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Design Studio Practice Using Co-Design Between Student and AI

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Abstract. This study conveys a new methodology using Artificial Intelligence (AI) within the design process. In this design methodology, there is a co-design collaboration between designers and AI tools. The experiment took place in the Architectural Design Research and Architectural Design module of the master's in architecture course where 20 students took part. For this work, we will focus on one project that successfully illustrates the experiment. The experiment occurred in the Autumn and in the Spring term of 2022-23 for an extent of 12 weeks. The methodology is based on the use of AI text-to-image technology using an open-source mainstream software Midjourney. The main purpose of the study is to test the enabling of creativity allowing for a computer tool to enlarge the design space in conceptual stages which allows for a more successful design exploration stage. This is an iterative process allowing for adjustments of inputs versus output assessment.

Keywords: Co-design with AI, Collaborative design, AI design process, Human-AI design, Text-to-Image AI

1 Introduction

Over the last few years, the digital revolution has introduced tools like Midjourney, DALL-E, and Stable Diffusion, which can assist designers in the concept stage by creating imagery that may enhance creativity (Dreith, 2022). These tools do not replace designers but help generate visual material that can inspire, especially for young designers. Chen identifies two types of designers: expert and junior (Chen & Stouffs, 2022). Junior designers often struggle with design fixation and early commitment to ideas (Gonçalves & Cash, 2021; Cash et al., 2019). In

contrast, expert designers use accumulated design solutions and empirical knowledge to address problems.

Design exploration is beneficial for junior designers due to their fewer preconditions and restrictions. Expert designers rely on empirical experience and cultural references. Design exploration involves systematically producing and assessing design alternatives using quantitative methods. This process can be empirical, using physical models or drawings, or automated, using tools like CAD, 3D modeling, or scripting software such as Grasshopper. Design exploration externalizes the design process, allowing the brain to process, extract, and combine past experiences (Woodbury & Burrow, 2006).

The design space, described as the universe of design alternatives a system can develop, is explained within shape grammar theory and represented graphically using Cartesian charts (Benros, 2018).

This study explores a new methodology using AI tools for imagery production as a design exploration tool. AI imagery tools have been used to create compelling images for leisure (Dreith, 2022). This study proposes using AI tools for text-to-image prompts in an academic context. Implemented in an architecture design unit, students were instructed to follow typical procedures (site analysis, research, listing precedents) and then use the AI tool to co-design and explore concepts. They input spatial, morphological, tectonic, and material qualities into Midjourney, utilizing intuition during reflection and site analysis, and analytical methods during interaction with AI outputs and refining requests (Chen & Stouffs, 2022).

Creativity is linked to situated interpretation. AI tools use situated cognition informed by human briefs (Kelly & Gero, 2015). Creativity arises from interpreting the conceptual space of design solutions (Veale et al., 2019). Computational Creativity (CC) fosters interdisciplinary discussions producing novel designs seen as creative.

Designs are co-created in human-computer interactions, instantly assessed by humans, resulting in novel spatial hybrids. Ethical considerations in AI co-design require transparency, accountability, and control over ethical dimensions, ensuring AI augments rather than replaces designers (Diakopoulos, 2016). Design thinking now combines human references and computer creativity, deconstructing biases. AI generates images based on text-fed ideas, with potential future advancements in 3D visualizations or videos and bias-free outputs from image-to-image software (Dreith, 2022). Co-design tools optimize processes and prompt creative exploration (Hsieh et al., 2022).

2 Methodology

This study aims to explore the potential of collaborative design and design exploration, the use of AI through open-source tools such as Midjourney, the democratization of design, and the creation of a theoretical framework for future design processes. Firstly, the study aims to improve and streamline the design process by leveraging a collaborative design approach between humans and machines. By integrating AI tools like Midjourney into the design workflow, designers can harness these tools to analyze existing designs, gain inspiration, and guide the development of future designs. This collaboration can enhance the creativity and efficiency of the design process, providing a rich space of alternatives for thorough design exploration (Chen & Stouffs, 2022).

Secondly, the study emphasizes the use of open-source software to democratize access to advanced design tools. Open-source tools are typically user-friendly and accessible to non-experts, enabling a wider audience to engage in the design process. This democratization allows individuals, small companies, and less experienced users to achieve expert-level design outcomes without the prohibitive costs and complexities associated with proprietary software (Diakopoulos, 2016).

