules to store different items*.

The results were once again not satisfactory. This was primarily due to our approach of detailing functional aspects, hoping to get a corresponding design. However, the algorithm still struggles to handle these types of associations. This realization led us to independently determine a concrete design direction by setting a design problem to solve creatively. Subsequently, we used that solution as a basis for the prompts to explore the AI's interpretations. Analyzing this experience, while Midjourney did not directly facilitate the inspiration for the design brief, it did offer some insights. By delineating what it could and

Figure 8

[Prompt]

A minimal and modular desk organiser, of geometric shapes and bold colors. **Interchangeable modules that can store different items.** Matte plastic material. Modern design trends. Realistic photo. 8k.

could not do, the tool inadvertently guided our design choices, educating us on its capabilities through its shortcomings and influencing our decisions in a subtle yet meaningful way.

7.2 Design Brief

Scenario:
Personal desk usage involving constraints of small spaces and the need to store various items. Users might have evolving requirements, which can also vary significantly among individuals.

Product to design:
Design a highly adaptable modular tray system, offering various storage options to meet the diverse needs of a personal desk.
The design should be transformative, enabling users to rearrange components according to their specific requirements while prioritizing space efficiency on the desk.

Requirements:

- Customizable Modules: The system should feature modules that can be easily rearranged or detached to adapt to evolving storage needs.
- Multi-Item Storage: It must provide varied storage options for various items, such as pens, small stationery, and electronics, facilitating organized and accessible storage.
- Compact Design: The organizer should have a footprint that ensures it complements rather than dominates the area to avoid overcrowding the limited desk space.

+ Playful Aesthetic: Incorporate a design that adds a pop of color to the desk environment without overpowering, enhancing the space with a visually appealing element.

+ Electronics Charging Capability: Include the ability to charge electronics directly, catering to the common need for power access on personal desks, thus enhancing functionality and convenience.

7.3 Generative Phase

With the design brief defined, we could restructure the prompts to align closely with the specific brief and its requirements.

In the following paragraphs, we will explore the iterative generations and the considerations that led to the definition of the concept.

7.3.1 Concept Generations (3rd Stage)

We initially tried using text-only prompts, incorporating specifications derived from the brief, such as a *modular tray system*. We opted for a long, detailed prompt that described features and physical attributes, intentionally steering clear of overly conceptual notions (Step 1 – Figure 9, p. 111). However, text prompts failed again. We concluded that generating effective outcomes on this topic with text prompts was improbable, likely due to the nuanced nature of the product category. Consequently, we decided to use image references and blending images.

We added reference images to the textual prompts (Step 2 – Figure 9, p. 111). The resulting images displayed feasible and more logical products in their composition than the previous ones. Yet, they presented a lack of innovation. Iterations presented qualitatively similar results to the ones shown in Step 2. This led us to directly explore the blend option, acknowledging that text prompts were not guiding the development of this product as effectively as anticipated. We selected some notable reference designs, each incorporating a tray system solution or playing with the geometries to define spaces (Step 3 – Figure 9).

The final outputs are showcased in Figure 10, p. 112; they are the results of using both the Blend Feature and the Text + Reference Images Option, which underwent post-production in Photoshop to remove major nonsensical elements generated by the AI. While not directly inspiring, they marked the point at which we concluded the generation phase, aiming to develop a solution from what had been generated. This decision was driven by the realization that Midjourney was not yielding beneficial results for this specific product.

In Figure 11, p. 113, we report the results of some other final variations. We made those last attempts out of curiosity and obtained something unexpected: the software successfully produced tray family designs in a form that was not structurally significant but was particularly inspiring language-wise. This success underscored the moodboard-like value of AI-generated designs, a topic already discussed in Chapter 3.

Figure 9.
Steps followed to reach concept generation, with sample images for each prompt option.

Figure 10.
Selected Images.

Figure 11.
Variations.

7.3.2 Selected Results

Upon completing the generation process, we distinguished between results based on their moodboard value and their potential as concept inspirations. Indeed, the process did not deliver a single image to be used as a concept but provided various visual hints for combination. In seeking inspiration for the concept, we noticed a recurring theme: the presence of three or four modules, capable of fitting into each other, characterized by a rectangular shape with pronounced rounded edges. While this observation did not constitute a concept, it inspired us to envision a solution based on these visual cues.

Figure 12.
Images selected to inspire moodboard.

Figure 13.
Images selected to inspire concept.

7.4 Concept

Leveraging the selected images, we envisioned a way to render them functional and meaningful. We considered how three rectangular elements of varying sizes could intelligently nest within each other. We conceptualized a set of three nesting modules, each successively smaller than the last, designed so that their placement could dynamically alter the configuration of compartments (Figure 14). For instance, aligning a smaller one all on the side creates a single, expansive area in the bigger one, whereas positioning them centrally results in two distinct, smaller spaces.

Before moving on to concept refinement, we wanted to assess Vizcom's capability to develop concepts based on initial sketches characterized by unclear lines. Due to its literal interpretation of sketches, the renders were of poor quality.

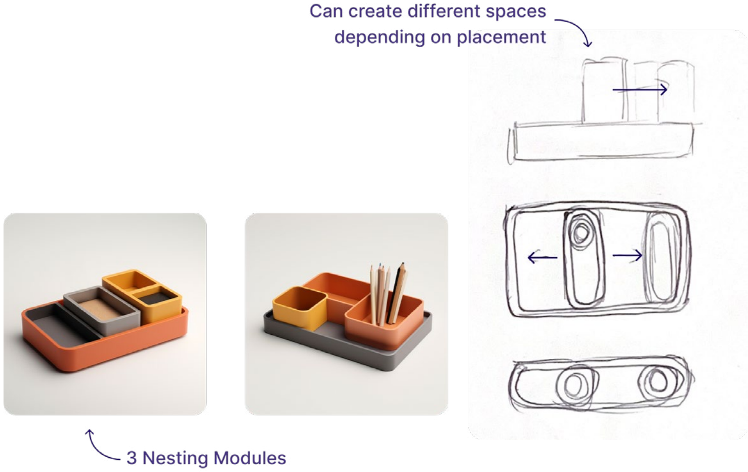


Figure 14. Development of the idea starting from Midjourney's generations.

Despite adjusting the parameter settings, achieving a satisfactory result from a rough sketch was impossible (Figure 15). As a result, we chose to exclude Vizcom from developing the following two concepts, re-evaluating the initial process hypotheses.

We therefore transitioned directly to sketching first and 3D modeling then for enhanced precision. By designing a system where each tray is one-third the size of the next larger one, we achieved optimal dimensions for a system that allows the smaller tray to fit inside the larger one. Additionally, this design permits the placement of multiple smaller trays within a larger one (Figure 17, p. 116). We also graduated their heights, adhering to a module where the shortest

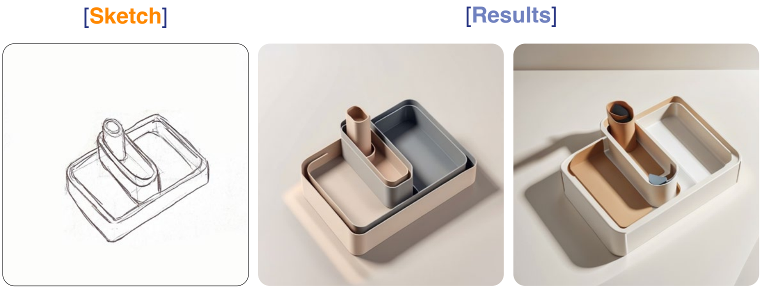


Figure 15. Unsuccessful attempt at using Vizcom for concept refinement.

tray is one-third, and the middle tray is two-thirds the height of the tallest. This solution facilitates movement and extraction of the trays and accommodates various products, such as allowing pens to stand in the tallest tray (Figure 18, p. 118).

The utility of this design lies in its adaptability, allowing for simple reconfiguration by moving a tray from the center to the side. Furthermore, the trays can be adjusted freely to create spaces of varying sizes, different from the standard configurations of all trays to one side or centrally located (Figure 16).

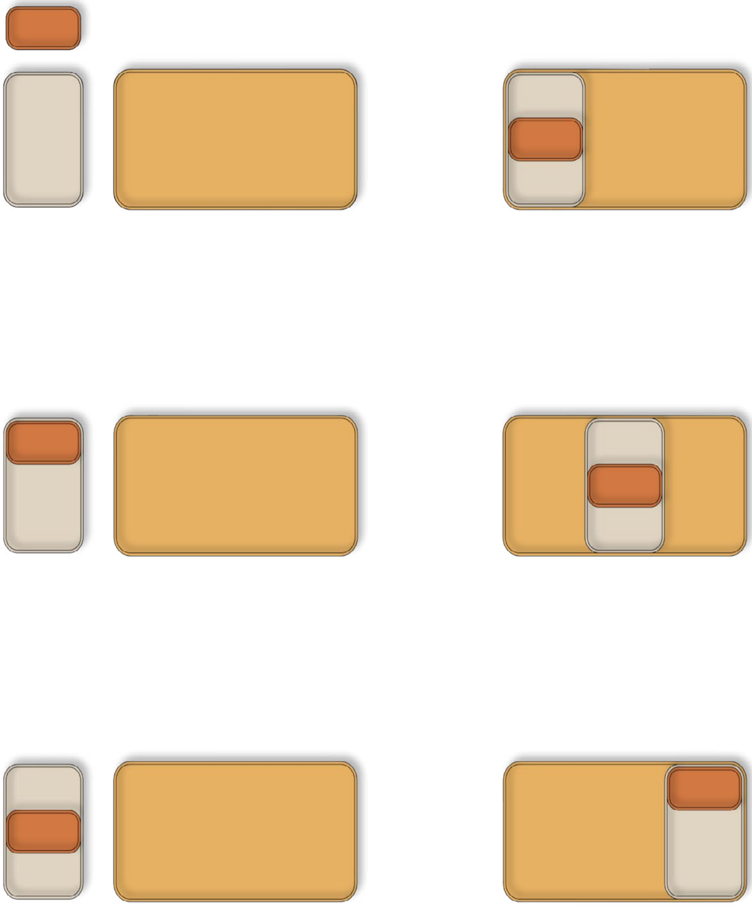
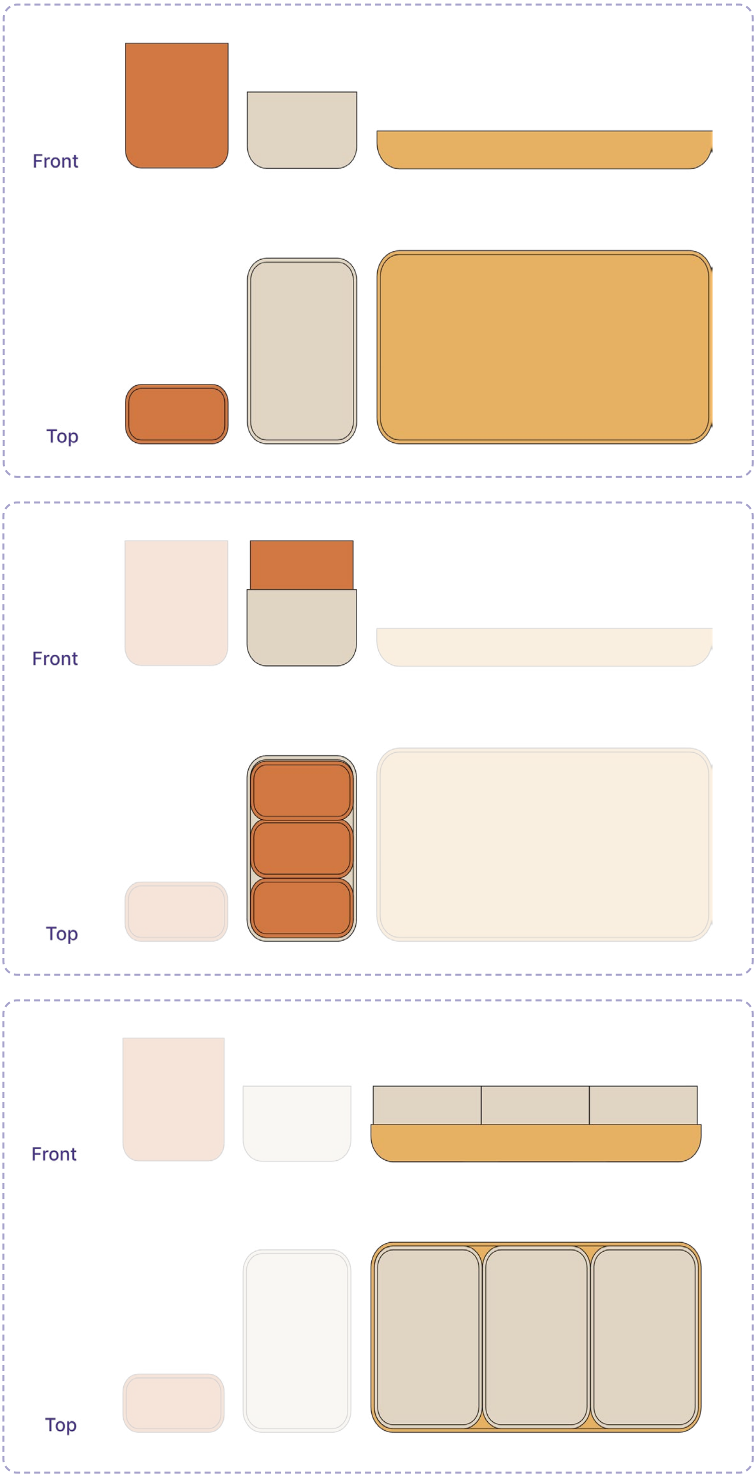


Figure 16.
Top views illustrating all possible placements of the three tray sizes.

Figure 17.
Top and front views of the nesting trays, highlighting spaces and nesting ability.



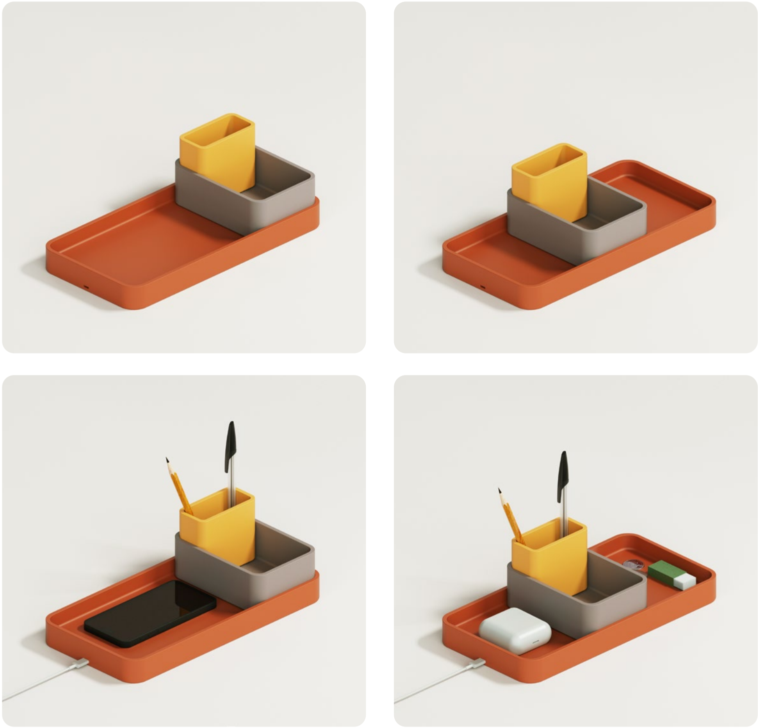


Figure 18.
Renders illustrating various use options for the product.

Another consideration for personal desk usage is the need to charge electronic devices such as phones or earphones. Incorporating inductive charging capabilities into one of the trays could address this requirement, enhancing the system's functionality.

7.4.1 Feasibility Evaluations

The dimensions of the trays were meticulously considered.
The bottom tray, being the shortest yet widest, measures 30 cm by 15 cm in plan projection. The second tray has dimensions of approximately 9.5 cm by 13 cm, while the smallest measures about 4.5 cm by 8.5 cm. These measurements ensure that the base tray can accommodate a charging phone, which typically measures 14 to 16 cm by 7 to 8 cm.

The heights of the trays increase progressively from the bottom to the top, with heights of 75 mm, 50 mm, and 30 mm, respectively. This arrangement is inverted from the tallest one downward to ensure the tallest tray can stably hold pencils.

