

Artificial Intelligence Applied to Ideation in Design

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Abstract. This paper is based on two main concepts: Concept Design and Artificial Intelligence (A.I.). According to Leach (2021), people are surrounded by A.I. in various aspects of daily life. This circumstance highlights the importance of creative professionals to interpret A.I. as a Design tool. The objective of this paper is to evaluate how A.I. can be used in early stages of the ideation process for the development of an artifact. The methodological framework is exploratory-descriptive and was developed through a case study. The practical contribution is to exemplify the simultaneous use of AI and Design tools in a simulation of the creative phase of a furniture project, this result was diagrammed to represent a systematization of where each tool fits into the creative process. The theoretical contribution is to add to the debate around this subject.

Keywords: Artificial intelligence, Concept Design, Creative processes, Design Methods, Ideation.

1 Introduction

The contemporary Design process, within the focus of everyday practices, and the uniqueness of each work environment, makes use of various tools added throughout the design process. Consequently, there are tools that seek to help in the initial stages of designing, whether defining the scope of projects, stimulating pollination of ideas, reducing obstacles in the flow of thoughts, or some other way of guiding the ideation process in order to achieve project objectives. Therefore, it is valid to suggest that accelerating the process of using these tools and facilitating their user interaction can be positive aspects. From this perspective, this acceleration of use and the automation of mechanical processes associated with these tools are directly contributing to a more fluid creative process, enabling ideas to be put into practice as soon as possible and reducing obstacles between ideation and visualization.

In this sense, with the expansion of interest and use of AI tools. (Figure 1), they started to be integrated in the design processes, accentuating the need for a systematic foundation of their incorporation. In addition to the potential of photorealistic imagery representation of current A.I. tools, it should also be noted that they can perform tasks that would be very repetitive, or that could not be reviewed by a human given the immense number of iterations (Mason, 2021; Leach, 2021; El-Namaki, 2019).



Figure 1. Growth in the search for “Artificial Intelligence” in the world in the last 5 years. Source: Google Trends, 2023.

Considering the extension of this paper, it is necessary to establish that the focus is solely on the utilization of A.I. and Design tools in the initial stages of the design process, specifically within Concept Design. According to Fiona Raby (2007, apud Franzato, 2012), the precedence of the idea over any material consideration is the distinguishing feature of this definition of Concept Design compared to others. Furthermore, it can be added, according to Franzato (2012), that this refers to a project idea still in its embryonic state. Thus, it is assumed that ideas do not arise out of thin air: creative professionals (designers, architects, artists, etc.) possess a repertoire of works, experiences, tools, references, and methods (Pazmino, 2010) that make the creation and development of ideas possible.

Artificial Intelligence, in turn, will be defined as: the ability of a computer to mimic human cognitive functions, such as learning and problem-solving (Microsoft, 2022). In this work, the type of A.I. utilized was of image generation and transformation, and the process explored in the case study was the generation of images from text, commonly known as "text2img."

Considering this conceptual aegis, the starting question is: how can the use of artificial intelligence assist in the early and conceptual stages of a project? The purpose of this study is to identify and systematize the technical and critical aspects associated with artificial intelligence that can be used to enhance the artifact conception process. In order to achieve this goal, partial objectives were defined to be accomplished: 1. apply A.I. tools in a simulated project to illustrate and describe the ideation process facilitated by their assistance; 2. enumerate the prerequisites and decisions taken while utilizing A.I. tools for

the ideation process, with the intention of making these choices educational; 3. identify guidelines for a systematic process of using A.I. tools in ideation of a Design creative process.

2 Methodology

This work is an exploratory and descriptive study, employing a qualitative approach, utilizing both Case Study and Design Science Research (DSR) technical procedures. The choice of conducting a case study is rooted in the recent nature of the subject matter, lacking academically established references, so it was necessary to first understand how A.I. use is present in Design processes, to later try to apply it. Additionally, the use of DSR is justified because it sought to solve problems through the proposition of an artifact, in this instance, the artifact being a systematic proposed process.

Five project phases were adopted, according to Dresch (2015), they are: problem awareness, suggestion, artifact development, evaluation and results. In the first stage, a literature review was conducted on two main subjects: Concept Design and Artificial Intelligence. Subsequently, a search for similar works was undertaken to comprehend the state of the art. This search, however, did not point to works that related the use of image generation A.I. tools for the production of Concept Design.

