How Can Generative AI Techniques, Enhance a User-Centred Design

A case study with football stadium design

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Artificial Intelligence is attracting attention across various disciplines due to its potential to optimise workflows and support creative processes. In architecture, AI offers promising opportunities as a tool for bridging the gap between abstract ideas and their visual representation (Owen and Roberts, 2024). This research explores how generative AI techniques can enhance a user-centred design in football stadium design. With growing interest in the emotional impact of spaces, there is an increasing focus on designing buildings that enhance human well-being (Ribeiro and Albuquerque, 2023). We hypothesize that generative AI techniques, such as text-to-image and collage-to-image methods can generate stadium designs that align with users' expectations. The methodology consist of three stages: gathering user insights through surveys and interview, generating images based on these insights and users then evaluating the images. This approach helps identify key design elements and build a framework for football stadium design.

Keywords: *Artificial Intelligence, Workflows, Design, Architecture, Football Stadium Design, User Centred Design, Image Generation, Generative AI, Text Prompt.*

INTRODUCTION

The fast growth of AI and its integration into the design process is transforming how architectural workflow is approached (RIBA, 2024). Generative AI can potentially optimise our workflow, allowing us to generate visual concepts and ideas based on textual or image-based inputs (Li et al., 2025a). This paper explores **the use of generative AI to design specific architectural programs.**

While AI is being widely adopted to fasten workflows in various industries, its role in architecture is still being explored. Architects have begun to explore AI as a tool for enhancing efficiency, creativity, and user experience (Li et al., 2025b). A recent report by RIBA indicates that 41% of respondents on a survey are using AI in their projects, and from those, 43% agree that AI has improved efficiency in the architectural design processes while only a small percentage of 11% believes that AI has enhanced the accuracy of their specifications (RIBA, 2024). According to Jaina Valji, the fields where architects use AI are mainly generative design, project management and scheduling, BIM, digital twins, energy efficiency, sustainability and technology interactions (RIBA, 2024). Recent literature has highlighted the application of AI models across various stages of architectural design, often varying from initial form or text to final images (Baudoux, 2024; Li et al., 2025a). Generating high-quality architectural images has rapidly become simple and accessible to

all, which makes **generative AI** through techniques such as diffusion models (Midjourney, Stable Diffusion, Dall-E, etc.) a very promising technique for architects to explore during their design processes although still in the early stages of research (Ramesh et al., 2021; Vissers-Similon, Dounas and Walsche, 2024). Traditionally, the architects' design process is a labour-intensive, human-driven and non-linear process. Therefore, to assess how generative AI can enhance the architect's design process, it is essential to focus on the human-machine workflow within the design process rather than solely on the architectural images and end results (Vissers-Similon, Dounas and Walsche, 2024).

Despite the potential of generative AI, there is a notable gap concerning its application in a **user-centred approach** (Xavier, 2022). As interest in the emotional impact of architecture grows, more attention is being given to how buildings can better support human emotions and overall well-being (Gao et al., 2023; Ribeiro and Albuquerque, 2023). While functionality remains a crucial element in architecture, there is an increasing shift towards spaces that are also meaningful for their users.

More specifically, introducing generative AI to a design process brings exciting possibilities for the design of **football stadiums**, where functionality is often prioritised over emotional engagement and user needs during the design process (Shi et al., 2024). The design of football stadiums prioritises functionality and capacity, with less focus on spectators' emotional and psychological experiences, which are fundamental aspects of stadiums (Bouw, 2020). While these structures are intended to host large crowds, limited research considers whether they create meaningful and engaging environments for fans (Ribeiro and Albuquerque, 2023). The stadium is more than just a venue for football matches; it is a cultural and social hub that brings people together and plays an important role in our society.

Generative AI offers a unique opportunity and provides new perspectives on the future of user-centred design, allowing external parties to participate in the preliminary research of a design (Melikoğlu, 2024). Unlike traditional architectural design processes, which rely heavily on manual sketches and the architect's creativity, often starting from scratch, generative AI can serve as a conversational partner to the architect, to quickly produce multiple design options and enable a broader exploration of possibilities. Moreover, generative AI allows the architect to visualise emotional experiences – crucial to user-centred design – by adding textual descriptions of those experiences or images of projects that successfully create those experiences to the generative AI prompts. It can translate abstract user preferences into concrete visual representations.