Their design features simple geometry with edge rounds of 20 mm, 15 mm, and 10 mm, respectively, determined by a wall thickness of

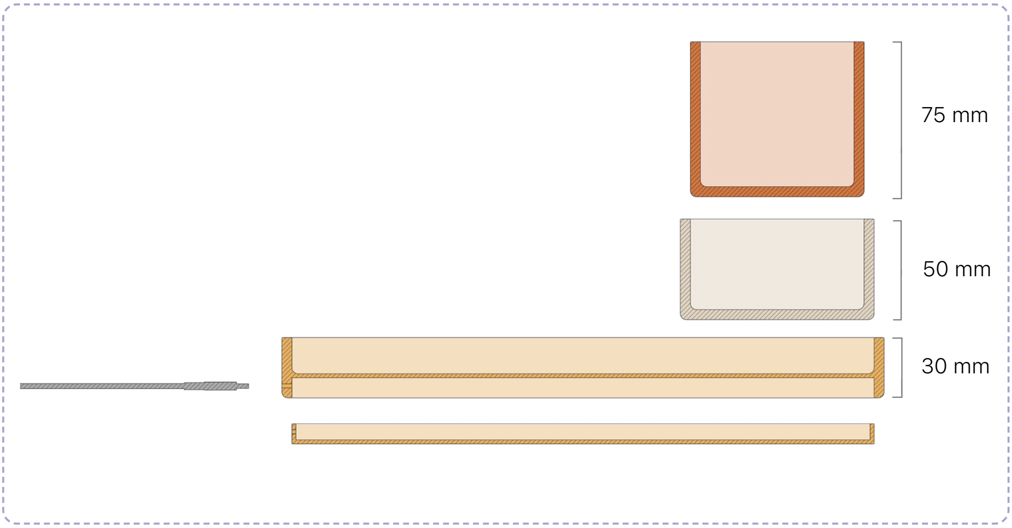


Figure 19.
Front view sections.

5 mm. While this thickness might appear substantial, it is essential for the stability of the pen holder, and the dimensions of the other trays are adjusted accordingly to maintain this stability. Feasibility assessment indicates that they can be easily manufactured from ABS/PP via injection molding, making the design practical and manufacturable.

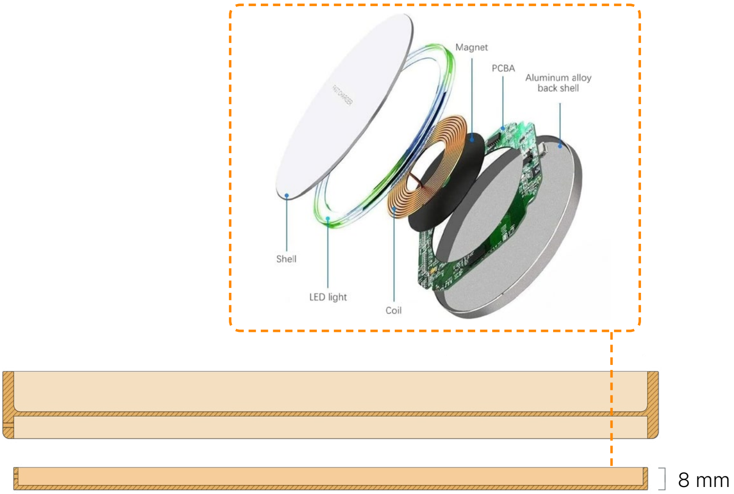


Figure 20.
Bottom tray's section with an example of an inductive charging device.

7.4.1 Material Choice

ABS is a prime candidate for these trays due to its mechanical robustness and ease of finishing. ABS has a tensile strength of about 40 MPa and can withstand considerable handling, making it suitable for everyday use on a personal desk. Additionally, its surface can be finished to a high quality, allowing for a range of colors and textures to contribute to the playful aesthetic envisioned for the product.

7.4.2 Manufacturing Processes

Injection molding can consistently produce the specified wall thickness of 5 mm, which will contribute to the trays' stability and longevity. The rounded corners will require careful consideration in the mold design to ensure they are accurately replicated and that the mold parts separate cleanly without damaging the product. The process tolerances for injection molding typically range from ±0.500 mm for a dimension of 125 mm, ensuring precision in the final product that aligns with the design specifications.

The bottom tray has a slightly more complex geometry because it contains the charging elements (Figure 20, p. 119). Based on the design of most inductive chargers on the market, their overall thickness (plastic case included) is less than one centimeter. For this reason, a space of 8 mm has been left for the charging components, which include a PCB, a magnet, and a coil, all with minimal thickness. There is then a hole for the charging component. The wall surface where the electronic devices are placed will be thinner to enable efficient induction.

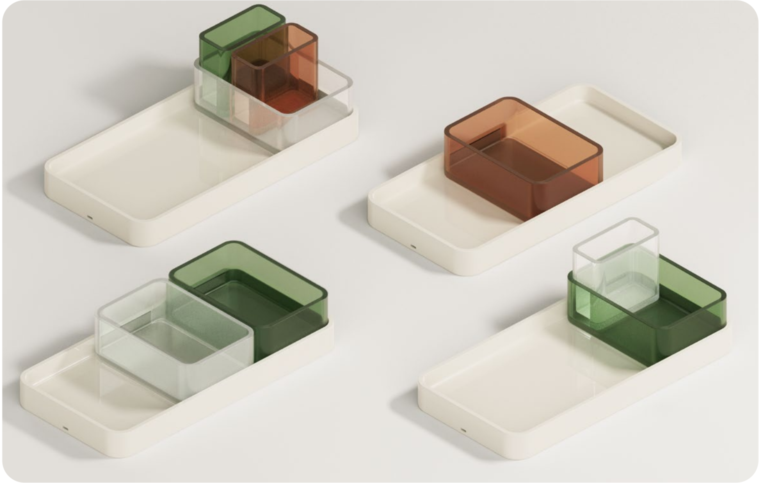
7.4.2 Variations

To conclude, we realized some render variations inspired by Midjourney: we applied different materials and finishings, following the images selected for their aesthetic qualities and moodboard value (Figures 21 and 22).

The intriguing results suggested the potential for a combined approach to Midjourney-generated products. During the image generation process, it is beneficial to retain different generations, even if they seem insufficient on their own, as their combination can spark creativity.

Figure 21.
The smallest image is generated by Midjourney, and the other is a render of the concept developed by adopting Midjourney's language.

Figure 22.
Similarly as above, the first image is generated by Midjourney, and the second one by the authors developing the concept.



7.5 Outputs

This first experimentation gave as output a concept that was only partially inspired by the AI, leading to an unexpectedly long process. Our observations yielded insights into three distinct aspects of the process: Midjourney and Vizcom's performances and considerations regarding the overall process.

The analysis of this concept's Generation Stages is reported in Graph 4 (p. 125), while the process revision consequent to this study is illustrated in Graph 5 (p. 125).

Regarding Midjourney's performance:

- Midjourney fell short of producing outputs that suggested functional innovation, particularly in the usability and arrangement of components. Despite numerous attempts with varied prompts, the results tended toward conventional ideas, repeatedly generating unrealistic or poorly designed concepts, such as simplistic tray-like structures.
- The two processes of concept ideation and concept development were quite discontinuous; while the results from Midjourney inspired the product language and general functioning, the concrete concept had to be developed independently. Occasionally, it created outputs that could be used as a moodboard, enriching the aesthetic ideation phase.
- Unable to use text prompts successfully, we turned to the Blend function; however, it struggled to combine images in a coherent and logical manner. Here, as for the first point, Midjourney's inability to generate realistic products is possibly due to its unfamiliarity with the product category, meaning that the algorithm does not precisely correlate images with syntactic definitions. Product design in this category is less established compared to others. During initial tests, it was evident that for certain products, just a few words could immediately generate realistic designs, with a better likelihood of creating functional combinations in an interesting way.

Regarding Vizcom's performance:

- The experiment confirmed that Vizcom performs optimally with high-quality sketches, a requirement we could not fulfill for this experiment.

About the Overall Process:

- The absence of inspiring results led to an extensive period of prompt iteration, which extended the design process significantly.
- The risk of design fixation emerged when we found ourselves attached to high-quality images that were not directly applicable, dictating a tendency to force a rationale on images simply because they were visually appealing.

7.6 Process Revision after Concept 1

The first experiment refined the process hypotheses, excluding Vizcom from aiding concept generation. In Chapter 5, we positioned Vizcom as most useful in the later stages of ideation, to refine sketches that have evolved beyond the conceptual phase. In the context of this study, not only was the focus on initial inspiration, but also, due to resources and time constraints, it was considered more beneficial to concentrate on one tool.

However, this observation should not detract from Vizcom's value in industrial design. Indeed, Vizcom can be highly advantageous in specific contexts, where it can refine sketches and propose design enhancements. A notable limitation of Vizcom is its demand for proficiency in drawing or the availability of tools like an iPad for sketch refinement. In this regard, Midjourney is more accessible, enabling anyone to generate images with the only requirement of access to a computer or smartphone.

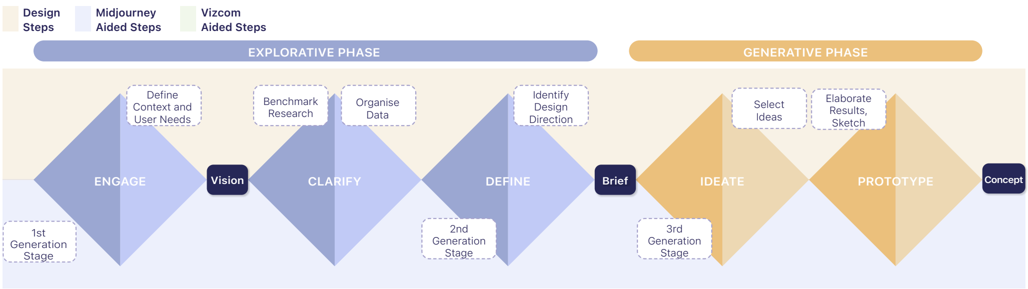
This experience prompted a reevaluation of the initial process. While the Vizcom step was excluded, the steps involving Midjourney were retained, adhering to the anticipated number of iterations and their placement in the concept generation process (Graph 4). The division of Midjourney's generations into three steps allows for analyzing and allocating observed advantages and disadvantages of the tool and the process throughout the experiment, as well as hypothesizing the connection between problem phases and the process. Moreover, this division will be used throughout the study to compare the three concept generation processes.

Reflecting on the three AI-generation steps outlined in the initial scheme (Graph 3), the first step — occurring during the explorative phase — was particularly prominent in this experiment due to the complexity of defining the product and probably because it was the first test of our research.

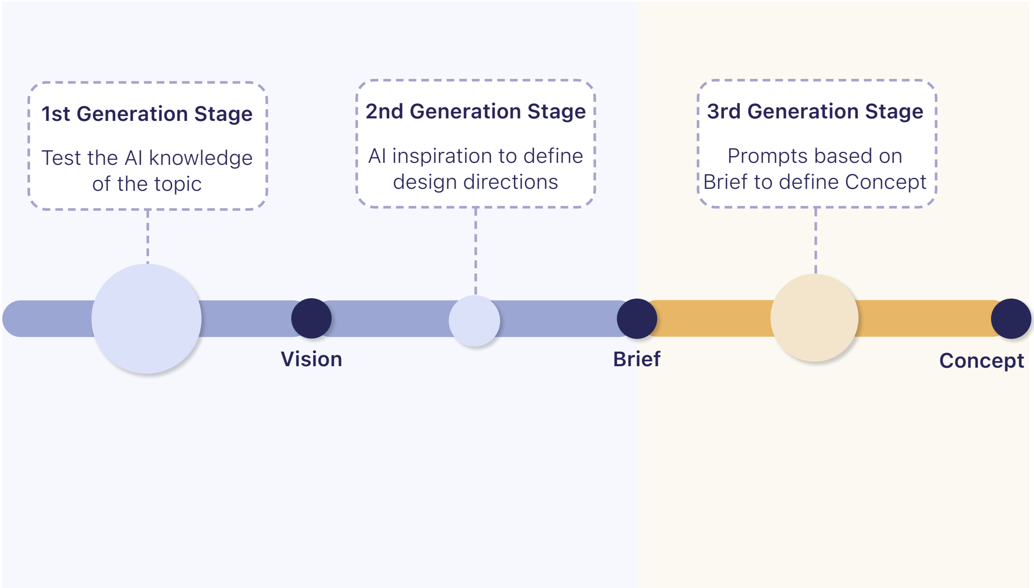
The second generation, aimed at defining the design direction, was rapid. This was due to the AI's difficulty in producing coherent results, which confirmed our understanding of the tool's limitations and led us to define the design direction independently.

The third generation, focused on concept definition, was again quite challenging and time-consuming as we endeavored to extract meaningful outcomes, reflecting the difficulties in navigating toward valuable results.

Graph 5 visualizes the three generative stages, with the circles' sizes varying according to how many iterations were necessary for each step.



Graph 4.
Revised Concept Generation Process, focusing on Midjourney.



Graph 5.
Compared number of generations required for each Generative Stage in Concept 1.

Figure 23.
Other Midjourney-generated images for the concept.

8. Concept 2: Electric Kettle

8.1 Explorative Phase

This product category was selected for its more complex engineering requirements. An electric kettle is a kitchen appliance typically used for heating water quickly and efficiently. It operates through a heating element that brings the water to a boil, and it is equipped with an automatic shut-off feature for safety once the desired temperature is reached. Electric kettles come in various forms, but the main types can be broadly categorized into traditional kettles, which resemble their stovetop counterparts, and modern electric jugs, which are more upright and have a handle and spout.

For this project, we already had in mind a teapot-style electric kettle explicitly designed for brewing tea and making infusions. This type often includes additional features to facilitate the steeping process, such as built-in tea baskets or temperature settings tailored for different types of tea.

8.1.1 Preliminary Generations (1st Stage)

Initial generations revealed that Midjourney has a solid understanding of this product category. As a result, only a few generations were necessary. While simply writing *electric kettle* in the prompt led Midjourney to generate overly complex products with a cartoonish aesthetic, specifying attributes such as *minimalist* or *smart* yielded substantially better results.

The images in Figure 1 and 2 demonstrate that despite some unconventional features, all iterations were easily identifiable as electric kettles. It was interesting to observe how swapping *electric* for *smart* in the prompt led to nuanced differences. Although not all images are showcased here, *electric* often introduced retro elements, whereas *smart* resulted in sleeker, more minimalist designs, frequently incorporating elements like smartphones or screens. This change in wording brought about distinctive shifts in the generated outcomes, highlighting the sensitivity of the generation process to specific descriptive terms.

[Prompt]
Design a minimalist smart kettle. --style raw

Figure 1

[Prompt]
Design a mnimalist electric kettle. --style raw

Figure 2

8.1.2 Product Research

In this case, unlike the previous experiments, providing product definitions to Midjourney was unnecessary. The AI demonstrated a comprehensive understanding of electric kettles, allowing us to focus directly on research into the functional aspects of kettles. We explored the key components and characteristics to grasp their operation and to identify considerations for the conceptualization stage. The core insights of the investigation are listed in the following points.

Materials:
The selection of materials for kettles plays a pivotal role in their functionality and safety. Durability is achieved by using robust materials such as stainless steel, glass, or premium plastic. It is also imperative that any plastic components are food-grade and BPA-free to ensure health and safety.

Additionally, materials are chosen for their insulation and temperature resistance qualities. Excellent thermal insulation is necessary to maintain the water's temperature while also keeping the exterior safe to touch. High-temperature resistance is equally crucial, enabling the kettle to withstand repeated heating cycles without material degradation.

Safety Features:
The safety features of kettles are designed with user protection in mind. An automatic shutoff mechanism is crucial to prevent potential hazards. Additionally, a cool-touch exterior is essential to ensure the kettle's surface remains at a safe temperature to touch, thereby preventing burn injuries. Moreover, a stable base, characterized by a broad and solid design, is vital in minimizing the risk of the kettle tipping over.

Benchmark:
After assessing the product's main design characteristics, we conducted a benchmark analysis of existing products, similar to the previous concept, categorizing them based on the design problems they aim to solve.

Most trends were focused on overall physical design. For instance, numerous models incorporate water level indicators that denote portions, significantly enhancing user convenience. Some kettles have eliminated the conventional separate base, adopting a single-piece design that offers improved agility and ease of use. Alternatively, specific models prioritize tea-making practices; for example, products like the Fellow Stagg EKG emphasize pouring precision, catering to aficionados who value control over the flow and temperature of water. Lastly, there is a growing trend towards environmental consciousness, with innovations to reduce water and power consumption. An example is the KTTL by Anna Czaniecka, which implements solutions to minimize waste.

8.1.3 Defining Design Direction (2nd Stage)

We chose to tackle the water wastage problem by imagining an individual living alone, searching for a quick and efficient way to prepare infusions without the inconvenience of filling the kettle with too much water and discarding the excess.

The general direction was summarized as a single-serve electric teapot designed to be a compact product that caters specifically to the needs of a single user.

The design requirements were preliminarily established as follows:

- Compact Dimensions: To ensure the teapot occupies minimal counter space.
- Portion Control: Allowing for precise measurement to prevent water wastage.
- Integrated Infuser: To streamline the process of making tea or infusions without additional tools.
- Effective Insulation: To maintain the temperature for optimal brewing and energy efficiency.
- Boil and Keep Warm Function: To provide immediate boiling and sustain the desired temperature.

Following these preliminary design directions, we refined the prompts for the second generation phase, emphasizing concepts such as *single person use* and *ideal for a quick cup of tea*, focusing on functional attributes that the AI had previously misinterpreted, while hoping for unexpected and serendipitous outcomes.

The results are displayed in Figure 3. Remarkably, only a few iterations were necessary, as the image we ultimately selected — highlighted on the next page — emerged after just a couple of iterations.

Surprisingly, the AI offered an exciting interpretation of the input. This happened somewhat by accident, as specifying aspects such as *quick cup of tea* and compact dimensions led the AI to generate an image that resembled an electric mug. We found this unexpected result fascinating. In this case, the AI's difficulty interpreting functional aspects was inspirational. This insight led us to consider refining the brief to create a product that combined a mug's convenience with a kettle's functionality.