In the second stage, it was determined which Design tools should be used in the case study, and Design project methods were also chosen to support this process. Both Jones (1992) and Löbach (2001) methods were used as reference, requiring adaptations to be applied, since they were not originally conceived with emerging technologies, such as A.I., in mind. In conjunction with these design methods, the following design tools were employed: Briefing defined the project's scope; Brainwriting served to blend ideas; Syntactic and Semantic Panels served as visual and vocabulary associations with the developed object, based on its aesthetic, material and conceptual information. From these 4 tools, keywords that better described the evolving object were extracted and compiled into a Morphological Chart to input into the A.I. tools, to enable the maximum number of keywords combinations to be generated.

The third stage was the production of images, intermediated by A.I. tools, within a creative process, in the simulation of a kitchen cabinet project. In the fourth stage, after the production of these primary images, it was performed a descriptive analysis of the inputs used and the corresponding generated images, comparing them in order to identify how the results were influenced by the tools used and which of them led to better outcomes. Thus, the inputs were evaluated and refined, according to the options available in each one of them.

The fifth stage, the results, included the identification of guidelines to suggest a systematic approach to the ideation process, based on the decisions made during the previous stages.

3 Results

The choice of the artifact to be developed arose from the need to create alternatives to an everyday problem, seeking to reach wide appeal. From this, it was decided to design a cabinet under the kitchen sink. This furniture should store multiple utensils, be durable, water resistant, have internal shelves and achieve innovative solutions.

The first Design tool applied was Briefing (Figure 2), using the structure suggested by Pazmino (2010). Using this tool, the scope of the project and the main characteristics of the object were defined. In addition, aiming to connect the tool in question with the use of A.I. in future stages, keywords were extracted for potential use in composing a prompt.

Basic topics	Categories	Content
Nature of the project and context	Validation	Broken furniture, exchange for another
	Project's goal	Have a space under the counter to store kitchen utensils
	Desirable results	Durable, water-resistant furniture, with internal shelves and external doors, creative and innovative solutions
	Delivered results	Concept and Preliminary Study
Industry analysis	Product list	Kitchen countertop cabinet (shelves and doors)
	Expected budget	Preferably low cost , but there is a lot of creative scope
	Artistic Movements / Design Styles	Baroque/rococo, minimalist, high-tech, classical, cottage-core, neolithic, greek/roman, byzantine, victorian, tropical, neo-classic, art-nouveau, art-deco, arts and crafts, tuscan, rustic, provencal, modernist, eclectic, bauhaus, cubist, mediterranean, scandinavian, contemporary, nautical, asian, industrial, ethinical (boho?), shaker style
Target Audience	Project context characteristics	Large apartment, Ceará, northeast, Brazil
Approval, implementation and evaluation	Criteria for evaluating project results	Visual coherence (not being crooked, distorted or meaningless) , personal assessment and keeping with the prompt (the described text)
Research information	Reference / Brand Search	(Minimalist, cosmopolitan. Ex.: IKEA, Herman Miller, Steelcase, Knoll, Fritz Hansen Tok-Stok, Decorart)

Figure 2. Briefing, with keywords marked in yellow. Source: Authors, 2023.

The second tool was Braiwriting (Table 1). The authors wrote 18 words related to the project idea and the previous Briefing step, they could be new suggestions or improvements to the previously written ones. The objective was to increase the creative potential, mix ideas, identify secondary characteristics of the furniture and, finally, extract more keywords.

The third tool was a Semantic Panel (Figure 3). It was considered as an expression of broader influences, being used to determine the mood, the emotions that should be evoked to help build the project. Thus, 6 images were selected as references directly to the furniture in question. Subsequently, to give a more "abstract" semblance to the tool, image pairs were chosen for the previous images through the association of concepts, colors, textures, shapes, and other Gestalt similarity patterns (Filho, 2008, p.35). It is worth highlighting here the importance of the designer during this process, in which their experiences and previous references contributed in a more sensitive rather than exclusively using a computational tool.

Table 1. Brainwriting, with keywords marked in yellow.