Thirdly, by promoting the use of open-source design exploration tools, the study aims to widen the scope of human creativity. Non-experienced users and smaller entities can participate in sophisticated design processes, contributing to a more diverse and innovative design landscape. This inclusive approach fosters a broader range of design solutions and encourages creative thinking across different skill levels and backgrounds (Cash, Gonçalves, & Stouffs, 2019). Lastly, the study aims to establish a formal framework for future design processes that incorporate AI co-design. By documenting and assessing the design process (Figure 1), the study provides valuable insights and guidelines for others who wish to engage in collaborative design with AI tools. This theoretical framework serves as a foundation for future research and practical applications in the field of design (Benros, 2018).

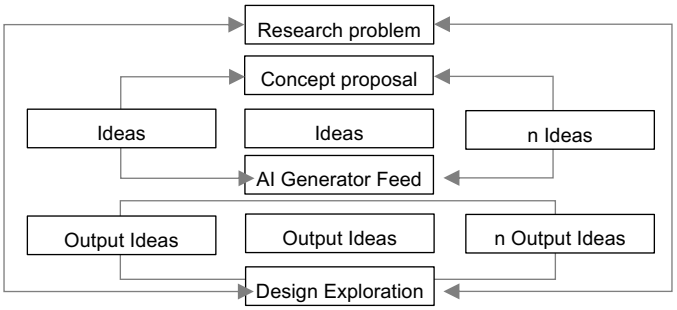


Figure 1. AI-Designer co-design framework. Source: Authors, 2024

The project methodology is outlined in the following steps:

1. Research and Site Analysis:

The project's brief involved developing a social/community equipment building in Barcelona to address a local shortfall.

The selected site was in *'El Poble-Sec*,' near Jardins de *'les Tres Xemeneies*,' surrounded by residential buildings, offices, and some industry.

- The research revealed that the region had faced several economic crises, high unemployment, an aging population, and a lack of digital skills (Kelly & Gero, 2015).
- A training and incubation center was proposed to provide retraining opportunities, workshops for business skills, robotics, advanced manufacturing, electronics, and industry 4.0.

2. Reference Project Research:
   - The study included analyzing the Endesa Pavilion, designed by the Institute of Advanced Architecture, which utilized automatic manufacturing and solar panels.
   - Key features such as the façade's angular panels and materiality provided important references for future components as shown in (Figure 2) (Veale, Gervás, & Pérez, 2019).
3. Keywords Input in AI Midjourney:
   - Based on the research and reference images, a selection of keywords was arranged for the Midjourney experiment, including texture, massing, structure, façade tectonics, and atmospheric conditions.
   - Specific keywords like modularity, geometries, triangular prisms, random openings, and solid projections guided the AI's image generation as seen in (Figure 3) (Gonçalves & Cash, 2021).
4. Output Imagery from Midjourney:
   - The AI generated several computer-rendered images based on the input keywords (Figure 4), providing visual outputs that incorporated imaginative elements into the design process (Hsieh et al., 2022).
   - Workshops were conducted to refine these images, incorporating micro-scale surface façade tectonics and meso-scale volumetry.
5. Production of Massing:
   - Workshop 2 produced aesthetically pleasing results, which hinted at an overall massing composition accessible from a single perspective.
   - Initial massing models were created in Rhino, establishing the basic form and generating renderings for assessment (Dreith, 2022).

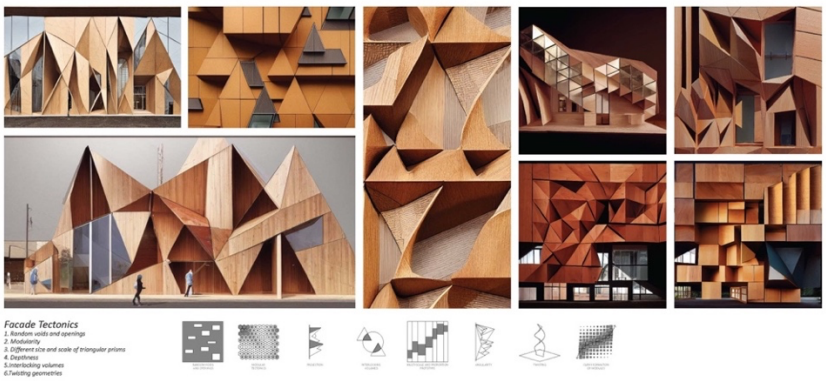


Figure 2. Midjourney output imagery following the text-to-image inputs.