Figure 3.
Prompt with following generations, with highlighted the one suggesting a specific design direction.

[Prompt]

Design a **compact electric kettle specifically tailored for single-person use.** Focusing on convenience, efficiency, and ease of transport for users with limited space. **Ideal for a quick cup of tea** ad tailored for small living spaces or office environments. **Easy to carry and use.** The design should be sleek, stylish, minimalist and modern, following design trends.

Therefore, we went back to the research phase to investigate the presence of similar products in the market. While electric cups do exist, they typically offer a keep-warm function. Those capable of boiling water are noticeably larger. This discovery underscored a market opportunity for a compact, single-serve electric mug with boiling capabilities. Some models are capable of boiling water and are typically engineered to stew and prepare soups as well. This secondary category more closely mirrors the design of thermoses rather than traditional mugs. Furthermore, these units often consist of a single piece, diverging from the conventional mug design with its distinctive base.

Comparing these two product categories with a standard kettle, our goal was to strike an ideal balance between the aesthetics of electric mugs and the boiling functionality of a kettle. The objective was to create a product that embodies both qualities: a kettle from which one can directly drink.

8.2 Design Brief

Scenario:
Targeted at individuals such as tea enthusiasts, environmentally conscious consumers, or those with a fast-paced lifestyle who aim to simplify their tea-making process.

Product to design:
Design an electric mug that combines the functionality of an electric kettle with a tea infuser, enabling users to boil water, steep their tea, and enjoy their beverage all from the same device. This design emphasizes efficiency and minimalism by reducing the number of utensils required to a singular item, and it minimizes water and energy usage by boiling only the necessary amount for a single serving.

Requirements:

- Compact Design: The electric mug should be small enough to conveniently use and store without sacrificing capacity for a full serving.
- Portion Control: Allows for precise measurement of water
- Integrated Infuser: For steeping tea directly within the mug
- Safe to Drink From: The mug must be designed with materials and ergonomics that ensure it is safe and comfortable to drink from.
- Boiling and Keeping-Warm Function: Provides the capability

to not only boil water but also maintain the temperature for a set period, ensuring the beverage remains at the ideal drinking temperature.

8.3 Generative Phase

Moving into the generative phase, we aimed to develop the AI suggestion into a defined concept, referring back to the brief as a foundation for crafting new text prompts.

8.3.1 Concept Generations (3rd Stage)

We initially tried text-only prompts. However, based on the previous experience, we used a long, detailed prompt describing the object's physical attributes, avoiding overly conceptual notions.

When we requested an *electric kettle with the shape and dimensions of a mug*, the algorithm struggled to interpret the request, as the object did not fit into the categories of either a mug or a kettle. In Figure 4, one of the attempts with a text prompt is documented.

Therefore, to avoid excessive iteration, we opted for the Blend feature, which, in this instance, proved exceptionally effective. This success was likely due to the mainstream nature of the kettle and mug categories, which enabled the algorithm to generate designs combining elements from both product categories swiftly.

Two steps of the generation process are reported in Figures 5 and 6 (p. 134), showing the images used for the Blend function and presenting some of the outcomes.

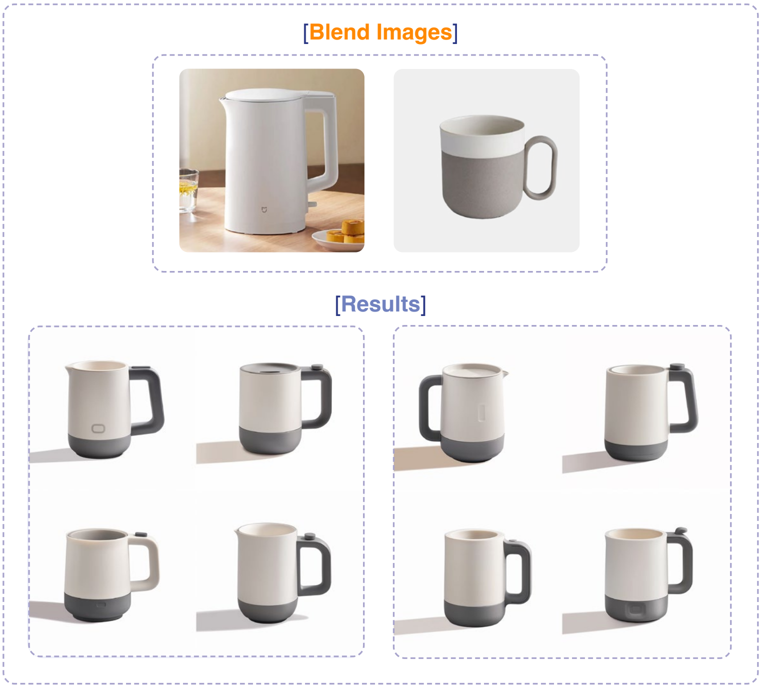
Figure 4

[Prompt]

Design a **compact and light electric kettle with the shape and dimensions of a mug.** Focusing on convenience, and ease of transport for users with limited space. Ideal for a quick cup of tea ad tailored for small living spaces or office environments, so the shape should be short, not tall, and occupy the space of a mug. Easy to carry and use. The design should be sleek, stylish, minimalist and modern, following design trends.

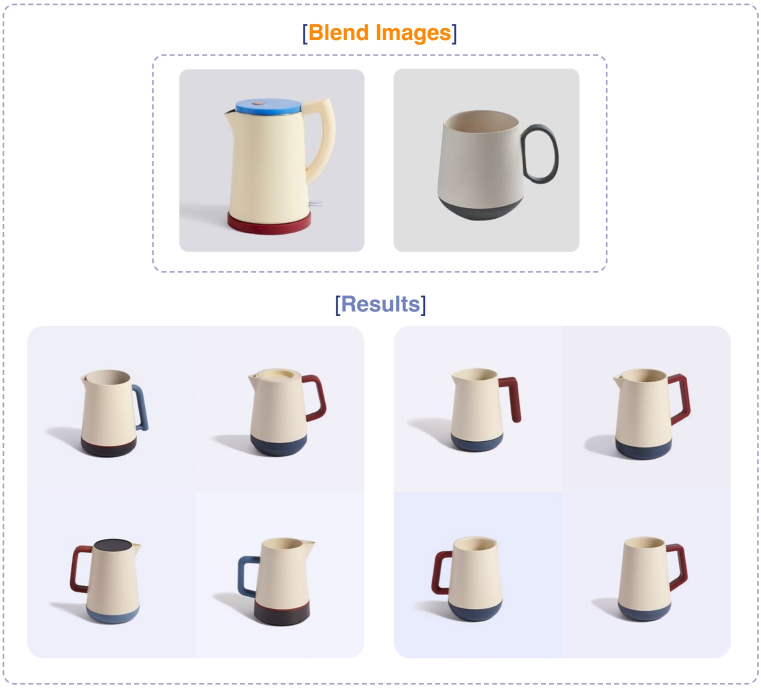
Step 1

Figure 5



Step 2

Figure 6



The initial generations depicted mugs that were not entirely coherent with the brief. Far from being inspiring, the images lacked the aesthetic appeal and realism often present, even in less coherent designs, making it impossible to consider them for their moodboard value. We continued to iterate using images of various products, and relatively soon, we encountered designs that sparked inspiration.

In a subsequent iteration (Step 2), the resulting designs became significantly more inspiring by changing the input images. Although still somewhat illogical — resembling more the aesthetics of non-electric kettles or mugs rather than their electric analogues — the designs from this iteration caught our attention with their shapes, proportions, and the distinct product language. These results inspired us to refine and rework those images into a coherent design.

Figure 7.
The two selected images among those generated by Midjourney.

Figure 8.
Synthesis of the two images realized in Photoshop.

8.3.2 Selected Results

We chose two specific images (Figure 7, p. 135) as primary references and synthesized them by post-producing Midjourney's outputs in Photoshop (Figure 8, p. 135). The conical shape and the lid from the first image caught our attention, but we eliminated the spout, aiming for a design more akin to the second image once the lid was removed. Intriguingly, we employed Photoshop's generative AI features to transform these elements into the final image.

The following steps involved determining the design of the buttons and power plug and improving the lid's design. However, we were uncertain about the feasibility of the concept as depicted in the image.

8.4 Concept

The concept includes a heating base with control features like temperature regulation and an on/off switch. The main body, designed to boil water, would be detachable, allowing it to be used and transported like a traditional mug. Additionally, it would feature a removable lid for easy access and refilling (Figure 9).

Figure 10 presents a concept rendering incorporating modifications based on thorough feasibility evaluations.

Figure 9

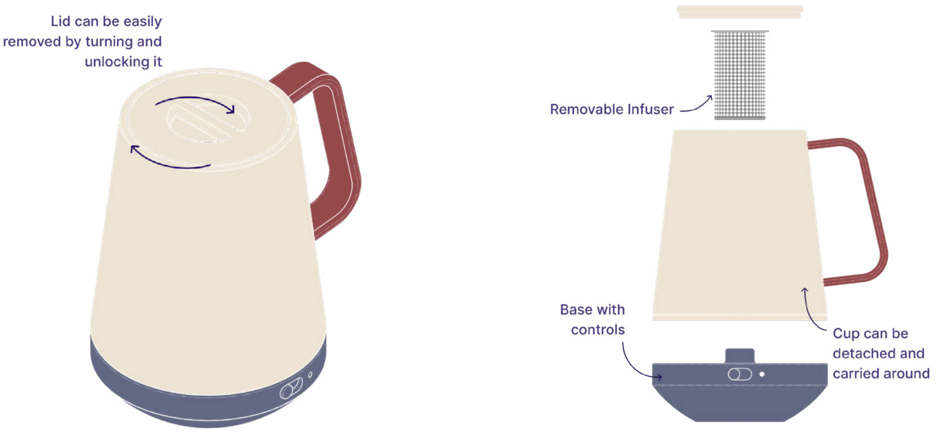


Figure 10

8.4.1 Feasibility Evaluations

We analyzed the structure of existing electric kettles and boiling mugs.

In electric kettles, the heating element is typically housed within the main body. In contrast, the base is the hub for power connections and houses the PCB with control functions. The heating mechanism involves a coil located inside the main body.

Conversely, electric boiling mugs consolidate all components within the mug itself, eliminating the separate base. This integration, however, contributes to their notably larger size, which can compromise comfort and convenience.

Given this information, our concept evolved to incorporate the heating element directly into the mug's body, mirroring the arrangement found in larger kettles but with an emphasis on minimizing dimensions. Similar to a conventional kettle's design, the base would be dedicated to the PCB and power connection, aiming for a significant reduction in overall size (Figure 11). Aligning with the brief's requirements, we envisioned the inclusion of the removable infuser.

We calculated the dimensions of the mug, considering the space required for internal components, as well as manufacturing and insulation requirements.

Due to its geometry, the mug body could not be fabricated as a single piece; thus, we opted to design a separate bottom lid for manufacturing, which would then be assembled.

For the heating element, a metal casing of 3,5 cm in height and 8,5 cm in diameter was deemed necessary (Figure 12).

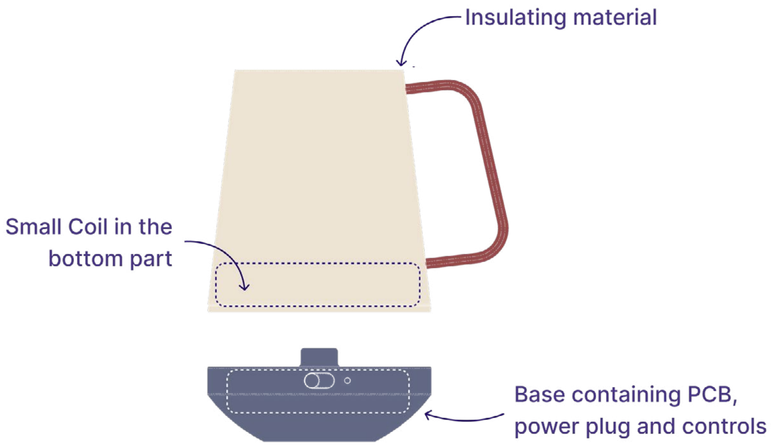


Figure 11

Considering the mug's main body, selecting suitable materials for each layer is pivotal to ensuring effective water heating while maintaining safety and comfort in handling. A prevalent approach involves constructing a three-layered structure: an interior ceramic glaze for optimal heat conduction, a middle layer of stainless steel for durability and heat retention, and an exterior layer of anti-scalding ABS plastic to safeguard the user from heat.

Interior Layer - Ceramic Glaze:

- Function: Provides a non-reactive and easy-to-clean surface for the water and tea.
- Thickness: Ceramic glaze coatings are thin, usually around 0.5 to 2 mm.

Figure 12

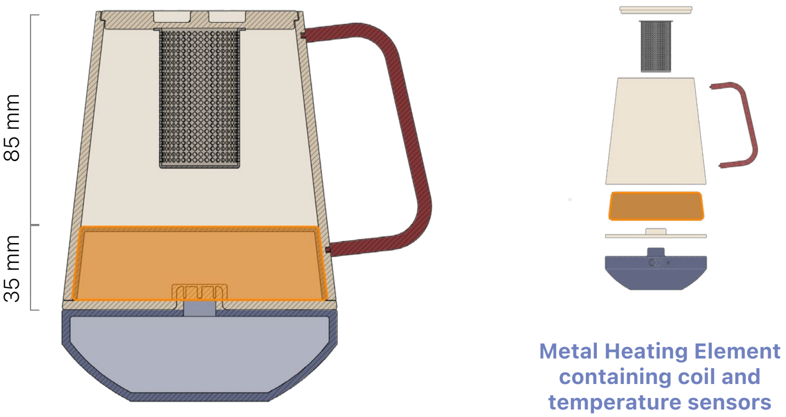
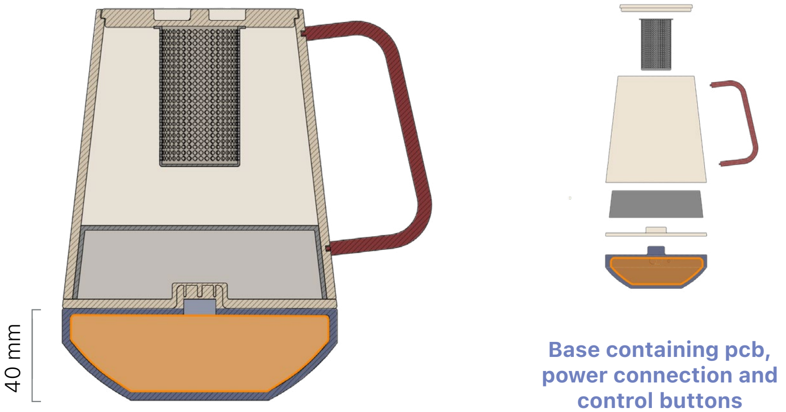


Figure 13



- Manufacturing: Usually applied through dipping, spraying, or brushing onto the ceramic substrate. Once applied, the glaze is fired in a kiln, resulting in a smooth, hard, and durable finish.

Middle Layer - Stainless Steel:

- Function: Acts as the primary container for the water, providing durability and good heat conductivity for boiling water.
- Thickness: The stainless-steel layer is usually about 0.5 mm to 1.5 mm thick for electric kettles. This thickness ensures durability and efficient heat conduction while keeping the overall weight manageable.
- Manufacturing: It is highly versatile and can be fabricated into various shapes, including conical forms. The desired shape is commonly done using spinning, deep drawing, or welding.

Exterior Layer - Anti-Scalding ABS:

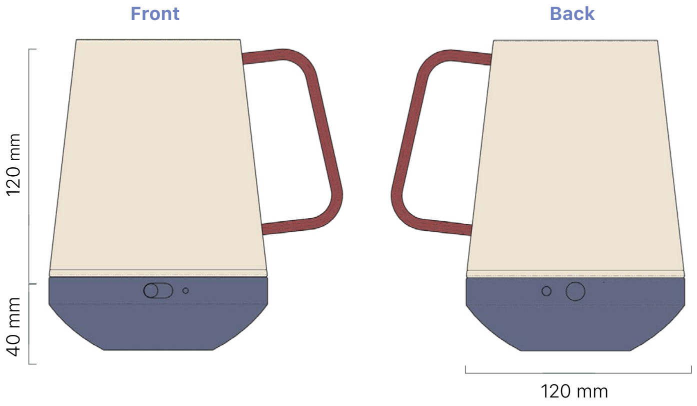
- Function: Insulates the heat, ensuring the exterior remains cool enough to touch.
- Thickness: ABS plastic can be effective at about 2 mm to 5 mm thicknesses. This range provides sufficient insulation to protect against burns while also being lightweight.
- Manufacturing: ABS is known for its strength and rigidity. It can be molded into a wide range of shapes, including cones, and is a suitable choice for creating ergonomic and safe-to-touch outer layers for kitchen appliances.

The exact mug's wall thickness can vary slightly; we considered 4 mm (the average total thickness that emerged from the research) for the 3D model. Additionally, the design should be carefully tested through prototyping to ensure adequate thermal insulation between the hot internal components and the external surface, especially for the stainless steel and ABS layers. The product should comply with relevant safety standards and regulations for electric kitchen appliances.