This research aims to examine the potential of generative AI for football stadium designs to enhance user experience by developing a user-centred approach. User-centred design places users' needs, emotions, and experiences at the heart of the design. For that, this study involves football fans in surveys and interviews to identify how AI can act as a design tool that enhances a user-centred design.

This research follows a **methodology consisting of four key stages** and is based on the **triangulation method** to explore different perspectives regarding the use of generative AI for a user-centred football stadium design.

The paper is structured into five sections. First, we present the research problem, goals, and theoretical framework. The Methods section outlines the research methodology and tools used. The Results section summarizes findings from surveys and interviews. Finally, we conclude with a discussion of the results and a brief conclusion.

METHODS

This research employs a structured methodology to explore generative AI's potential as a tool for a user-centred football stadium design. The **triangulation method** (Muratovski, 2022), in this case employs three different perspectives to assess the certainty of a conclusion. If the three perspectives suggest the same conclusion, such a conclusion can be stated with more certainty. The three perspectives in this research are of the researcher, the designer, and the users. The methods integrate research by design and the use of generative AI tools, surveys and interviews to gather insights into architectural preferences and emotional responses. The methodology follows four stages:

1. Definition of architectural concepts to be used
2. Development of design solutions by using generative AI tools
3. Surveys and interviews
4. Evaluation of the results

Stage 1 - Definition of architectural concepts to be used

Three architectural concepts were chosen as key aspects to be analyzed in the research due to the basic spatial qualities they bring to architecture:

1. *Promenade architecturale*: a sequence of spatial experiences where movement through a building reveals a series of perspectives.
2. Transparency: the quality of creating a visual connection between interior and exterior by investigating concepts such as materiality, openness and spatial depth.
3. Inside-outside: seamless transition and integration between the built environment and the surrounding landscape, enhancing the spatial experience.

Each concept was analysed using a key known architectural building, architectural literature, and an existing football stadium to form a vocabulary list. E.g., for concept 1 (*Promenade Architecturale*), Le Corbusier's Villa Savoye, the book "Le Corbusier and the Promenade Architecturale" (Samuel, 2010), and the Allianz Arena stadium were used to dissect the *Promenade Architecturale*. The vocabulary list was used as a starting point to generate images in stage 2 and as an end point to evaluate images through the annotations and participants' feedback in stage 3.

Stage 2 - Development of design solutions using generative AI tools

Various generative AI tools were utilised to ensure a broad spectrum of tools and an informed choice for later stages. Both commercial and open-source diffusion models were used to compare the different qualities. The commercial software used were Adobe Firefly, Krea, Photoshop, MidJourney and Dall-E. Open-source software includes stable diffusion and comfyui, which are equipped with control mechanisms such as controlnet, lora, and seeds. These tools made it possible to generate a diverse range of design outputs. The techniques used initially were moodboard generations, collage to image, text to image, model to image, and sketch to image.

Stage 3 - Surveys and interviews

Surveys and interviews were conducted, for which no personal data was stored. All collected data was processed anonymously, according to GDPR regulations. The aim was to evaluate generated images and identify the meaning they elicit in users. Evaluating the generated images instead of continuously generating new ones allowed for a deeper understanding of the output and helped refine the process. It provided opportunities to assess whether the images aligned with the desired vision and if adjustments were needed in the parameters.

The images underwent a multi-stage evaluation process, which consisted of the following sub-stages.

Substage 3.1 – Personal annotation. An initial review by the first author of the paper to identify key architectonic elements (e.g. structure and circulation), visual features (e.g. colour, lighting and texture) and how well the images aligned with the literature study. This substage selected the images to be used in substage 3.2.

Substage 3.2 – 1st survey: Image evaluation by students. Master students from Interior Architecture (IA) were asked to rate, by choosing 'very poor,' 'poor,' 'good,' or 'very good', and annotate four AI-generated images based on different parameters - 'architectural quality', 'realism', 'football fan experience', 'human scale' and 'imagination'. They were also asked to annotate the images to identify key architectonic elements. Fourteen students from the Interior Architecture Master at the University of Antwerp responded to the survey, each commenting on two images; images were assigned randomly to students. This substage aimed to assess whether the images were clear and of sufficient quality before presenting them to a larger audience.