Figure 3. Midjourney output imagery following the text-to-image inputs using the Endesa pavilion as reference. Source: Authors, 2023

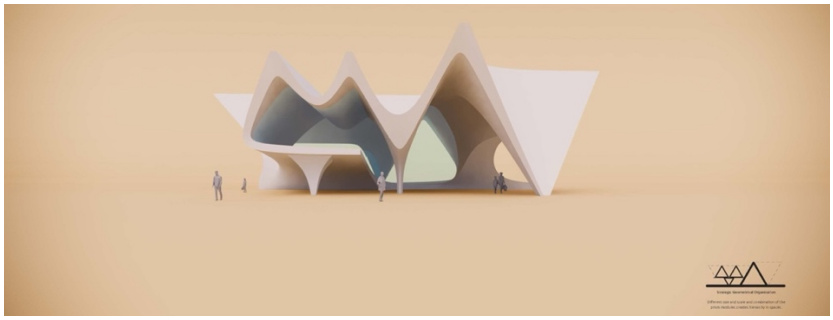


Figure 4. Following the design exploration proposed strategic geometric organization and massing – the image was key in the conceptional design of the scheme. Source: Authors, 2023

6. Development of Informed Massing:
    - Spatial sensibility from the Midjourney results guided the development of geometry and massing, adapting to site constraints and environmental factors (Woodbury & Burrow, 2006).
    - Volumetric studies were conducted considering daylight, precipitation, ventilation, views, shadow maps, and existing building masses.
7. Spatial Quality and Generative System Conception:
    - A generative system diagram illustrated the step-by-step proposal generation, from multiplying prismatic modules to creating orthogonal intersections and softening geometry.
    - This system can generate other designs with different parameters while maintaining a consistent language (Benros, 2018).
8. Building Massing and Concept Design:
    - The final massing was refined and represented three-dimensionally, with each elevation planned and assessed.
    - This process allowed for discussion between tutor and student, or designer and client. (Figure 5) and (Figure 6) illustrates the massing.

Figure 5. Volumetric massing studies using a design system which relates and responds to the site conditions and surroundings. Source: Authors, 2023

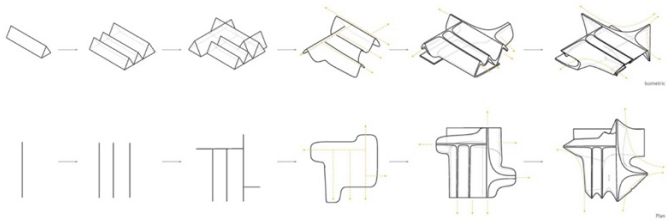


Figure 6. Spatial derivation and development of a design system based on the exploration obtained from human-AI interaction (plan and isometric) 1) insertion of module 2) multiplying the main prismatic module 3) by creating orthogonal intersections 4) by softening the geometry with curved eaves and profiles 5) by integrating a continuous interconnecting floor 6) by softening acute angles connecting floors-walls-roofs. Source: Authors, 2023

9. Initial Spatial Studies in Rhino:
    - Modelling refined the solution based on Midjourney interactions, accommodating the programmatic features of the project (Diakopoulos, 2016).
10. Spatial Program Development:
    - The internal layout was developed holistically using modelling tools, adjusting to inform overall modelling.
    - Re-training workshops and new skills were allocated functionally, with vertical circulation cores located strategically (Kelly & Gero, 2015).
11. Circulation Development:
    - Circulation followed the main orthogonal axis, connecting occupied spaces to vertical circulation cores, aligning with the generative system's axis (Gonçalves & Cash, 2021).
12. Structural Solution Development:
    - Aiming to achieve large spans and ecological sustainability, the structure used laminated timber in parallel ribs, connected with vertical columns or 3D-printed concrete walls.
    - This structural solution can be replicated in other configurations (Woodbury & Burrow, 2006).
13. Material and Building Tectonics Selection:
    - Material considerations from the design exploration included Gulam beams, timber panels, ceramic tile cladding, and wood boards, complementing the look achieved during the exploration period (Veale, Gervás, & Pérez, 2019).
14. Detailed Design:
    - The final design was detailed based on the proposed model, following traditional methods (Hsieh et al., 2022).