The base is designed with sufficiently ample dimensions for the required small PCB. This component could also be made from colored ABS and would necessitate manufacturing through injection molding. For moldability, it will have to be divided into two separate pieces: a top and a bottom. At the back, the design incorporates the power connection and the on/off button. Meanwhile, the front features a slider to toggle between the boiling and keep-warm functions. Additionally, a small indicator light will signal when the mug is heating and when the beverage is ready.

The overall dimensions are intended to be more compact than those of existing boiling electric mugs. The body of the mug matches the size of standard electric mugs, while the diameter of the base aligns with that of boiling electric mugs. Aside from accommodating the heating element, the internal volume available for water mirrors the cubic centimeters typically found in conventional mugs.

Figure 14



8.5 Outputs

The results of the second experiment were viable as a concept and proved feasible. The effectiveness of the AI-generated iterations can be attributed to the mainstream nature of the product category and the fact that we had a clear vision of the design direction from the outset. The fact that our inspiration for the final design came from a detail on an unexpected AI-generated image reflects the collaborative essence of human-AI co-design, which inherently embodies a level of unpredictability. The observations from this phase can be categorized into two main points:

Figure 15

Regarding Midjourney's performance:

- Midjourney's results were usable as a concept. It was beneficial to find a design direction, not only aesthetic-wise but also functional-wise.
- Conceptual inspiration came from Textual Prompts generations, and Design Inspiration came from Images Blend Function.
- Midjourney suggested more creative ideas, and we noticed a correlation with a better understanding of the product category.
- Even though the images were not blended coherently or meaningfully, they indirectly led to inspiration.

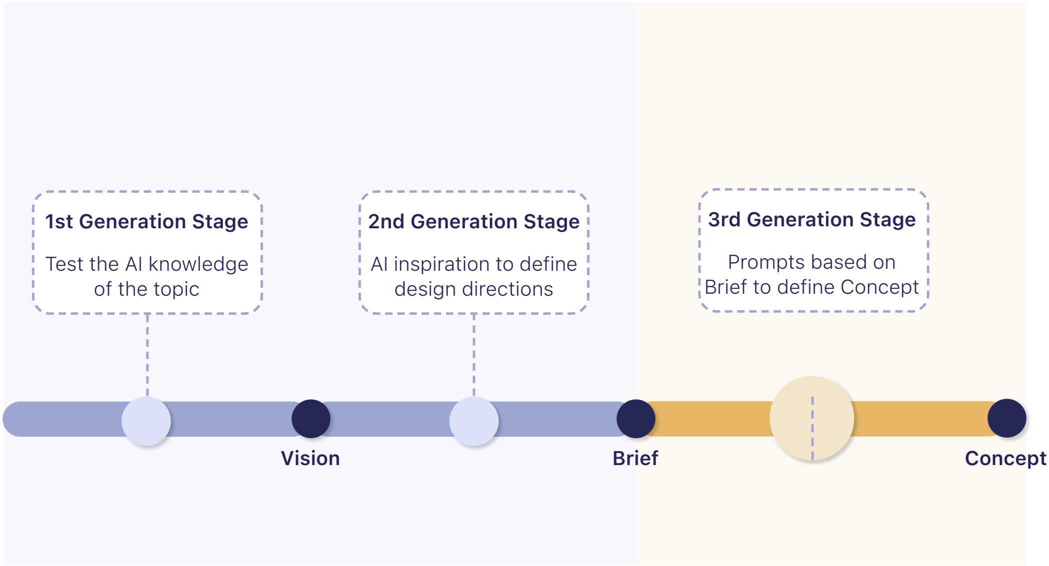
About the Overall Process:

- The immediate acquisition of sensible results significantly expedited the process, quickly pointing a clear design direction.
- Assessing feasibility proved more complex, requiring time to obtain a general understanding and would necessitate further engineering analysis.
- This process exemplified that AI inspiration does not always have to come as an image ready for direct use; rather, it can be more inspiring to challenge the AI with imaginative generations (such as blending product categories) and interpret the outcomes.

Graph 6 illustrates the duration and volume of generations across the three generative steps. Similar to the desk organizer concept, it utilizes circles sized proportionally to reflect the scale of each generation phase, arranged along a timeline.

Contrary to the first experimentation, the initial Generation Stage required only a handful of iterations, as it quickly became evident that the AI could produce consistent outcomes for the specified topic. The second-generation phase played a crucial role in refining the design brief despite the modest number of iterations.

In this instance, the most extensive generative stage was the final one, although the whole process was relatively brief.



Graph 6.
Compared number of generations required for each Generative Stage in Concept 2.

9. Concept 3: Smart Thermostat

9.1 Explorative Phase

A smart thermostat is an advanced device for controlling a home's heating, ventilation, and air conditioning (HVAC) system. Unlike traditional thermostats, smart thermostats offer enhanced features, such as remote control, programmable settings, Wi-Fi connectivity, learning capabilities, and integration with home automation systems.

This product category combines engineering constraints with user interface requirements, providing an opportunity to assess AI's ability to interpret these elements while considering its limitations in processing both textual and numerical data.

After our previous two experiments, we realized that Midjourney could serendipitously capture and enhance the tangible aspects of design. This led us to explore whether it could also impact the more abstract domain of user interface aesthetics and functionality in a similar manner.

9.1.1 Preliminary Generations (1st Stage)

The initial phase of generation with Midjourney was rapid, showcasing that the AI had efficiently captured the core idea of the product. We generated only a few iterations (Figures 1 and 2) because the images accurately represented the product category. Although the designs of the generated products were not particularly sleek or innovative, this was understandable as the prompt did not specify any stylistic attributes.

Moreover, through the same set of generated images, we can identify Midjourney's challenges in processing numerical data and textual content. The limitation suggests a potential area for improvement, especially for applications requiring a nuanced understanding of text and numbers within design concepts.

Figure 1

Figure 2

9.1.2 Product Research

Searching for product categories to analyze proved unsuccessful; understandably, they were organized by technological functions such as *Remote Access and Control*, *Geofencing*, *Integration with Smart Home Systems*, and *Voice Controls*. These elements, relevant from an engineering point of vew, provided limited insights from a product design perspective. However, a few cases stood out. We can categorize them into designs emphasizing technological features, like Ecobee; interface-centric designs, like Google Nest and Wyze, which facilitate user interaction through a rotating element; and spatially-aware designs, like the freestanding designs, exemplified again by Google Nest.

These classifications helped identify design and user experience trends within the intended product category, offering valuable insights for defining design direction and crafting prompts.

We set out to identify the most prevalent interaction issues with smart thermostats, focusing on aspects of design and usability that fall short. Our analysis led to the selection of the following points:

- Poor Ergonomic Placement: Installing thermostats in hard-to-reach areas can render physical interaction with them uncomfortable.
- Aesthetic Dissonance: When placed in visually prominent locations, a design that clashes with home decor can detract from the overall aesthetic appeal. This often generates designs that conceal the product or minimize its size.
- Inconsistent User Experience Across Devices: Disparities in the user interface between the thermostat's physical controls and its smartphone application can lead to confusion, especially when there is an inconsistency in available features.

9.1.3 Defining Design Direction (2nd Stage)

Reflecting on the three design challenges identified, we concluded that the third one — Inconsistent User Experience Across Devices — lies beyond the scope of our research, being mainly centered on UI. Consequently, we focused our Midjourney explorations on the remaining two issues:

Poor Ergonomic Placement:

Thermostats installed in hard-to-reach places can result in an uncomfortable interaction, so we wanted to explore a portable solution. Initially, our prompts provided general directions and anonymous results (Figure 3, p. 148).

We realized we had bypassed a crucial step by prescribing a direct solution to the problem instead of allowing the AI to offer insights. Moreover, our approach yielded predictable results due to the straightforward nature of the solution proposed. Iterations involving longer and more detailed descriptions did not yield more satisfactory outcomes (Figure 4). Interestingly, the more effort we put into describing a refined product, the more the results seemed rough and unrealistic.

In the images, it is evident that Midjourney needs help interpreting functional aspects: we provided numerous attributes related to the functionality that were not reflected in the images. However, regarding precise aesthetic aspects, the AI performed significantly better (e.g. *add a touch of color*).

Figure 3

[Prompt]

A **portable smart thermostat** of sleek and minimalistic design, that appears like a playful element in the house and activates with touch. It should have an elegant yet curious shape, considering feasibility, and **can be placed in different places.**

Figure 4

[Prompt]

Design a portable smart thermostat that embodies a sleek and minimalistic design [...]. It should feature a **unique and elegant form, drawing attention and curiosity as a centerpiece on the table.** It should **integrate smoothly with various interior styles,** [...] maintaining a **polished and efficient functionality.**[...] Focus on its seamless integration into the environment, making it appear both as an advanced climate control device and a statement piece of decor. Circular shape, quite small in dimensions, **touch of color.**

Aesthetic Dissonance:

To tackle this challenge, we chose an approach contrary to typical solutions that aim to conceal the product or minimize its size, pursuing the concept of making the thermostat a visible, decorative element within the home, enhancing its presence rather than diminishing it.

In this instance, Midjourney also failed to grasp the concept of decorative elements, producing relatively mundane outcomes despite the lengthy and detailed prompt (Figure 5). The software did not effectively respond to the cues for decoration and attempts to elicit a distinct design using terms like *contemporary art piece* were not mirrored in the results. Indeed, the designs were simpler than those generated in the initial rounds of prompts. Moreover, it appeared that including descriptions of the home environment resulted in images that focused more on the overall scene than the product itself.

Figure 5

[Prompt]

Create a wall-mounted smart thermostat that embodies a sleek and minimalistic design, doubling as a **contemporary art piece in a modern home,** [...] making it a **versatile addition to any room.** Highlight its distinctive design that differentiates it from traditional thermostats, while maintaining a polished and efficient functionality. [...] **sophisticated look** Focus on its seamless integration into the wall, making it appear both as an advanced climate control device and a statement piece of decor.

Some results from subsequent iterations are presented in the following images (Figure 6, p. 150). Even though the latest iterations look pretty different from the earlier ones, they still lack a decorative element. This recalls the issue with the electric mug, where it seems challenging for the AI to blend product categories based solely on textual prompts.

Figure 6

9.2 Design Briefs

In our first exploration with Midjourney, we struggled to identify a design direction that appeared notably promising. Consequently, we opted for a strategic approach: we formulated two distinct briefs to explore their potential during the generation phase. This allowed us to observe and compare the outcomes to discern which brief might yield the most inspiring and innovative results.

Brief 1 - Addressing Poor Ergonomic Placement

Scenario:
In a home where the thermostat's installation site is hard to reach, users seek the flexibility to position it in more accessible locations for comfortable interaction.

Product to design:

The goal is to design a portable smart thermostat that enables easy placement around the house, such as on tables or shelves, eliminating the need for permanent wall installation. This product should integrate seamlessly into various home settings.

Requirements:

- Reliable HVAC Connection: Ensure a constant, reliable connection to the HVAC system, ideally through a direct electrical connection, comple- mented by dual communication systems (Bluetooth and Wi-Fi).
- Portability: The design must be compact and lightweight.
- Stable Base: Incorporate a base design that guarantees stability and prevents the device from tipping over.
- User-friendly Installation: Allow for simple, DIY installation by the user through an easy-to-mount system.
- Visible and Informative: When not used for temperature adjustments, the thermostat could display other relevant information, enhancing its utility and presence in living spaces.

Brief 2 - Tackling Aesthetic Dissonance

Scenario:

In homes where the thermostat is installed in a prominent, visible location, there is an opportunity to leverage its position as a decorative element, moving beyond mere concealment.

Product to design:

The objective is to design a smart thermostat that serves its primary function of regulating temperature and acts as a decorative piece, enhancing the aesthetic appeal of the space it occupies by changing the narrative of thermostats.

Requirements:

- Aesthetic-Functional Balance: Achieve a design that harmonizes its decorative aspect with its functional role, ensuring it remains ergonomic despite potentially larger dimensions.

- Informative Display: When not in use, the thermostat could show time and date or transform into a piece of wall art, blending utility with decor.
- Unified User Interface: The UI should align with the overall product design, ensuring a cohesive experience that complements its role as both a functional device and a decor element.

9.3 Generative Phase

During this phase, we made a series of generations grounded in the briefs to evaluate whether Midjourney could yield more inspiring outcomes for both scenarios. Recognizing each brief's distinct challenges, we adopted dif ferent strategies for each case.

9.3.1 Brief 1 Generations (3rd Stage)

We primarily used text prompts for this project, leading to varied outcomes. Some results were abstract and aesthetically pleasing, while others were more realistic but simplistic. Numerous iterations were conducted, but only four examples are showcased here. The first three images (Figures 7 to 9) display relatively realistic designs but lack innovation. The fourth image (Figure 10) aesthetically diverges from the others, showcasing a unique shape and style incorporating elements from various product categories. Despite its distinctive look, it did not fully meet the project's brief. Overall, unlike with the electric mug, we struggled to find strong inspiration through Midjourney. We chose not to pursue additional prompt methods for this brief. Instead, we decided to proceed directly with the second brief.

9.3.2 Brief 2 Generations (3rd Stage)

For the second brief, we realized that text prompts posed more of a challenge in capturing the desired concept, mainly due to the vague nature of the term *wall décor* for which specific references were needed. Consequently, we used the Images Blend Function and experimented with various combinations of wall decor styles and previous wall thermostat designs generated by Midjourney itself.

Figures 12 and 13 (p. 154) display examples of generations where we utilized the blend function, giving specific references for wall decor and wall-mounted thermostats (Figure 11, p. 154). The outcomes were aesthetically appealing, albeit they leaned towards the abstract.

Pursuing further iterations, we also experimented with text prompts, using the previous results as reference images. Gradually, the generated images began to resemble a device with a screen (Figures 14 and 15, p. 154), deviating from the traditional thermostat design yet aligning closer with our vision.

In the final two images (Figures 16 and 17, p. 1 54), we found two designs that we particularly appreciated. However, we ultimately chose not to adopt them as concepts. Despite their appeal, the decorative aspect was less pronounced than we had hoped; they resembled larger, more colorful thermostats rather than embodying a robust decorative element.

Figures 7, 8

Figures 9, 10

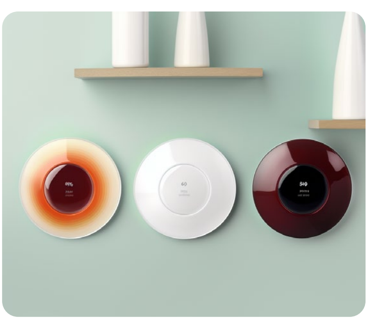
Figure 11

[Subject Reference]
Previous Generation

[Style Reference]
Existing Wall Decoration

Figures 12, 13

Figures 14, 15



Figures 16, 17

Figure 18

[Subject Reference]
Previous Generation

[Style Reference]
Existing Wall Decoration

Figure 19

Continuing with this approach, we experimented with various decorative objects, including mirrors and lights — essentially anything that adorns a wall and serves an aesthetic purpose (Figure 18). Below, we share some outcomes that intrigued us the most, showcasing designs with transparent light elements and screen-like features. This third-generation stage extended longer than anticipated.

The final iterations of these images (Figure 19, p. 169) were interesting, as their appearance straddled the line between a mirror, a lamp, and a thermostat. Motivated by this unique blend, we derived a concept from these hybrid designs, seeing potential in their multi-functionality and aesthetics.

9.3.3 Selected Results

While we could not derive a comprehensive product concept from most of the outcomes, we explored whether they could offer any inspiration for user interfaces.

1) UI Concept Inspiration

The portable concepts did not showcase innovative design elements, featuring essential aesthetic qualities that did not push the envelope in terms of creativity or functionality. We selected two images (Figures 20 and 21) for their visual appeal and potential as a preliminary foundation for UI development, even though they included nonsensical numbers. These images sparked curiosity about the possibility of

Figure 20, 21

Figure 22

deriving a screen interface concept from their abstract representations, hinting at an underlying method to conceptualize UI design from seemingly unrelated visual elements. Similarly, in the case of the wall-mounted design, we engaged in extracting an interface idea from the image in Figure 22.
This process required a careful examination and interpretation of the visual elements within the image, aiming to discern hints or suggestions for a feasible UI layout.

It required a creative approach to finding inspiration for UI design, even without a direct, concrete product concept as a starting point, illustrating the potential to abstract meaningful design cues from general aesthetics or thematic suggestions.

2) Product Concept Inspiration
Two images generated with the decorative concept in mind caught our attention because of their distinctive light-like appearance (Figures 23 and 24).

This visual feature inspired the idea that light could be a key element in enhancing user experience, elevating it from a mere aesthetic addition to a functional design component. Integrating light into the design allows for creating interactive feedback mechanisms or setting the mood. This perspective elevates the role of light from simply decorative to a significant contributor to the product's overall usability and atmosphere, offering new avenues for design exploration.

As for the desk organizer concept, this kind of inspiration was indirect. For the desk organizer, the recurrent element of three nesting trays, even if not usefully designed by the AI, made us imagine a

Figures 23, 24

way to develop the concept. In this case, the process was similar, as the AI suggested an element of light without further utility, which gave the idea for further development. The concept was developed based on the two following images.