Substage 3.3 – 2nd survey: Image evaluation by football fans. A Google Forms survey was made available and distributed through football fan communities on Facebook and Instagram. This survey included both AI-generated images and real images. A total of 280 responses were collected. The survey focused on the participants' perception of both real images and AI-generated images. Two images side by side were presented: one real image and one AI-generated; both were edited using KREA to give them an AI look, making them harder to distinguish. In this survey, the goal was to determine which images were perceived as more pleasant, and this was achieved by asking the same question in a different way to observe the emotions these images triggered in football fans. Participants analysed stadiums in five key scenes of the *promenade architecturale,* comparing real stadium images with AI-generated images which resulted in five times two pictures. The five scenes chosen consisted of two hallways, one ring around the stadium, one facade, and one of the stands. Using the five scenes provided richer material for the analysis. The survey consisted of four questions:

- Which image feels more pleasant? (multiple choice)
- Which features do you find pleasant or attractive? (open question)
- Which two features make the biggest difference between the two images (open question)
- Which image feels more realistic? (multiple choice)

Substage 3.4 - Interviews: One-on-one interviews with football fans. Twenty individuals (10 men, 10 women) of different ages (20-45) and professional backgrounds (architects, designers, and non-designers), all football fans, participated in the interviews. The participants were recruited through facebook and instagram. The interviews were conducted online and devised around a design scenario: "Imagine that your football club is building a new stadium (capacity 10,000-15,000 seats), and you are involved in the design process." The structure of the interview was as follows:

- What do you generally find important in a football stadium?
- Based on a randomly assigned stadium area (e.g., interior, façade, public space or stands), what do you find important in such an area?

During the interview, and based on the participants' answers, an image of a stadium was generated that suited the participants' needs within a short time frame (3-5 minutes). After being confronted with the image, the researcher asked for the participant's feedback.

Stage 4 - Evaluation of results

The results were analysed using narrative interpretation and basic statistical methods.

RESULTS

The results of the three different perspectives are reported in this section. Sections Stage 1, 2 and Substage 3.1 show the results from the **perspective of the researcher** who conducted a qualitative study on image-generation using generative AI tools. Section Substage 3.2 presents the results from the **designer's perspective**. In this study, interior architecture (IA) students participated, as they offer a less biased viewpoint compared to professional interior architects, whose perspectives are often shaped by their specific design practices. IA, in contrast with architecture ones, receive training that emphasises a client- and user-centred approach, utilising mood boards as both design and communication tools. Additionally, their focus is more attuned to the intersection of spatial design and human interaction, making their insights particularly relevant for this analysis. Lastly, the results from the **users' perspective** are added in sections Substage 3.3 and 3.4 with a quantitative study targeting football fans and added with in-depth interviews and new image generation.

Stage 1 – Architectural concepts – researcher perspective

This stage defined a direction for prompt engineering in AI image generation. A list of words was created and used as a starting point for prompting in the AI tool. This first exploration of AI tools involved implementing concepts from the combination of an architectural reference, a stadium reference and literature on architecture, resulting in the formulation of prompts. Approximately 100 images were generated by Midjourney using text-to-image. An example of a prompt used in Midjourney on basic settings to generate Figure 1 is the following: '*A public space outside a football stadium inspired by Luis Barragan. The scene features bold geometric forms, high walls in vibrant pinks, oranges and yellows, and a dramatic interplay of light and shadow. A long reflecting pool mirrors the colours of the wall, creating a tranquil contrast to the excitement of the stadium. Minimalist benches and pathways guide visitors through the space with strategically placed trees providing shade.*'

Figure 1
Stadium image generated by MidJourney for the *Promenade architecturale* concept.

The generated images represent the atmosphere of the chosen architectural reference and contain the intrinsic values of architectural spaces and the structural characteristics of a stadium. These results provide support for further exploration of prompting as a starting point for investigating the potential of generative AI between architects and potential users in the next stages of the research. However, the text-to-image technique offered the architect little control or precision over the outcome of these images; therefore, in the second stage, generative AI tools that use methods other than text-to-image are included.