3 Results

The results are described in this section. (Figure 7), (Figure 8) and (Figure 9), illustrate the result as submitted in the module of Architectural Design as part of the methodological experiment of co-design. A sample of other students from the design module for the same unit is illustrated in (Figure 10). The short sample illustrates the range and diversity of the designs but also the before and after

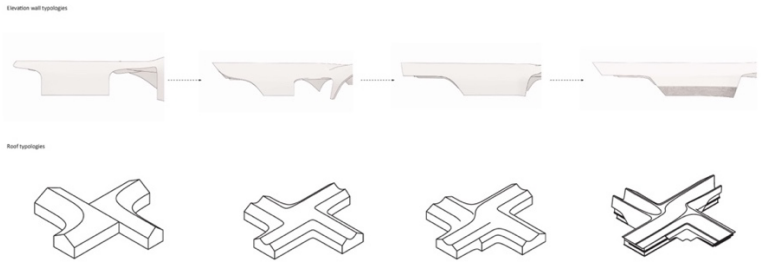


Figure 7. Initial spatial studies and initial experimental modelling. Source: Authors, 2023

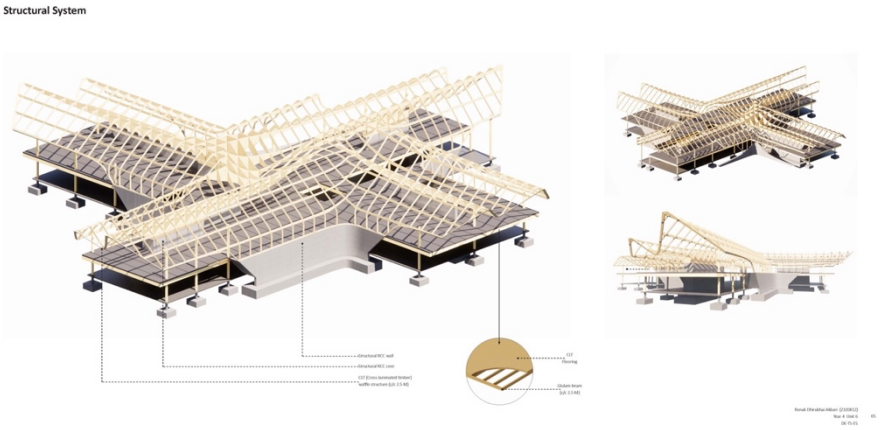


Figure 8. Proposal of structural system, and infrastructure following the design development. Source: Authors, 2023

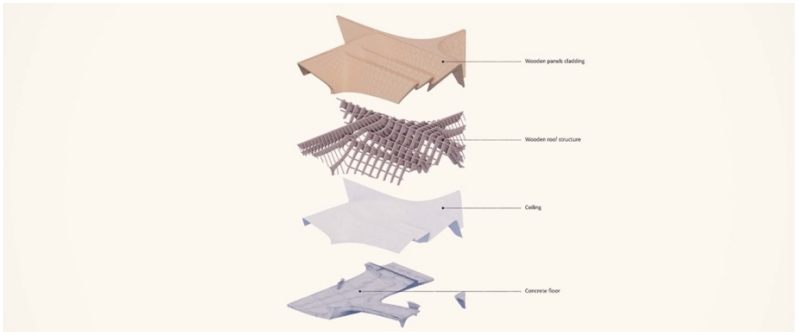
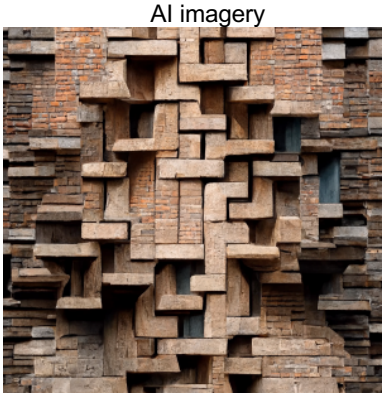


Figure 9. Proposal of constructive system, infrastructure, internal skin, structure and external cladding following the design development. Source: Authors, 2023