9.4 UI Concepts

While some outcomes from the generative process may not fully qualify as distinct concepts — being essentially portable thermostats lacking specific features — they proved unexpectedly valuable in generating a base layout for user interface development.

Portable Design n. 1
We began by closely examining the elements displayed on the screens (Figure 25) and attempted to transform them into meaningful information. We recreated the screen designs in Figma and tried to imagine how to turn it into a user-friendly interface.

In Figure 26, the thermostat's home screen is displayed in two color configurations. We started by transforming the central number into a temperature or time display. The small elements resembling text beneath the central number inspired adding other thermostat information, such as humidity levels and eco mode settings, within a sliding menu. The underlying dots, suggested by the AI-generated image, were repurposed to indicate the sliding menu's page numbers. Another significant element, the bottom line, hinted at an interactive flow, serving as a slider menu; by pressing and sliding up, a menu would emerge.

Building on this foundation, we conceptualized the UI screens, with the initial inspiration proving remarkably coherent. For the menu design, we arranged the elements in a circular pattern to mirror the device's shape, introducing an intuitive way to adjust settings, such as temperature, through a circular motion. Figure 27 presents some menu settings incorporating this circular interaction design and menus.

Figure 25.
AI render used as inspiration.

Figure 26.
UI redesigned in Figma based on the AI layout (Home Page).

Figure 27.
UI redesigned in Figma based on the AI layout (Second Page).

Figure 28.
AI render used as inspiration.

Figure 29.
UI redesigned in Figma based on the AI layout (Home Page).

Figure 30.
Function Selection and Temperature Adjustments.

Portable Design n. 2

We applied the same methodology to the second concept (Figures 28 to 30). We interpreted the numbers shown as temperature displays, with the smaller numbers above potentially representing humidity and time. In this instance, the images depicted an opaque lower section of the screen featuring elements that resembled buttons. This led us to envision a design where interactions could be based on three buttons: left, right, and confirm. By pressing the central button, a user can access all available settings. The left and right buttons allow navigation through the menu, while the confirm button selects a specific setting for adjustment. For temperature adjustments, one can incrementally increase or decrease the degrees and press confirm upon reaching the desired setting. A visual indicator, such as a symbol, would appear to signify the temperature adjustment process. This approach introduces user interaction through clearly defined physical controls.

Decorative Design

In this final example, the seemingly nonsensical symbols generated by AI once again served as a source of inspiration. We transformed the central element into a temperature display, with small text above it, to clarify the type of information being shown (Figure 32, p. 162).

Additionally, we introduced a menu-page indicator at the bottom, composed of little dots, communicating that users could swipe through different screens. Swiping through, users would sequentially encounter screens displaying humidity, time, and various settings (Figures 33 and 34, p. 163). A long press would allow for selecting and adjusting the displayed information.

In Figures 35 and 36 (p. 163), we included the settings option that might be featured in the menu, while the second image showcases the method for adjusting the temperature. Finally, we envisioned transforming this decorative element into a digital clock when not actively used for temperature control (Figures 37 and 38, p. 163). Upon a user's approach, it would revert to showing the temperature and settings.

Designing these interfaces proved engaging and enjoyable, leaving us surprised by the extent to which AI could facilitate the conceptualization of initial layouts. This experience underscored AI's potential as a design ideation tool, especially in crafting user interfaces that blend functionality with aesthetic appeal.

Figure 31.
AI render used as inspiration.

Figure 32.
UI redesigned in Figma based on the AI layout (Temperature Display).

Figures 33, 34.
UI redesigned in Figma based on the AI layout (Time and Humidity Display).

Figures 35, 36.
Temperature Adjustment and Settings.

Figures 37, 38.
Clock function when not in use, with two designs for displaying time.

9.5 Product Concept

For the product concept, we drew inspiration from images that featured a glass-like luminous element along the screen's external border. We envisioned this element to signal temperature changes by altering the product's appearance. Figure 39 presents an AI-generated visual to which we added interface information. We incorporated the UI concept from UI Concept 3 and adapted it to the new screen, leveraging its similar dimensions and shape. Figures 40 and 41 illustrates the thermostat's indication of temperature adjustments, showing how the light on the external part shifts to a warmer color as the user increases the temperature. Conversely, when the temperature is lowered, the light turns cooler.

The light gradually changes as the user selects their preferred temperature. Upon confirmation, the light stabilizes to that color temperature and then gradually returns to neutral as the ambient temperature of the house aligns with the set point. This interpretative approach to AI-generated images integrates visual cues with functional utility.

We selected two images generated by Midjourney - the one in Figure 39, and the second design in Fig ure 42 (p. 166) - and applied the same use of light concept (Figures 43 and 44, p. 166), creating two variations of the same design. The interface was readapted in this case, although it maintained the same functionality. In Figures 45 and 46 (p. 167) we reported two visualizations of the thermostat when not in use, displaying time information.

Since the goal of the concept is not to serve as a light source but to provide a color indication, LED lights with minimal brightness capable of changing color temperature could be placed beneath an opaque glass surface. Further research on this is reported in the next section.

Figure 39.
AI render (Design 1) on which the UI elements were added based on previous UI Concept.

Figures 40, 41.
Use of light's color temperature to signal temperature changes.

Figure 42.
AI render (Design 2) on which the UI elements were added based on previous UI Concept.

Figures 43, 44.
Use of light's color temperature to signal temperature changes in Design 2.

Figures 45, 46.
Clock function when not in use, with two designs for displaying time.

9.6 Feasibility Evaluations

To assess the feasibility of both portable and wall-mounted designs, we examined the internal components of existing thermostats, using Google Nest as a reference point, while acknowledging that comparisons with other models have been considered and the layout of dimensions and component placement is generally consistent.

Main Components:

- Case: The main body houses all other components.
- Sensors: Include temperature and humidity sensors, with some products featuring occupancy or motion sensors.

- Processor, Memory, and Storage: Essential for processing inputs, storing settings, and managing the thermostat's operations.
- Display Screen and User Interface Controls: These may consist of physical buttons or touch-sensitive areas for direct user interaction.
- Power Supply Components: This can include a connection for the standard wire (C-wire) or battery compartments.
- HVAC Control Interface: Includes the necessary circuitry and connection terminals for integrating with the HVAC system.
- Mounting Hardware: Comprises screws, mounting plates, and possibly adhesives to facilitate installation.

In Google Nest, we observed two primary components: the Main and Base Unit. The former houses the display, sensors, and controls, while the latter includes the wall mounts and connections to the Heating, Ventilation, and Air Conditioning (HVAC) system. With dimensions of 84mm in diameter and 34mm in depth, these measurements are consistent across most competing designs, with widths reaching a maximum of 40mm.

Generally, every thermostat requires a connection to the HVAC system. The HVAC connection is still essential for portable designs like the Google Nest, but the interface is integrated into the portable unit, which connects to a power source. Within the HVAC cover, Wi-Fi or Bluetooth modules facilitate communication with the portable interface. As seen with the alternative model of the Google Nest, a speaker may be incorporated to offer an additional system control method. In considering the assembly design for the two briefs, we examined the HVAC connection element, adopting the dimensions of Google Nest's base unit as a standard reference.

For the portable design (Figure 47, p. 184), this base unit accommodates only a few components, mostly housed within the main portable body. Therefore, a width of 25mm was considered sufficient for it. The allocation of components into the portable body is facilitated by its larger dimensions compared to wall-mounted designs. For this reason, evaluating the internal placement of components for feasibility was considered unnecessary, as ample space is available.

For the decorative design (Figure 48, p. 185), the central unit containing all essential components is mounted on top of the base unit featuring the HVAC connection. In this case, a width of 40mm was considered appropriate, reflecting average dimensions observed across similar products. The illuminating body houses light elements, complemented by a touch display with a 30cm diameter. Given the substantial overall dimensions, specific measurements for internal component placement were considered less critical, as the spacious design comfortably accommodates all necessary elements.

The desired light effect can be successfully obtained through strategic material choice and layering, such as employing a thick or double layer of transparent material, like Plexiglass or glass. Opting for materials with these characteristics allows light to be dispersed more evenly across the surface, creating a soft glow rather than harsh direct illumination. As an alternative or in addition to material thickness, the material's surface can be treated to become opaque or frosted. Such treatment minimizes glare and contributes to a more ambient and enveloping lighting environment. This nuanced control over light distribution is vital for achieving the intended visual impact and atmosphere.

Furthermore, the ability to change the light temperature can be achieved using tunable LEDs that utilize a technology that allows for adjustments in terms of color temperature, usually ranging from 2700K (yellow-orange warm) to 6500K (bluish cool). By adjusting the intensity of each diode's output, the overall color temperature of the light can be changed. This adjustment process can be manual or automated, as in this scenario. It can be integrated into smart home systems to change the light temperature in accordance with changes in the home's temperature.

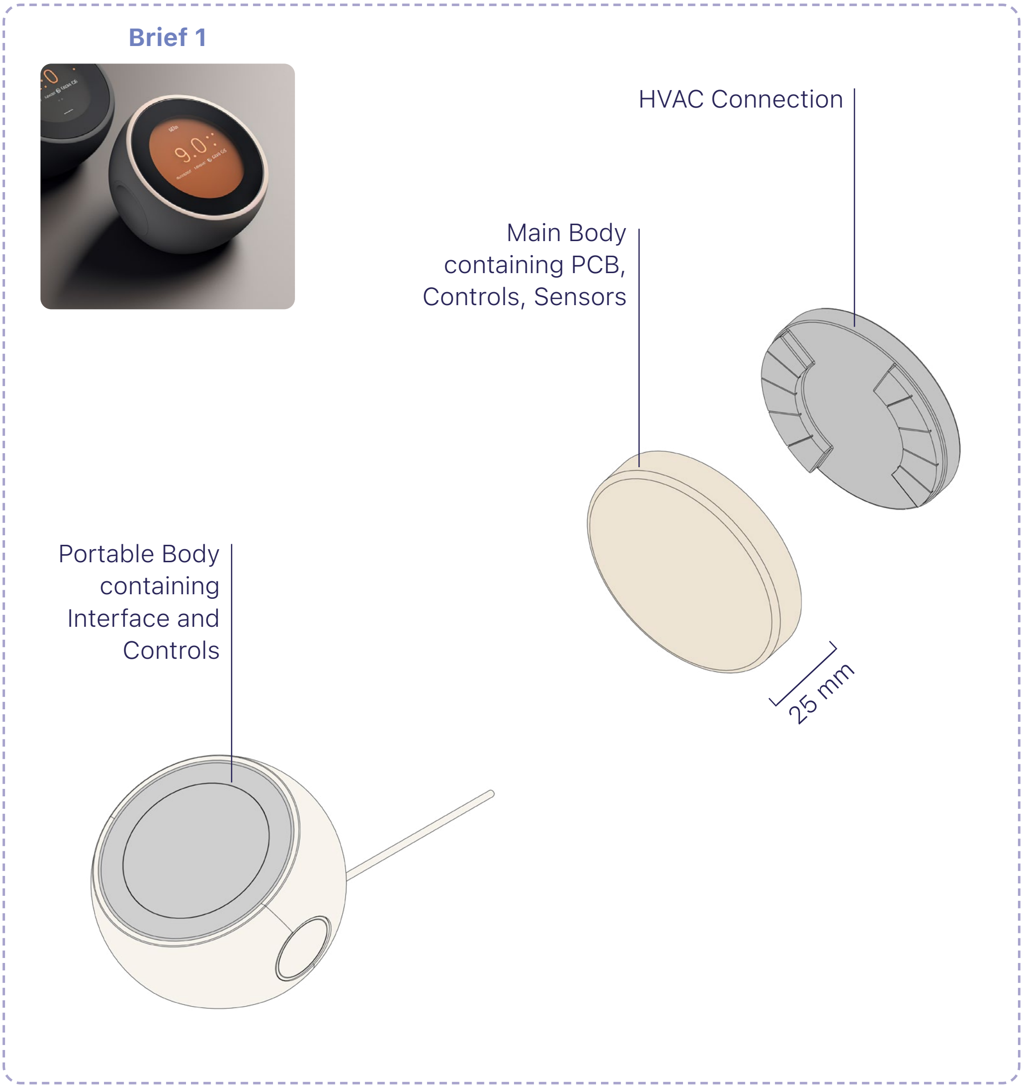


Figure 47.
Drawings and main parts of the portable design.

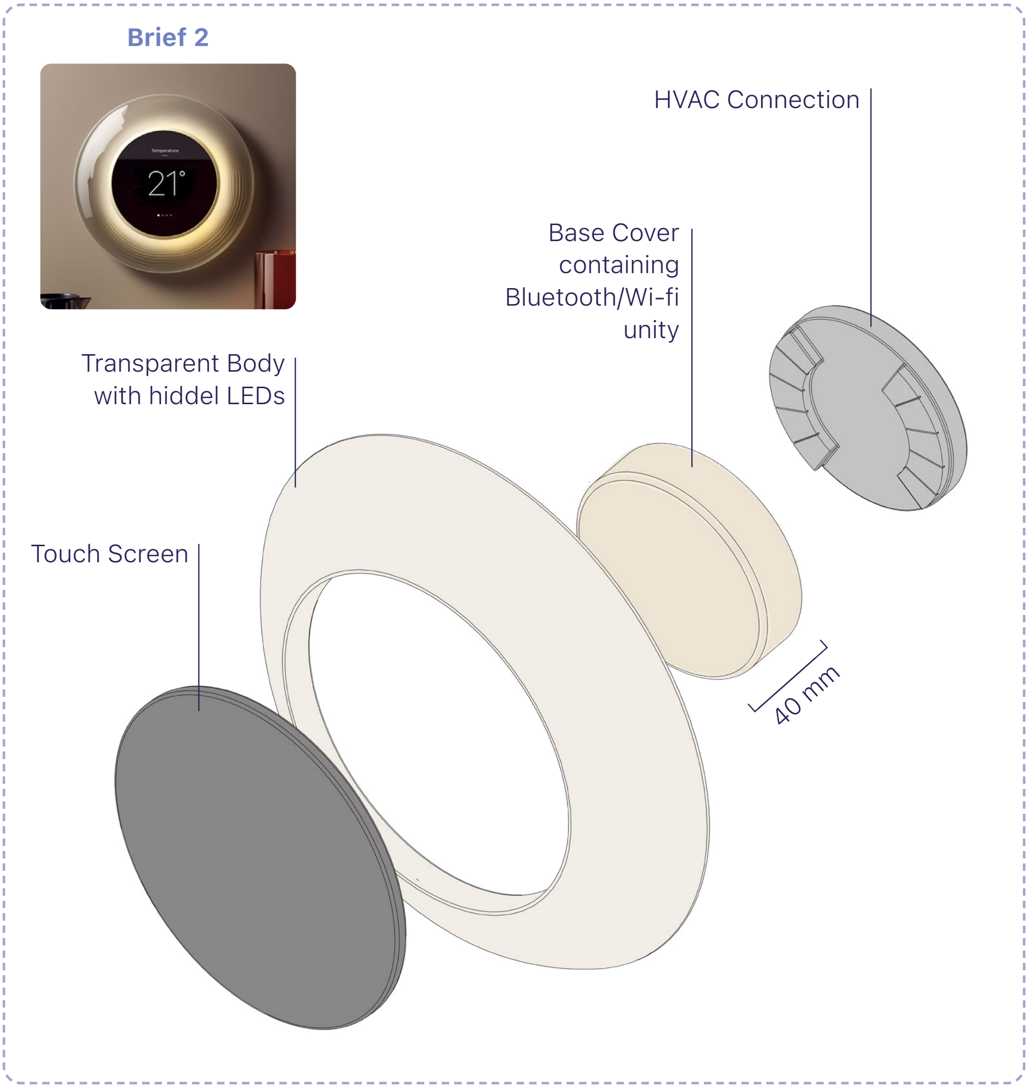


Figure 48.
Drawings and main parts of the wall-mounted design.

9.7 Combining Concepts (4th Stage)

Among the three experiments, this was the only instance where the AI did not significantly aid in concept generation, providing some hints for UIs but failing to offer a clear design direction for the product. This was probably due to some flaws in our approach, which will be addressed in the final chapter. Therefore, instead of finalizing the design after evaluating the feasibility of the results, we embarked on one last iteration.

Both briefs — portable and decorative — exhibited certain shortcomings: the former tended towards a predictable execution, leaving a base unit on the wall serving no additional function while consolidating all functionalities within the portable body; the latter fell short in fulfilling its decorative role. Prompted by these observations, we conceived an idea to merge the two concepts.

Indeed, it is possible to combine the two issues — poor ergonomic placement and aesthetic dissonance — since both stem from the challenge of integrating the product within the home environment. We realized that the portable design resulted in a redundant element on the wall with a useless base unit, whereas the decorative approach faced challenges in achieving its aesthetic objectives due to the necessity of a screen. We aimed to change this dynamic by integrating the functionality of a smart thermostat with the aesthetic appeal of modern wall art. The solution involved adopting a portable interface that could be detached from the wall, transforming the base unit into a decorative element. However, it was crucial that this decorative ele- ment also served a functional purpose to avoid superficial design. Here, the transformative aspect of the previous concept proved helpful, suggesting that the base unit on the wall could display information related to temperature changes in a decorative way, thereby merging functionality with aesthetical appeal.