Round	Person 1	Person 2
1	L-shaped cabinet	Dark wood
	Wood	Low/straight profile
	Hidden handle	Aged metal detail
2	Clean	Horizontal and vertical pivot doors
	No sliding doors	Coating 3D
	Easy to assemble	Can be wood-imitating material
3	Ergonomic height	Fills pre existing space
	Internal shelves	Asymmetric division
	For pots and pans	Recessed handle

Source: Authors, 2023

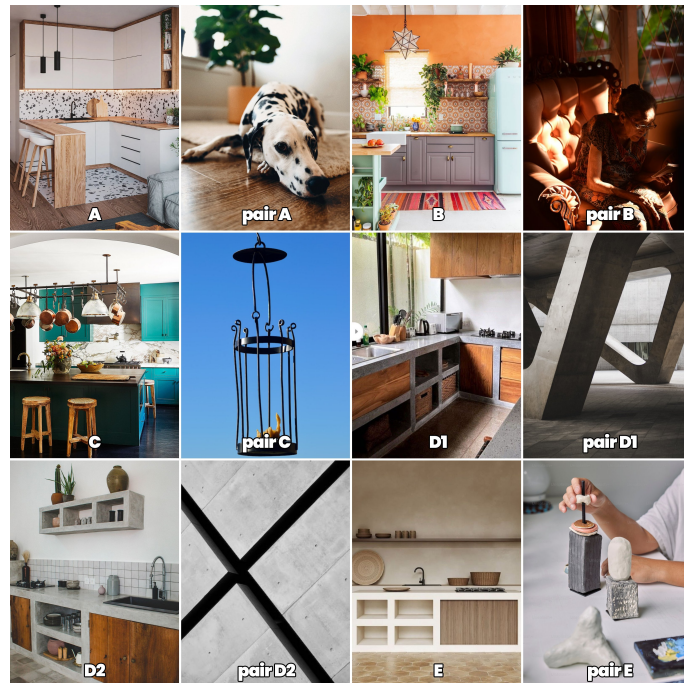


Figure 3. Semantic Panel. Source: Authors, 2023.

The next tool was a Syntactic Panel (Figure 4), used to complement the previous Panel. This tool was more focused on the final result, seeking to synthesize and reinforce which tangible elements should be incorporated into the product to be developed.

This panel was made from images of three categories: the first one used figurative photos with the intention of showing examples of kitchen cabinets (project-type). What guided these choices was the search for minimalist and Scandinavian styles. In the second category, the most meaningful colors of the Semantic Panel (blue and warm colors) and some relevant materials for the project were chosen. Both colors and materials can be used by the A.I. on furniture or scenery. The last category is about the characteristics of the furniture itself. The image of the parrot, however, still encompasses more of an emotional atmosphere and makes reference to the terms “tropical” and “Brazil” present in the Briefing.

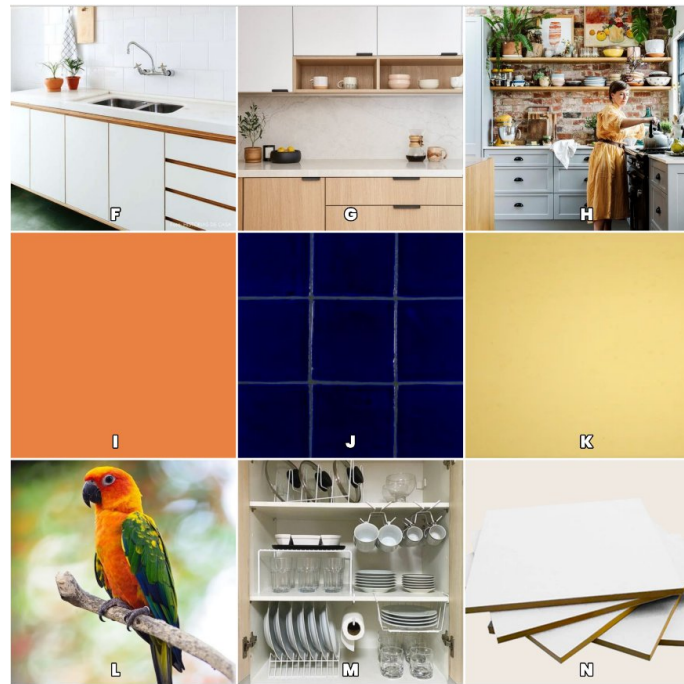


Figure 4. Syntactic Panel. Source: Authors, 2023.

The fifth tool applied was the Morphological Chart (Figure 5). To assemble it, it was necessary to compile the different keywords found in the previous stages in order to use them as a text prompt. This compilation of words was made through different categories created to make the composition of the prompt more coherent. These categories were based on other research and guided experiments in the recent area of prompt engineering, according to

several authors (Allen, 2022; Diab et al., 2022; Hertz et al., 2022 and Oppenlaender, 2022).