AI imagery



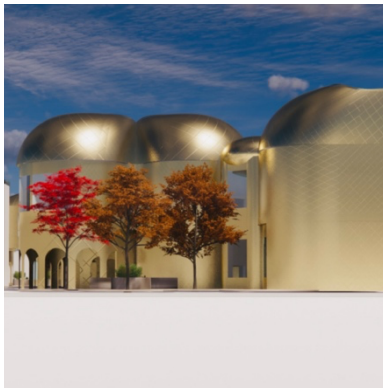
Developed design

Naomi Nakoulma's AI output

Naomi Nakoulma’s design

Vanessa Mawoneke AI Output

Vanessa Mawoneke design



Hamza Ahmad AI Output

Hamza Ahmad design

Figure 10. Design unit AI inputs and outcomes sample. Source: Authors, 2023

for each process. Despite the variety of design outcomes and inputs the inspiration sparked by the Midjourney imagery is obvious.

There is a clear correlation between input and output where in most cases the experiment resulted in interpretations of the 2D imagery into three-dimensional experiments. Some are more literal than others. Some were inspired by the materiality and texture of the AI outputs such as Nakoulma, others proceeded into a more literal interpretation while the latest (Ahmad) disassociated from the materiality and focused on the massing. Nevertheless, the influence is notorious and visible.

Whether AI and co-design will empower designers remains to be seen but interesting results were observed with promising human/machine interaction. These controlled experiences seem to show an increased level of critical analysis of existing design precedents examined via direct design output, leading into the production of new creative output.

The risk of producing science fiction-like scenarios which have no relevance or tectonics to back them up is a reality which can only be tamed with human interaction and supervision for the time being. The open-source AI Midjourney operates as a black-box and therefore there is limited or no control over its output or accuracy and detail.

The 'accumulation' of design images to stimulate creativity can be challenging with so many stimuli available and so much visual pollution, this is where AI can be useful (Figoli, 2022). AI using Generative adversarial networks (GANs) can generate high-resolution images relevant to the brief. This can be used for generative purposes with machine learning techniques. An example of similar examples is the chair project which used images of several celebrated Twentieth-century designs to generate new chairs. The results are successful in the sense they are relatable but unrecognizable (Schmitt & Wei, 2018). The criticism is that in many ways the level of 'computer creativity' has exceeded some of the parameters and some of the chairs do not look like chairs but deconstructed art pieces.

This seems to prove that collaborations between humans and computers should be more fruitful, enabling co-design and the reduction of shortcomings of both intervenient agents.

Some of the restrictive agents for a successful collaboration are:

1) Predisposition and biases
2) Perception
3) Communication
4) Human-Centric Design
5) Interdisciplinary Collaboration:

Predisposition and biases might allow mistakes, inaccuracies and repeated references to take place. This will affect mostly human counterparts rather than computer tools and mostly the AI text-to-image inputs.

Perception of the human counterpart will judge and assess the output from AI and biasedly react to it. If there is a second round of attempts the perceived reality will be prejudicially discussed, assessed and re-inputted.

While others might use different inputs such as image/text-to-image (Zhang et al., 2018), text-to-image might be more challenging.

Most AI tools, particularly the open-sourced work as a black-box where only inputs and outputs are known, the process is not available or described. (Figoli, 2022). The process and execution are never clear or straightforward. This could be both a handicap and an opportunity to hinder creativity. If the output is not to the expected level, a re-submission of an adjusted input is the only communication possible between humans and machines.

The described methodology worked well amongst junior designers allowing them some control over their precedent and reference research buildings and showing them examples that were not straightforward or directly envisioned. Important to mention that in this co-design the human counterpart had to raise the research, collate ideas and extract keywords, rationalizing the design concept route. This process also occurs in the traditional design process. What is novel is the re-interpretation of the concept expressed in the design research into the design exploration. This automatization of the re-interpretation process is now being optimized and streamlined by AI and seems like a valid tool for these processes.

As the main disadvantages, we highlight the lack of control in the AI output. The human co-designer can only articulate inputs and do not interfere in the process. The only possible interaction is the rearrangement of inputs which can be a tedious and counter productive.

Nevertheless, this seems to engage young designers eager for rapid outcomes.

The other danger is the pursuit of extremely formalistic design solutions which might become shallow and superficial in the pursuit of a singular rendered image, this lies in the responsibility of the human designer.

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