We returned to Midjourney to find inspiration for this final design. At this stage, we understood that crafting textual prompts describing these functional goals would unlikely yield satisfying outcomes. Therefore, we specifically requested to generate wall decorations with a design direction in mind to steer the images toward something we could adapt to an actual concept.

Figure 49

Figure 50

We envisioned utilizing color to indicate temperature changes subtly. To create a decorative piece conveying information through color, we thought of a main body consisting of multiple sub-parts designed to manipulate the colors in a pixel-like system.

Finding the precise terminology for the prompt that the AI could accurately interpret was challenging. Therefore, we employed the Describe Function for the first time. We provided Midjourney with images of wall decorations showcasing a body structure of many elements, featuring a dynamic composition of subparts. This approach resulted in receiving valuable keyword suggestions such as *scattered composition*, *dynamic composition*, and *color gradient*.

We formulated our following text prompts using the terms suggested by Midjourney, and almost immediately, we obtained interesting results. The image selected from our iterations features a wall decor composed of a dynamic array of elements colored in diverse tones (Figure 49, p. 187). It inspired a design concept where the scattered pieces transition from warm to cool tones based on the temperature settings. The basic layout includes colors ranging from green to red, with white and yellow elements. When the temperature is increased, the parts colored in cold tones should transition to warmer tones (red-yellow-orange); conversely, when the temperature is decreased, the colors should all transition to cold tones (Figure 50, p. 187). This dynamic color change is an intuitive indicator of temperature adjustments, integrating visual feedback into the design's aesthetic.

The interface is portable, as we integrated one of the previously generated designs into the image to illustrate the idea. This approach allows users to place interfaces wherever they prefer and receive pleasant visual feedback from the wall decor. Further development would require creating a coherent aesthetic across the pieces of the system.

The challenge lies in maintaining the appearance depicted in the images, featuring glass-like, opaque elements. Achieving this effect through lighting would result in an overly vivid and bright component, detracting from the desired outcome. Consequently, we delved into research to identify a technology capable of enabling color changes in the pieces without relying on traditional lighting methods.
This exploration aimed to find a solution that preserves aesthetic integrity while fulfilling the functional requirements of the design.

The research led to electrochromic materials. These materials change color or opacity when an electrical voltage is applied, offering dynamic control over their appearance. This transformation is due to the oxidation and reduction reactions within the material, which alter its optical properties. This technology is commonly applied nowadays to glass doors and walls to change their opacity. The color change can be precisely controlled, offering a spectrum of hues and opacities based on the applied voltage and the specific composition of the electrochromic material.

To achieve the design, each decorative piece must be individually supplied with a controlled voltage to enable color and/or opacity changes. The challenge lies in estimating the cost of implementing such technology, which falls beyond the scope of this research. The primary objective here is not to develop a finalized design but to evaluate Midjourney's capacity to inspire innovative design concepts while maintaining an awareness of their practical feasibility. Nonetheless, this outcome was compelling, achieved by creatively synthesizing previous results in a manner distinct from the first two experiments.

9.8 Outputs

The last experimentation saw many iterations, and the process was quite long. While some generations were more inspiring than others, Midjourney struggled to influence the design direction decisively. The product category was successfully represented in the first-generation stage, similar to Concept 2. However, in the second-generation stage, Midjourney-generated images that were not inspiring.

This lack of inspiration could be attributed to two main factors: a certain unpredictability, which is proper for this tool, and our willingness to convey in the prompts since the beginning a chosen design solution, which might have constrained too much of the possible outputs.

Regarding Midjourney's performance:

- The blend function proved again to help generate inspiring results, particularly when Midjourney needs concrete examples to guide its output.

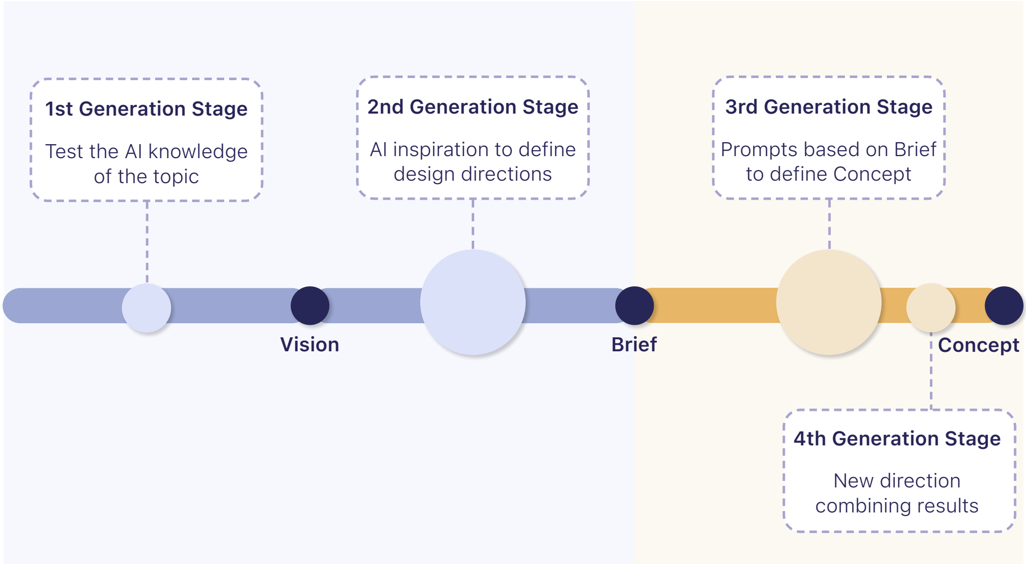
- The Describe function helped overcome challenges associated with crafting effective prompts.
- Surprisingly, it was a significant source of UI inspiration, demonstrating versatility beyond initial expectations.
- Changing prompts did not significantly alter the outcomes, indicating a level of consistency in the results despite varied inputs.

About the Overall Process:

- We had to develop some ideas at the beginning and some concepts' directions to get meaningful responses from the AI. However, this approach overly constrained the results, producing fewer inspiring images.
- Once again, the inspiration came from an indirect interpretation of the generated images.
- Not only did we encounter design fixation, but it also seemed as if the AI experienced a fixation, consistently generating similar results despite being provided with distinct briefs.
- The final additional generation step illustrated that the process is not linear and cannot be confined to predetermined steps; indeed, new generations can be necessary at any stage.

Considering the overall process for this last concept experimentation, although the first-generation stage was quick, the later stages were very long , as shown in Graph 7.

As anticipated, this experiment followed a slightly different process than others, meaning that we could not commit to a single product idea during the generative phase. Instead, we explored various aspects of different products, ultimately combining them in a fourth-generation stage not initially anticipated in the process design.



Graph 7.
Compared number of generations required for each Generative Stage in Concept 3, showing an additional 4th Stage.

PART 3

Discussing the Results

10. Research Outcomes

In this last conclusive chapter, we will trace comparisons between the three experiments and evaluate the three concepts' outputs.

Finally, we will divide the research outcomes into two main areas: those related to the process and those related explicitly to Midjourney use for product design purposes.

10.1 Three Processes Comparison

The three generative processes were compared to discern differences and similarities, thereby drawing conclusions.

As outlined in Graph 3, the design process entails three Midjourney generation stages. The initial stage occurs before vision development, testing the tool's familiarity with the subject matter. The second stage bridges the vision and the design brief, aiming to suggest a design direction that informs the brief's formulation. The final stage follows the design brief, assisting in concept definition.

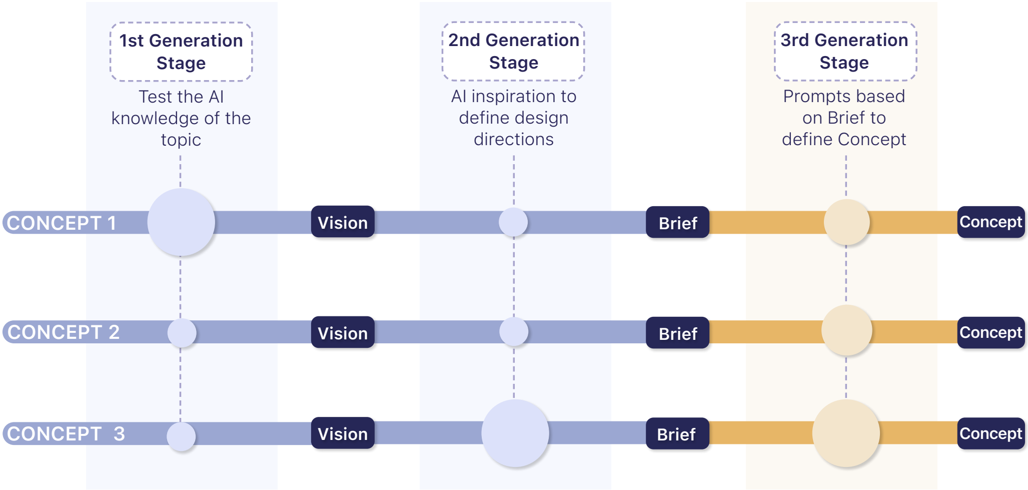
Before conducting the experimentations, we expected the initial stage to necessitate a minimal number of image generations, the second a moderate amount, and the third to be the most extensive. This expectation was based on the assumption that the first stage would mainly involve fine-tuning the prompts, the second would support defining the design direction, and the third was intended to be the actual stage for generating concepts. Surprisingly, each experiment required varying numbers of iterations per stage. The frequency of generations is denoted by three dot sizes: small for a few, medium for a moderate number of iterations, and large for a lengthy generative process requiring numerous iterations.

The process of fine-tuning the prompts varied significantly depending on the subject. Similarly, the clarity of the brainstorming phase could fluctuate based on the specifics of the brief. Graph 8 gives a visual comparison of these processes.

For the first concept, many iterations were unexpectedly needed at the beginning, in a phase expected to be swift. This happened for twofold reasons: firstly, it was the initial attempt requiring prompt refinement, and secondly, the object to be designed could potentially have many configurations, challenging the tool to generate meaningful visuals without clear design archetypes to follow. Conversely, the second stage was expedited, while the third stage, although extensive, was less prolonged than the first — this was also because we could not get optimal results and decided to stop. This concept experienced a long phase, a short one, and a medium-length one.

The second concept emerged as the quickest to yield satisfactory outcomes, featuring no extended phase but two short and one medium phase. The initial and second stages were swift, with Midjourney quickly grasping the product features and suggesting an intriguing design brief after a few iterations based on vision. The final stage was the lengthiest phase, which did not reach a high iteration count this time because the results were satisfactory.

The third concept was the most time-consuming overall, comprising one short-length phase and two long-length ones. Although the initial generation phase was as swift as the previous concept one, indicating a solid grasp of the subject, Midjourney struggled to deliver compelling product interpretations, necessitating numerous itera-



Graph 8. Comparison of the Three Concepts' differences in Generation Stages, showing differences in the number of generations required.

tions in the subsequent stages. Extensive iterations were required to refine the design brief and concept, and an additional step was also introduced to the generative phase, yielding further images beyond the initial concepts.

Regarding the randomness factor, AI algorithms produce statistically probable outputs for a given input, making the process similar to rolling dice with innumerable faces. Generative AI functions by analyzing vast datasets to identify patterns and generate outputs that mirror those patterns. This implies that, based on our prompt, the AI delivers an interpretation that is statistically likely coherent with it. This process, while sophisticated, introduces variability. As a result, each generation can vary widely, offering a range of possibilities where only a few may align with our expectations, making each prompt a gamble with unpredictable outcomes. The process of achieving an acceptable generated output can be frustrating for designers, as it may require numerous iterations. The extent of this frustration is subjective and largely depends on the designer's specific needs at the given moment of the design process. For example, a designer seeking inspiration might be more open to various outputs, whereas one with a precise vision in mind might be more selective and critical during the output evaluation phase.

As discussed earlier in this book, the division of agency between AI and humans reinforces the notion of a cooperative process. Design concepts emerge through a synergy of human creativity and AI's computational power, where one inspires the other. For the first concept, difficulties arose from the AI's struggle to identify the product category accurately. Our role involved recognizing the AI's limitations and maximizing the utility of its outputs. A decisive moment came when we chose to cease iterations and proceed with the available data, leading to a concept primarily shaped by human input yet inspired by AI in terms of aesthetics rather than function. This exemplifies how AI excels in suggesting product language while the human contributor focuses on functionality and conceptual depth.

The second concept exemplified a fruitful collaboration where the AI competently handled the product category, enabling a linear approach. This allowed for smooth guidance without imposing overly restrictive constraints and without abrupt changes. This cooperative effort resulted in a concept significantly influenced by AI, showcasing the potential of harmonious human–AI interaction.

In the third concept, we identified pitfalls primarily attributable to our approach. Like with the second concept, Midjourney accurately recognized the product category but failed to generate compelling designs. Unlike the first scenario, where we adapted quickly to the AI's limitations, we persisted in iterations, hoping for an inspirational breakthrough similar to the second concept. This approach was counterproductive, prolonging the process without offering further insights. Further considerations can be made about finding an effective approach for handling situations where, despite efforts, no improvements are achieved in the quality of AI, entering into a loop of trial and error where it is unclear how to proceed. We can reflect on two possible strategies: the first, as demonstrated by the initial concept, involves recognizing the blockage and deciding to work with the generated data, attempting to interpret it — or elements of it — meaningfully. The second strategy is acknowledging the approach's failure, leading to revision and opting for radical changes in the input preparation.

The structured division of the design process into three distinct generative stages has proven instrumental in identifying patterns and facilitating comparisons across the concepts explored. This approach allowed for a deeper understanding of how various factors — ranging from the AI's algorithmic tendencies to the designer's strategic choices and the unpredictable nature of creative generation — impact the development of design concepts. By examining these stages, we refined prompt engineering techniques and uncovered valuable insights into the collaborative dynamics between human intuition and AI capabilities.

11.2 Process-Related Considerations

After analyzing the three concepts and their respective processes, we made some considerations on the collaboration between designers and AI image generators. This validated the themes explored in Chapters 2 and 3, emphasizing the significance of sentence structuring and term retrieval for prompt engineering.

In Chapter 4.3, we hypothesized that AI image generators could benefit the industrial design process, particularly for brainstorming, Concept Inspiration, and Language Inspiration. This hypothesis was tested in the second and third-generation stages, with the former serving as a brainstorming session and the latter occasionally yielding either concept or language inspiration.

These and other themes will be elaborated on hereafter.

a - Direct and Indirect Inspiration

Much inspiration is derived from nuances and details within AI-generated images and their reinterpretation. This is a crucial point, as our inspiration often comes from a non-obvious and subjective application of a secondary aspect within an image. In this case, AI enables the designer to experience the so-called random stimulus principle of lateral thinking (Beaney, 2005). This principle highlights the importance of incorporating unexpected conceptual elements into the creative process to challenge and break down the designer's habitual thinking and biases. Introducing such stimuli, even when random and abrupt, can be beneficial as they often reshuffle priorities and enable the designer to reconsider the problem and discover new possible trajectories. Research by Liapsis *et al.* (2016) demonstrates that AI can effectively provide these random stimuli, facilitating lateral thinking. As a result, even when AI-generated suggestions are not directly implemented, they still significantly influence the final outcomes (Figoli *et al.*, 2022). We can call this indirect inspiration. Such was the case for the desk organizer's conceptualization and the initial insight for the electric mug design. Conversely, direct inspiration is less common and occurs when the AI generates an image where one or more elements are almost immediately usable with minimal modifications, requiring only minor adjustments rather than an intensive reinterpretation. These elements might include the entire image, specific shapes or curves, particular colors or finishes, the fundamental architecture of the product, the embedded meaning, and more. Direct inspiration was evident in the final iterations of the electric mug and, to a lesser extent, in the concluding stages of the thermostat design. To summarize, the core difference between direct and indirect lies in the extent of the interpretative effort the designer performs, limited in the first case and substantial in the second. It is crucial for designers approaching generative AI tools to recognize this distinction, as always expecting direct inspiration may not benefit the process, as was our experience with Concept 3.

b - The Critical Role of the Exporative Phase

The first-generation stage underscored the significant link between product research and prompt structuring. Initial generations, set as the first step of the design process, highlighted how prompts structured after the research were significantly more inspiring.

Term retrieval is essential for crafting effective prompts in Generative AI, as discussed in Chapter 3.2, where we acknowledged that researchers identify one of the main pitfalls of AI design applications as the cognitively tricky task of translating visual ideas into structured text.

Prompt structuring for design purposes can be enhanced by:

- Utilizing the design brief as a preliminary prompt. Once the brief is defined, the subsequent prompts are just a rework of it.
- Incorporating design requirements as attributes to make the prompt more specific. Adding the requirements after the brief rework in the prompt helps the AI understand the nuances of what you are aiming for.
- Employing benchmarking and trends analysis for appropriate terms selection, similar to the term retrieval process followed by AI artists, which in design can be augmented by targeted

benchmarking and research, particularly for specifying stylistic and typological terms.
- When the product category is ambiguous or uncommon, looking for product definitions is helpful, as exemplified in Concept 1.

c - Process Differences related to Product Category

The second critical insight of the first-generation stage was to highlight process differences related to product categories. When AI struggles to identify the products' archetypes, designers need to extend the initial tuning of prompts, requiring a deeper understanding of how to guide the AI and further research of specific terms to clarify the desired attributes. These products are also more likely to benefit from specific image-referenced prompts in later stages, as our imagination may not align with the AI's. Conducting preliminary prompt tests before defining the brief was instrumental in preventively assessing the AI's comprehension of each product. Indeed, as seen with Concept 1, the initial stage of prompt tuning might be significantly longer. Less mainstream products are more likely to benefit from indirect inspiration.