Colors	Modifiers	Locations	Objects	Materials	Artists	Movements	Features (flavors)	Aspects (flavors)
blue background	coherence of elements	arched doorway	bench	aged metal	Fritz Hansen	art-deco	amplitude	angular form
bright colors	full view	brazil	cabinet	concrete	Herman Miller	art-nouveau	concept	asymmetric
colorful	not distorted	home	cupboard	dark wood	IKEA	arts and crafts	cozy	dotted texture
fewer colors	not nonsensical	kitchen	furniture	forged metal	Knoll	asian	creative solutions	emptyspace
neutral colors	orthogonal	large apartment	hanging pans and pots	light wood	Steelcase	baroque	durable	ergonomic
vibrant colors	perspective	peaceful space	hidden handle	wood		bauhaus	early-stage design	external doors
warm colors	visual coherence	west-coast	L-shape cabinet			boho	easy install	handmade
			pans and vvvvvvv			brutalist vvvvvvv	innovative vvvvvvv	internal vvvvvvv

Figure 5. Morphological Chart. Source: Authors, 2023.

Then, an attempt was made to generate all possible combinations of words in the Morphological Chart, into all possible prompts, thus, covering the maximum number of solutions for ideation. The first attempt was to use an automated computational combinatorial method, programmed in Python. The program proposed 28.947.663.360 combinations, which made the use of this method unfeasible. It is important to say that this procedure would create numerous redundant combinations, therefore, this automation is not only impractical but also inefficient. Thus, we opted for a manual process of combining keywords with fewer prompt options, but with greater control

3.1 Application of A.I. tools

The generated prompts were applied to two A.I. tools, namely: DALL·E 2 and the Stable Diffusion model “Dreamlike Photoreal 2.0”. The first prompt applied was: “low cost (kitchen cabinet) made of (wood), (L-shaped cabinet), with hidden handles, aged metal trim details, asymmetric, texture mixing, (neutral colors), vibrant color details, boho , tuscan, ikea”.

For DALL·E 2, the generated product images (Figure 6) are very similar to some references from the Syntactic and Semantic panels, approaching the minimalist and Scandinavian styles. However, it is noticeable that neither the complete furniture nor its location appeared, which, after analyzing the process, was observed to not have been specified in the prompt. This analysis led to the future addition of the location category and the “full view” modifier in the revision of the Morphological Chart keyword table, an example of feedback between phases of the process (Jones, 1992).



Figure 6. DALL·E 2 first results. Source: Authors, 2023.

In parallel, the same prompt was tested in the Stable Diffusion web UI tool (Figure 7). The transferal of text parameters into image was better observed compared to DALL·E 2, mixing neutral and vibrant colors, different textures and woods and the requested boho style. Furthermore, the furniture was also inserted in an environment in a more coherent way, without the prompt specifying it directly. There was even a greater degree of differentiation between the images, such as camera angles, lighting, decoration, etc.



Figure 7. Stable Diffusion first results. Source: Authors, 2023.

After these results, another prompt was tested in the same A.I. tools: “creative solution of a concrete (cabinet), for pots and pans, light wood, use of empty space, cozy and warm, (warm colors) with blue background, art deco, tropical, fritz hansen, kitchen, brazil”. In the DALL·E 2 model, it was noticed that the generated images barely did not include the “concrete” material requested for the object in the prompt, appearing only in the image X’ (Figure 8). In addition, the images still do not show the environment and the entire object, even though a location was added to the prompt. After analyzing this result, it was verified the need to revise the Morphological Chart and add the “modifiers” category. Finally, these results were considered aesthetically unsatisfactory by the authors, especially the lack of details that could be used as visual reference, which compromised its use for this purpose.



Figure 8. DALL.E 2 second results. Source: Authors, 2023.

Next, in Stable Diffusion (Figure 9), it was noticed the appropriate use of warm colors, concrete material in the furniture, and extra elements (pans and pots) in different places inside the appliance. It also presented a mixture of the specified materials. The most expressive, and subjective, point to be observed is that the A.I. tried to answer the request of the prompt to bring creative solutions, delivering results in different approaches, with demonstrations of the object in more configurations than the previous tool, in addition to showing internal and external views of the artifact. However, it had difficulty separating the blue from the background and the object, also it was perceived as not meeting the “art deco” item. In short, the results delivered by the tool were considered more adequate to the prompt.



Figure 9. Stable Diffusion second results. Source: Authors, 2023.

From these results, two diagrams were created to synthesize and systematize the case study: the first describes the process in a linear fashion as a sequence of choices and results, adding a visualization of all the applied tools, while the second demonstrates where each one of these tools are found according to the stages of the Design process by Lobäch (2001).

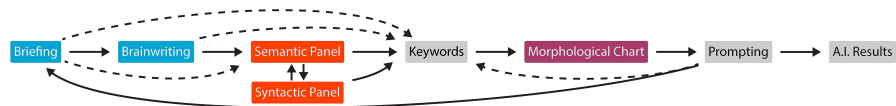


Figure 10. Synthesis diagram of results and choices and project phases in the case study. Source: Authors, 2023.

In the Case Study linear diagram (Figure 10), continuous line arrows signify direct contributions between tools while the dotted ones describe indirect contributions. Thus, it started with Briefing, then moved on to Brainwriting and then to the Semantic Panel, which contributed in parallel to the Syntactic Panel. From these 3 processes, keywords were extracted, later organized in the Morphological Chart. Based on the chart, the prompts were elaborated. At this stage, from the first images generated by the A.I., new ideas and references for the artifact to be designed were collected, so the line in the diagram connecting Prompting to Briefing means that these new ideas served to feedback the creation process. Finally, the last stage was the imaging results generated by the A.I. tools. With the support of the previous diagram and based on the theoretical research conducted, it was possible to list all the tools used (Figure 11) and allocate them in the sequence of phases proposed by Löbach (2001).

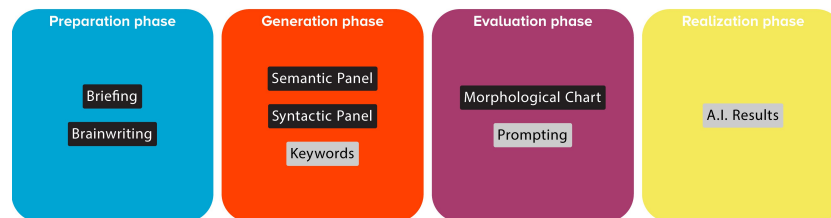


Figure 11. Synthesis diagram of project phases in the case study. Source: Authors, 2023.

It was observed from the synthesis diagram of project phases, that the traditional method of Löbach (2001) could not be fully used as a reference for this separation of tools, since, due to the time and context in which it was developed, the method did not was intended to cover tools like the current ones, with the use of Artificial Intelligence. Thus, despite using it as a theoretical basis, a need was identified for a new Design method capable of encompassing these new creation processes.

In this context, the developed systematization, in short, creates the following starting points for the ideation process: 1. outlines a Design process and a keyword extraction process within it; 2. these keywords are refined to compose detailed descriptions of the artifacts to be developed, in different possible configurations for use in the A.I. tool; 3. finally, after the practical application of the A.I. tools, an analysis of the imagery results generated is made, to identify whether or not they are in accordance with the initial design criteria, in addition to suggesting how they can be used during the Design process ideation, in order to improve the final product.

4 Discussion

Based on the conducted Case Study, it was possible to integrate the knowledge and processes of Design methods to A.I. tools, systematically applying them in the context of an ideation process for Concept Design. It should be emphasized that the flexibility of applying these tools depends on the design decisions made by each professional.

Regarding the theoretical contribution of this paper, a collection of bibliographical references has been assembled, with the aim of assisting designers in embracing an additional creative tool, that directly link the creative process, project development, and artificial intelligence, an area that has been relatively unexplored academically until now. It is important to move beyond the discussion of being in favor of or against the use of A.I. as a design tool. This dichotomy fails to encompass more relevant issues, such as utilizing the tool in a way that does not eliminate certain professions or, for example, exclude third-world countries from digital inclusion.

As for the practical contributions, a design process was exemplified, showcasing the applications of A.I. tools in the creative process of a designer. It was observed in this process that the generated alternatives allow, for instance, the identification of reference points in the image to progress the creative process. It is not possible, however, to say whether using A.I. in the design process improved the final results in relation to traditional practice, since this analysis is very subjective and pertinent to each specific project, but it was noticed that they assist in visualizing information and design alternatives, enabling the professional to make quicker and more efficient decisions. This is because the imagery output provided by A.I. could already be closer to the final product when compared to a traditional creation process within the same time frame.

Concerning the limitations of this work, the main one was the number of applications. In a prior study by the authors (Bastos, 2023), additional case studies were conducted. However, to present a critical viewpoint on current Design methods that embrace A.I. tools throughout the creative process, a more thorough investigation of the subject is required for its eventual consolidation.

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