Figure 1. First results respectively for the desk organizer and for the electric kettle, showcasing clear differences in realism.

d - Brainstorming applications of AI

The second-generation stage served as a proving ground for the brainstorming efficacy of text-to-image models. In this phase, prompts were crafted based on broad visions rather than concrete plans for addressing the selected scenarios, intentionally kept vague to receive a wide range of divergent options. When comparing the development of the three concepts, the brainstorming process varied for each, yet consistently relied on indirect inspiration. Indeed, brainstorming typically occurs at a stage where the ideas are vague and conceptual, and the AI is less likely to produce realistic and feasible results. For the desk organizer, the brainstorming generations inspired our concept indirectly; the AI's tendency to generate abstract images when asking for modular systems led us to specify modular trays, aiming for a tangible reference to avoid nonsensical results. The inspiration for the electric mug was again indirect, as an unexpected image from Midjourney nudged the design toward a more mug-like shape without a specific reference to follow. In general, expecting direct inspiration from text-to-image tools at this stage is unrealistic, given their current capabilities and the inherent nature of early conceptual brainstorming.

e - Concept-relevant and Moodboard-relevant Results

The third-generation stage for concept definition highlighted the multi-faceted utility of AI-generated images. As theorized in Chapter 4, AI-generated visuals can offer both conceptual and functional inspiration or act as stylistic references akin to components of a mood board. For example, with the desk organizer concept, images featuring three nesting elements indirectly inspired the system's functionality. On the other hand, while not directly contributing functional ideas, specific images showcased intriguing product languages, laying the groundwork for moodboard creation. The concept explorations highlighted the dual potential of AI-generated imagery. It's crucial for designers to recognize this aspect and not expect only concept- inspiring images in later stages. Instead, attention should be given to the moodboard value of some generations and how these can be integrated with the concept.

f - Human and AI Design FIxation

As we highlighted, the results of such processes are to be attributed to a collaboration between the designer and the machine. The three concept explorations offer a clear example of different approaches to this collaboration. In the first two, even when the AI did not yield optimal results, we were able to stop iterating new generations at some point and work with the available outcomes. Conversely, we iterated incessantly in the third scenario, fixated on achieving a specific result. The thermostat experience particularly emphasized the necessity of

Figure 2.
Example of images that inspired either the functional aspects or the language of the product.

recognizing when to conclude iterations to avoid design fixation and unnecessarily prolonging the process. The AI's tendency to produce visually appealing yet unsatisfying images is especially likely to induce fixation. It is the designer's task to be aware of this and to stop or change strategy when needed.

The third concept also highlighted what might be described as AI's fixation. Not only were we fixated on a specific idea, but the AI was also generating similar designs for varying prompts. This could be attributed to the AI's training, which may make it more proficient on specific topics. However, it consistently leaned towards a particular concept for some products. As AI has the potential to break our fixation and produce an unexpected image, we have to be aware of the mentioned aspects and break its fixation when needed. We can do it by diversifying our inputs or re-interpreting the brief from a different perspective.

11.3 Midjourney Prompts for Product Design

Midjourney emerged as a pivotal tool in this research, being the only one used to explore the three concepts and the most studied AI image generator in terms of prompt engineering by scholars and practitioners. Indeed, a vibrant community is engaged in discussing its prompt engineering for artistic purposes. This community is a testament to the tool's adaptability and the broad spectrum of creative possibilities it unlocks for users across various disciplines.

We found it pertinent to share the main prompt engineering insights I elaborated during this research, contributing to the discourse on prompt engineering for design purposes and aiming to foster the integration of this technology and creativity.

a - –style raw Parameter

It was vital in achieving desirable outcomes, and it was a game-changer when we were getting extravagant results. The *–style raw* parameter uses an alternative model offering more control over the generated image. Images made with *–style raw* undergo less automatic beautification, which can result in a more accurate match when aiming for specific results.

Style Standard Style Raw

Figure 3.
Differences in realism in generations with and without –style raw paramenter.

b - Visualization Style Attributes

Given Midjourney's tendency towards artistic representation, it is essential to specify a desire for realism in design applications. Early in the concept creation phase, a visualization focusing solely on the product, without further objects or settings, might be preferred. Directing Midjourney to produce a *designer-like visualization* helps steer it away from artistic or illustrative interpretations. As depicted in the provided image, the images rendered with these specifications exhibit a representation style more aligned with design visualizations.

Figure 4.
Differences in realism in generations with and without –style raw parameter.

[Prompt]
Product Design render of an electric kettle.

c - Product Style Attributes
To counterbalance Midjourney's inclination towards complex and sometimes grotesque compositions, incorporating attributes like *minimalism* can prevent overly complicated results. Phrases such as *sleek design* help avoid bizarre interpretations, while terms like *trending on Behance* or *Dribble design trends* can refine the aesthetic appeal.

Figure 5

[Prompt]
Product Design render of an electric kettle, **minimal and sleek design.**

d - Product Physical Attributes
Specifying shapes, colors, and other physical attributes significantly influences the results. This means that the more we give descriptions and details, the more material the AI has to work with, potentially leading to more meaningful results. However, adding these attributes can also over-constrain results, restricting creativity and leading to fixation. Therefore, it is essential to be aware of the stage of the process we are in and use more general attributes when aiming for serendipity.

[Prompt]

`Product Design render of an electric kettle, minimal and sleek design, `**`black with white details,`**` add `**`curves.`**

Figure 6

e - Conceptual Attributes

Incorporating abstract aspects of the product, such as functional aspects, overall moods, and conceptual aspects, introduces an element of unpredictability that is useful for serendipitous results. While achieving conceptually or functionally coherent results directly from these prompts may be challenging — almost impossible — for the AI, they provide additional data for the algorithm to enhance the overall appearance and inspire unexpected outcomes. This happened for Concept 2, where the AI moved the concept direction from an electric kettle to an electric mug.

[Prompt]

`Design a `**`compact and portable`**` electric kettle [...] `**`single-person use. [...]Ideal for a quick cup of tea.`**` Easy to carry and use. [...]`

Figure 7

f - Text Prompts for serendipity and Divergent Inspiration / Blend Function for control and Convergent Inspiration

Text prompts usually yield less aesthetically innovative results, but because of the serendipity typical of their outcomes, they help find initial design direction. They also facilitate idea generation based on brief before arriving at specific solutions. In Concept 2, text prompts produced what has been defined as indirect inspiration, while Image

Prompts produced more direct inspiration. While there is no guaranteed correlation between these prompt types (text or image) and the nature of the inspiration (direct and indirect), which often emerges randomly, they are predisposed to generating either a convergent or divergent kind of inspiration. This means that blending existing or previously generated images can refine the inspiration toward a more specific outcome once the design direction has been defined. Conversely, before defining the brief, employing text prompts based on initial ideas can open up new possibilities.

Figure 8. On the left images resulted from text prompts for divergent inspiration, on the right images obtained blending existing images for design refinement and convergent inspiration.

g - Positive Results for UI Inspiration

The main reason behind the decision to pursue Concept 3 was assessing Midjourney's capability to inspire UI design, knowing that rendering text and numbers is still one of the main weaknesses of this model. UI inspiration emerged as a notable success for the thermostat concept, offering valuable layout and general style insights. The current limitations of the algorithm in generating meaningful text did not prevent it from being inspiring in other dimensions. This suggests that further algorithm refinements will significantly enhance AI's capacity to inspire UI design as well.

11.4 Limitations and Future Work

We embarked on an exploratory journey to understand the potential and limitations of integrating AI image generators in the design process, mainly using Midjourney, in industrial design. After discussing the potential benefits of such integration, we now focus on the limitations of our research and ideas for future developments.

Figure 9

First, we based our hypothesis and conclusions on personal experimentation with designing three products using Midjourney. This approach offers preliminary insights but falls short of capturing the diverse experiences and outcomes possible across different designers and design contexts. Therefore, a significant limitation of our study is the lack of statistical validity. Future research should validate these preliminary findings statistically through broader experimentation involving multiple participants. This could involve a standardized set of prompts and metrics for evaluating AI-generated designs, allowing for a more definitive analysis of the utility and limitations of AI tools in industrial design.

Secondly, the rapidly evolving nature of AI tools underscores the provisional status of these findings. Midjourney's capabilities, like those of other AI image generators, are in constant flux, with new features and improvements that could substantially alter its utility for design and ease of use. We had to limit the research and decided to focus on Midjourney, which was chosen for its promising representation and realism capabilities, but this narrows the scope of the findings. Different AI tools, with varying functionalities, might represent distinct advantages or challenges for industrial designers. Midjourney's specialization towards artistic creation highlights a misalignment with the specific needs of product design and feasibility evaluation, pointing to a gap that future tools might fill more aptly. Expanding the research to include multiple AI image generators would offer a comprehensive view of the available tools, identifying those best suited to various design tasks. Investigating AI's integration within design teams could illuminate how these tools enhance collaboration, idea generation, and decision-making. There is a critical need to monitor and contribute to developing AI tools tailored for industrial design, advocating for features that meet the field's unique requirements. A longitudinal study tracking the evolution of these tools would provide insights into their changing role in the design process; in general, it is essential to consider the constant and rapid evolution of AI tools.

Moreover, as AI becomes more sophisticated and user-friendly, prompt engineering is expected to evolve, necessitating continuous research into effective communication strategies with AI to achieve desired design outcomes.

Lastly, the feasibility of the generated outputs was considered to a certain extent, and some feasibility assessments were conducted. However, a comprehensive product development process involving detailed design development and final testing was beyond the scope of this study due to the research's focus on evaluating AI-generated concept outcomes. As such, it is challenging to precisely evaluate the extent to which these products might require redesign or adjustment in a real-world development scenario. Exploring the detailed development process of AI-conceptualized products would offer deeper insights into the practical application of AI-generated designs, further enlightening AI's role in product design processes.

In conclusion, this book lays the groundwork for a deeper understanding of AI's role in industrial design. The path forward calls for a balanced approach that acknowledges AI's limitations while leveraging its strengths, ensuring that designers can navigate the evolving landscape of AI-assisted design. This necessitates ongoing exploration, validation, and adaptation to harness the full potential of AI in enriching the creative process and achieving innovative, feasible design solutions.

11. Conclusions

We conducted an exploration of the evolving landscape of generative AI, particularly focusing on its application in industrial design. By exploring the capabilities of AI tools like Midjourney, we aimed to uncover the potential and limitations of AI-assisted concept generation processes, offering insights into the integration of such technologies in design practice.

Starting from the initial curiosity that sparked this exploration, the research has proceeded to a three-concepts study, revealing the nuanced dynamics between human designers and AI tools. These interactions showcased a complex collaborative pattern, which depends on the AI tool's functionality and limitations, the designer's choices and biases, and an ever-present element of randomness. These factors render the collaborative process challenging to systematize and generalize. For these reasons, the research required a focus on a specific tool, Midjourney, and a division of the design process into distinct generative stages for a structured investigation. This enabled an in-depth analysis of AI's impact across different phases of concept generation, resulting in twofold outcomes: general considerations of the designer-AI collaboration and specific conclusions related to the choice of Midjourney.

The AI tool choice deeply shaped the experiment, leading to practical insights for prompt engineering with Midjourney in product design. Key findings emerged, validating the initial hypotheses from the literature review and personal exploration. AI's capacity to enhance concept generation, introduce serendipity, and act as a collaborative partner in the early stages of the design process has been tested and proved to have a positive impact on some stages of the process. However, it has also shown limitations, particularly regarding the fluctuating capabilities of AI tools and the need for a nuanced understanding of their application within specific design contexts.

Lastly, this exploration underscored that we are far from a point where AI can autonomously execute the creative work of designers. The designer's role in maintaining conceptual coherence and evaluating functional innovation remains crucial. Indeed, AI is promising to speed up rendering processes unprecedentedly, which makes us wonder to what extent our way of visualizing projects will change in future years.

During this research, new exciting tools emerged with the potential to revolutionize the design process, such as Genie by Luma AI for text-to-3D generation and OpenAI's Sora for text-to-video, alongside the use of sketch- to-image AIs like Vizcom for quick concept rendering.

As this book concludes, it is evident that the field stands before significant transformation. Our journey through generative AI and design highlights the need for continuous research, adaptation, and critical engagement with AI tools as they evolve and become increasingly integrated into design practices. This book also reaffirms the importance of a balanced approach to AI in design, one that recognizes the potential of AI to enrich the creative process while being mindful of its limitations. As designers navigate the AI-assisted design landscape, the insights from our research offer a perspective on leveraging AI's strengths, addressing its challenges, and shaping the future of design in an increasingly digital world.

Figure 1.
Midjourney generations from the request to produce moodboards based on the images of the three concepts developed.

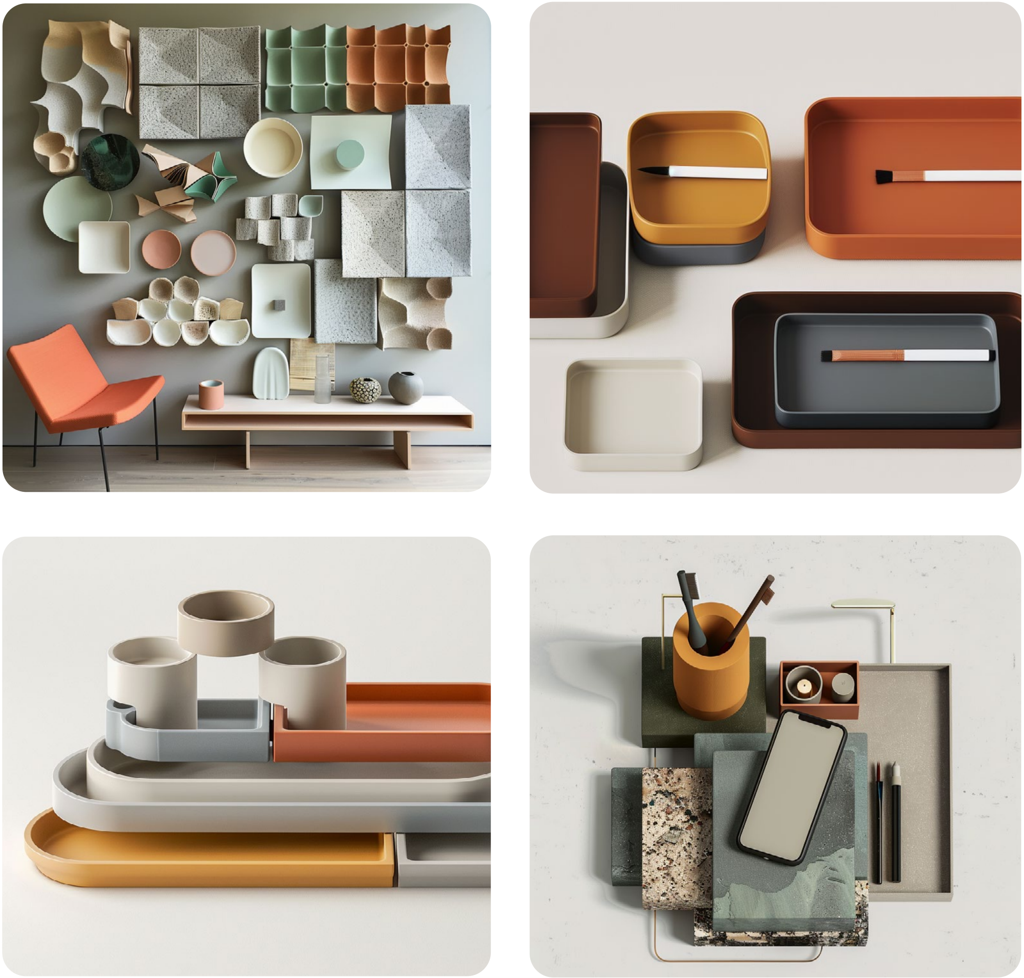


Figure 2.
Some absurd results, displaying nonsensical elements typical of AI generated imagery, that were not presented during the process.

References

Bibliography

Atkinson, D.P., & Barker, D.R. (2023). AI and the social construction of creativity Convergence, 29(4), 1054-1069. https://doi.org/10.1177/13548565231187730

Beaney, M. (2005). Imagination and creativity. Open University Press.

Benbya, H., Strich, F., & Tamm, T. (2024). Navigating Generative Artificial Intelligence Promises and Perils for Knowledge and Creative Work. Journal of the As- sociation for Information Systems, 25(1), 23-36. https://doi.org/10.17705/1jais.00861

Bruno, C. (2020). Creativity in the Design Process. Exploring the Influences of the Digital Evolution. Springer. https://doi.org/10.1007/978-3-030-87258-8

Burnap, A., Hauser, J.R., & Timoshenko, A. (2023). Product Aesthetic Design: A Machine Learning Augmentation. Marketing Science, 42(6), 1029-1056. https://doi.org/10.1287/mksc.2022.1429

Cai, A., Rick, S.R., Heyman, J., Zhang, Y., Filipowicz, A., Hong, M.K., Klenk, M., & Malone, T. (2023). DesignAID: Using Generative AI and Semantic Diversity for Design Inspiration. In M. Bernstein, S. Savage, & A. Bozzon (Eds.), Collective Intelligence Conference (CI '23), November 06-09, 2023, Delft, Netherlands (pp. 1-11). ACM Digital Library. https://doi.org/10.1145/3582269.3615596

Caporusso N. (2023). Generative Artificial Intelligence and the Emergence of Creative Displacement Anxiety: Review. Research Directs in Psychology and Behavior, 3(1), Article n. 9. https://doi.org/10.53520/rdpb2023.10795

Dang, H., Mecke, L., Lehmann, F., Goller, S., & Buschek, D. (2022). How to Prompt? Opportunities and Challenges of Zero- and Few-Shot Learning for Human-AI Interaction in Creative Applications of Generative Models. ArXiv:2209.01390 [cs.HC]. https://export.arxiv.org/abs/2209.01390.

Dang, H., Brudy, F., Fitzmaurice, G., & Anderson, F. (2023). WorldSmith: Iterative and Expressive Prompting for World Building with a Generative AI. In S. Follmer, Han & J. Steimle (Eds.), Proceedings of the 36th Annual ACM Symposium on User Interface Software and Technology (UIST '23), October 29–November 01, 2023, San Francisco, CA, USA (pp. 1-17), ACM Digital Library. https://doi.org/10.1145/3586183.3606772

Das, P., & Varshney, L.R. (2022). Explaining Artificial Intelligence Generation and Creativity: Human interpretability for novel ideas and artifacts. IEEE Signal Processing Magazine, 39(4), 85-95. https://doi.org/10.1109/MSP.2022.3141365

Deckers, N., Fröbe, M., Kiesel, J., Pandolfo, G., Schröder, C., Stein, B., & Potthast, M. (2023). The Infinite Index: Information Retrieval on Generative Text-To-Image Models. In J. Gwizdka & S.Y. Rieh (Eds.), Proceedings of the ACM SIGIR Conference on Human Information Interaction and Retrieval (CHIIR '23), March 19-23, 2023, Austin, TX, USA (Article n. 63). ACM Digital Library. https://doi.org/10.1145/3576840.3578327

Epstein, Z., Hertzmann, A., Investigators of Human Creativity, Akten, M., Farid, H., Fjeld, J., Frank, M. R., Groh, M., Herman, L., Leach, N., Mahari, R., Pentland, A. S., Russakovsky, O., Schroeder, H., & Smith, A. (2023). Art and the science of generative AI. Science, 380(6650), 1110-1111. https://doi.org/10.1126/sci- ence.adh4451

Figoli, F.A., Mattioli, F., & Rampino, L. (2022). Artificial intelligence in the design process: The impact on creativity and team collaboration. Serie di Architettura e Design. Franco Angeli, ISBN 9788835134640. http://hdl.handle.net/11311/1204154

Figoli, F.A., Rampino, L., & Mattioli, F. (2022). AI in design idea development: A workshop on creativity and human-AI collaboration. In D. Lockton, P. Lloyd, S. Lenzi, P. Ekkert, A. Oak, J. Sádaba, & P. Lloyd (Eds.), Proceedings of DRS2022: Bilbao, 25 June - 3 July, Bilbao, Spain (Paper n. 117). DRS Digital Library. https://doi.org/10.21606/drs.2022.414

Fisher, J.A. (2023). Centering the Human: Digital Humanism and the Practice of Us- ing Generative AI in the Authoring of Interactive Digital Narratives. In L. Holloway-Attaway & J.T., Murray. (Eds.), 16th International Conference on Interactive Digital Storytelling, ICIDS 2023, Kobe, Japan, November 11-15, 2023, Proceedings, Part I (pp. 73-88). Springer Nature.

Hanafy, N.O. (2023). Artificial intelligence's effects on design process creativity: A study on used A.I. Text-to-Image in architecture. Journal of Building Engineering, 80, Article n. 107999, https://doi.org/10.1016/j.jobe.2023.107999

Hoggenmueller, M., Lupetti, M.L., Van der Maden, W., & Grace, K. (2023). Creative AI for HRI Design Explorations. In G. Castellano & L. Riek (Eds.), Proceedings: Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction (HRI '23 Companion), March 13-16, 2023, Stockholm, Sweden (pp. 40-50). IEEE-ACM Digital Library. https://doi.org/10.1145/3568294.3580035

Hong, M.K., Hakimi, S., Chen, Y., Toyoda, H., Wu, C.C., & Klenk, M.E. (2023). Generative AI for Product Design: Getting the Right Design and the Design Right. ArXiv:abs/2306.01217 [cs.HC]. https://doi.org/10.48550/arXiv.2306.01217

Isgrò, F. (2020). Artificial intelligence in design. Master's Thesis, Politecnico di Milano.

Jeon, Y., Jin, S., Shih, P.C., & Han, K. (2021). FashionQ: An AI-Driven Creativity Support Tool for Facilitating Ideation in Fashion Design. In J. Kitamura & A. Quigley (Eds.), Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21) (Article n. 576). ACM Digital Library. https://doi.org/10.1145/3411764.3445093

Kantosalo, A., & Toivonen, H. (2016). Modes for Creative Human-Computer Collaboration: Alternating and Task-Divided Co-Creativity. In F. Pachet, A. Cardoso, V. Corruble, & F. Ghedini (Eds.), Proceedings of the Seventh International Conference on Computational Creativity (ICCC 2016) (pp. 77-84). Sony CSL. http://www.computationalcreativity.net/iccc2016/proceedings-2016/

Liapis, A., Yannakakis, G.N., Alexopoulos, C., & Lopes, P. (2016). Can computers foster human users' creativity? Theory and praxis of mixed-initiative co-creativ- ity. Digital Culture & Education, 8(2). https://www.um.edu.mt/library/oar/bitstream/123456789/29476/1/Can_computers_foster_human_users_creativity_the- ory_and_praxis_of_2016.pdf

Lin, L., & Long, D. (2023). Generative AI Futures: A Speculative Design Exploration. In Proceedings of the 15th Conference on Creativity and Cognition (C&C '23), June 19-21, 2023, Virtual Event, USA (pp. 380-383). ACM Digital Library. https://doi.org/10.1145/3591196.3596616

Liu, V. (2023). Beyond Text-to-Image: Multimodal Prompts to Explore Generative AI. In A. Schmidt, K. Väänänen, T. Goyal, P.O. Kristensson, A. Peters, S. Mueller,

Liu, V., & Chilton, L.B. (2022). Design Guidelines for Prompt Engineering Text-to- Image Generative Models. In S. Barbosa, C. Lampe, C. Appert, D.A. Shamma, S. Drucker, J. Williamson, & K. Yatani (Eds.), Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '22), April 29-May 5, 2022, New Orleans, LA, USA (Article n. 384). ACM Digital Library. https://doi.org/10.1145/3491102.3501825

Liu, V., Qiao, H., & Chilton, L.B. (2022). Opal: Multimodal Image Generation for News Illustration. In M. Agrawala, J.O. Wobbrock, E. Adar, & V. Setlur (Eds.), Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology (UIST '22), October 29-November 2, 2022, Bend, OR, USA (Article n. 73). ACM Digital Library. https://doi.org/10.1145/3526113.3545621

Liu, V., Vermeulen, J., Fitzmaurice, G., & Matejka, J. (2023). 3DALL-E: Integrating Text-to-Image AI in 3D Design Workflows. In D. Byrne, N. Martelaro, A. Boucher, D. Chatting, S. F. Alaoui, S. Fox, I. Nicemboim, & C. MacArthur (Eds.), Proceedings of the 2023 ACM Designing Interactive Systems Conference (DIS '23), July 10-14, 2023, Pittsburgh, PA, USA (pp. 1955-1977). ACM Digital Li- brary. https://doi.org/10.1145/3563657.3596098

Oppenlaender, J. (2023). A taxonomy of prompt modifiers for text-to-image generation. Behaviour & Information Technology, 43(15), 3763-3776. https://doi.org/10.1080/0144929X.2023.2286532

Oppenlaender, J. (2022). The Creativity of Text-to-Image Generation. In Proceeding of the 25th International Academic Mindtrek Conference (Academic Mindtrek 2022), November 16-18, 2022, Tampere, Finland (pp. 192-202). ACM Digital Library. https://doi.org/10.1145/3569219.3569352

Oppenlaender, J. (2023). The Cultivated Practices of Text-to-Image Generation ArXiv:2306.11393 [cs.CY]. https://doi.org/10.48550/arXiv.2306.11393

Oppenlaender, J., Linder, R., & Silvennoinen, J. (2023). Prompting AI Art: An Investigation into the Creative Skill of Prompt Engineering. ArXiv:2303.13534 [cs.HC]. https://doi.org/10.48550/arXiv.2303.13534

O'Toole, K., Horvát, E.A. (2024). Extending human creativity with AI. Journal of Creativity, 34(2), Article n. 100080. https://doi.org/10.1016/j.yjoc.2024.100080

Popescu, R., Schut, A. (2023). Generative AI in creative design processes: a dive into possible cognitive biases. In M. De Sainz Molestina, L. Galluzzo, F. Rizzo, D. Spallazzo (Eds.), Proceedings of the International Association of Societies of Design Research (IASDR 2023), October 2023 (Article n. 784). ACM Digital Library. https://doi.org/10.21606/iasdr.2023.784

Radhakrishnan, M. (2023). Is Midjourney-Ai the New Anti-Hero of Architectural Imagery & Creativity? Global Science Journal, 11(1), 94-114. https://doi.org/10.11216/gsj.2023.01.102270

Rampino, L. (2011). The innovation pyramid: A categorization of the innovation phenomenon in the product-design field. International Journal of Design, 5(1), 3-16

Runco, M.A. (2023). AI can only produce artificial creativity. Journal of Creativity, 33(3), Article n. 100063. https://doi.org/10.1016/j.yjoc.2023.100063

Sætra, H.S. (2023). Generative AI: Here to stay, but for good? Technology in Society, 75, Article n. 102372. https://doi.org/10.1016/j.techsoc.2023.102372

Safinah, A., & Devi P. (2021). Telling Creative Stories Using Generative Visual AidsArXiv:2110.14810 [cs.HC] https://doi.org/10.48550/arXiv.2110.14810

Sanchez, T. (2023). Examining the Text-to-Image Community of Practice: Why and How do People Prompt Generative AIs?. In Proceedings of the 15th Conference on Creativity and Cognition (C&C '23), June 19–21, 2023, Virtual Event, USA (pp. 43-61). ACM Digital Library. https://doi.org/10.1145/3591196.3593051

Sarkar, A. (2023). Exploring Perspectives on the Impact of Artificial Intelligence on the Creativity of Knowledge Work: Beyond Mechanised Plagiarism and Stochastic Parrots. In S. Boll, A. Cox, T. Ludwig, & M.E. Cecchinato (Eds.), Annual Sympo- sium on Human-Computer Interaction for Work 2023 (CHIWORK 2023), June 13-16, 2023, Oldenburg, Germany (Article n. 13). ACM Digital Library. https://doi.org/10.1145/3596671.3597650

Shneiderman, B. (2022). Human-centered AI. Oxford University Press. https://doi.org/10.1093/oso/9780192845290.001.0001

Tholander, J., & Jonsson, M. (2023). Design Ideation with AI - Sketching, Thinking and Talking with Generative Machine Learning Models. In D. Byrne, N. Martelaro, A. Boucher, D. Chatting, S.F. Alaoui, S. Fox, I. Nicemboim, & C. MacArthur (Eds.), Proceedings of the Designing Interactive Systems Conference (DIS '23), July 10-14, 2023, Pittsburgh, PA, USA. (pp. 1930-1940) ACM Digital Li- brary. https://doi.org/10.1145/3563657.3596014

Turchi, T., Carta, S., Ambrosini, L., & Malizia, A. (2023). Human-AI Co-creation: Evaluating the Impact of Large-Scale Text-to-Image Generative Models on the Creative Process. In L.D. Spano, A. Schmidt, C. Santoro, & S. Stumpf (Eds.), End-User Development. Proceedings of the Department of Computer Science, Università di Pisa. Pisa, Italy (pp. 35-51), Springer. https://doi.org/10.1007/978-3-031- 34433-6_3

Wakkary, R. (2020). Nomadic Practices: A Posthuman Theory for Knowing Design. International Journal of Design, 14(3), 117-128. http://www.ijdesign.org/index.php/IJDesign/article/view/4039/917

Wakkary, R. (2021). Things We Could Design: For More Than Human-Centered Worlds. The MIT Press. https://doi.org/10.7551/mitpress/13649.001.0001

Wang, Y., Shen, S., & Lim, B.Y. (2023). RePrompt: Automatic Prompt Editing to Refine AI-Generative Art Towards Precise Expressions. In A. Schmidt, K. Väänänen, T. Goyal, P.O. Kristensson, A. Peters, S. Mueller, J.R. Williamson, & M.L. Wilson

(Eds.), Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23), April 23-28, 2023, Hamburg, Germany (Article n. 22). ACM Digital Library. https://doi.org/10.1145/3544548.3581402

Wang, B., Zuo, H., Cai, Z., Yin, Y., Childs, P., Sun, L., & Chen, L. (2023). A Task-Decomposed AI-Aided Approach for Generative Conceptual Design. In Proceedings of the ASME 2023 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 6: 35th International Conference on Design Theory and Methodology (DTM). Boston, Massachusetts, USA. August 20-23, 2023. (Paper n. DETC2023-109087, V006T06A009), ASME Digital Collection. https://doi.org/10.1115/DETC2023-109087

Wilson, H.J., & Daugherty, P.R. (2018). Collaborative intelligence: Humans and AI are joining forces. Harvard Business Review. https://hbr.org/2018/07/collabora- tive-intelligence-humans-and-ai-are-joining-forces

Zhang, C., Wang, W., Pangaro, P., Martelaro, N., & Byrne, D. (2023). Generative Image AI Using Design Sketches as Input: Opportunities and Challenges. In Proceedings of the 15th Conference on Creativity and Cognition (C&C '23), June 19-21, 2023, Virtual Event, USA (pp. 254-261). ACM Digital Library. https://doi.org/10.1145/3591196.3596820

Zhou, E., & Lee, D. (2024). Generative AI, Human Creativity, and Art. PNAS Nexus, 3(3), Article n. pgae052. https://doi.org/10.1093/pnasnexus/pgae052

Sitography

Adobe. (n.d.). IA in Photoshop. Retrieved Jan 15, 2024, from https://www.adobe.com/it/products/photoshop/ai.html

ERCO. (n.d.) LED: what is tunable white? https://www.erco.com/en/designing-with-light/lighting-knowledge/led/led-tunable-white-7731/

Interaction Design Foundation - IxDF. (2016, December 19). What is Artificial Intelligence (AI)?. Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/topics/ai

Midjourney. (n.d.). Midjourney Documentation. Retrieved Jan 15, 2024, from https://docs.midjourney.com/v1/docs

Nielsen, L. (2022, Sep 3). An advanced guide to writing prompts for Midjourney (text-to-image). Medium. https://medium.com/mlearning-ai/an-advanced-guide-to-writing-prompts-for-midjourney-text-to-image-aa12a1e33b6

Niio. (n.d.). Mario Klingemann: Into the wilderness of AI. Retrieved from https://www.niio.com/blog/mario-klingemann-into-the-wilderness-of-ai/

Product DesAIn. (2023, 11 Nov). Midjourney-AI for Product Design [Video Playlist]. YouTube.https://www.youtube.com/playlist?list=PLR4oNwHaXHqMGpPFnGqZwY4LvvCvYNjq

Sartor, M. (2023, Nov 7). The Evolving Role of Product Designers in the AI Era. Medium. https://medium.com/@design.byMartina/the-evolving-role-of-product-de- signers-in-the-ai-era-efd263d7151e

TechBlick. (n.d.) Brilliant Electrochromic Materials. https://www.tech- blick.com/post/brilliant-electrochromic-materials#viewer-9b3hu

Vizcom. (n.d.). Homepage. Retrieved Dec 20, 2024, from https://www.vizcom.ai

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This book presents the evolution of a master's thesis research conducted within the Master of Science in Design & Engineering at Politecnico di Milano. It explores the role of generative AI—particularly text-to-image tools like Midjourney—in the early stages of the product design process. The research aims to examine how these tools can support the conceptual phase of industrial design by fostering inspiration, accelerating ideation, and enabling new forms of creative collaboration.

Drawing from a literature review, observation of practitioners' approaches, and hands-on experimentation, the book offers reflections on the evolving relationship between human creativity and algorithmic generation. It is structured in four parts and includes both theoretical insights and practical guidelines.

Through the creation and analysis of three AI-generated product concepts, the author investigates the need to translate visual outputs—primarily intended for creative expression—into meaningful and realistic design developments.

The work proposes a design-oriented approach to applying AI-generated content within the design process, offering insights into human–AI collaboration. Intended for researchers, designers, and practitioners interested in integrating emerging AI technologies into design workflows, the book provides a timely snapshot of a rapidly evolving field, outlining key opportunities, challenges, and potential trajectories for future development in industrial design.

FrancoAngeli
La passione per le conoscenze