Stage 2 – Generation of design solutions – researcher perspective

For the image generation in the next stages of the research, we opted for two techniques that were easy to use and presented results closer to what was expected: text-to-image with Midjourney and image-to-image with Adobe Firefly and KREA to refine images. Midjourney allows customisation through the following parameters: format (to adjust the aspect ratio), stylization (artistic freedom; higher values make the image more abstract), weirdness (adds unexpected, unconventional elements) and variety (increases diversity in outputs). An image can

also be used as a reference for generating a new one. The image-to-image method was applied specifically with Adobe Firefly. Adobe Firefly allows the generation of images from sketches through the following parameters: style reference image, composition reference image, format and view. Composition reference image was crucial because it allowed adding reference images that are closely followed. It can be applied at 0-50% or 100%, and at 100% the original image is followed very precisely.

Figure 2 provides an example of a mood board. This mood board, created in InDesign, includes four Pinterest images, colours and material. ChatGPT generated a text prompt based on the mood board of Figure 2, which was then used in Midjourney with default settings to generate Figure 3. The prompt generated by ChatGPT is the following: '*Generate a fragment of a small, modern football stadium with a focus on sustainability and natural materials. The design features warm wooden beams for structural support, combined with smooth concrete surfaces and large glass panels for transparency and natural light. The space has a clean, minimalistic layout with soft curves and an open, airy atmosphere. The roof must have a clear slope, indicating it is part of a stadium tribune, and provide coverage while maintaining an elegant, futuristic design. Include yellow and blue accents to reflect Union Saint-Gilloise's identity.*

Text-to-image stood out for its ability to generate rich and atmospheric visuals in the fastest way, whilst image-to-image allowed for a more efficient communication between designer and AI model by speaking the same visual language.

Substage 3.1 – Personal annotation – researcher perspective

In this stage, images were annotated to systematically extract and interpret the defining characteristics of the AI-generated visual content.

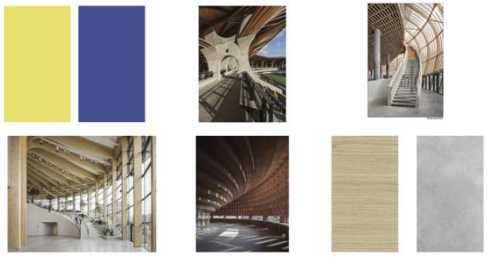

Figure 2
Moodboard used to generate a prompt in ChatGPT.

Figure 3
Stadium image generated by MidJourney for concept 'promenade architecturale' and for the fragment 'inside a football stadium'

The interpretation through the researcher's annotation combined analytical assessment and imaginative projection, to envision existing spatial qualities and potential functional applications. Additionally, the analysis considered necessary human-centric modifications - such as ergonomic adjustments or interactive elements - that would enhance usability and contextual relevance. For example, in the case of the illustrated football stadium scene (see Figure 4), the presence of elevated walkways was annotated as a significant architectural feature.

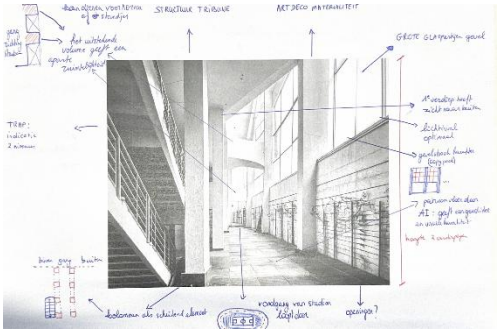

Figure 4
Example of an annotated image during substage 3.1.

Approximately 50 to 60 images were annotated, selecting those that represented the best results per architectural concept. The annotations focused on the number of architectural elements and visual features such as realism and material atmosphere - for example, structures that have a regular appearance yet also function as spatial dividers. A key conceptual insight derived from this observation is that structural elements in such environments serve a dual purpose: they function not only as load-bearing components but also as spatial organisers, influencing movement patterns and perceptual boundaries within the built environment.

Substage 3.2 – Image evaluation by students – designer perspective

In this substage, 14 Interior Architecture master's students evaluated AI-generated images using a fiche similar to the one shown in Figure 5.

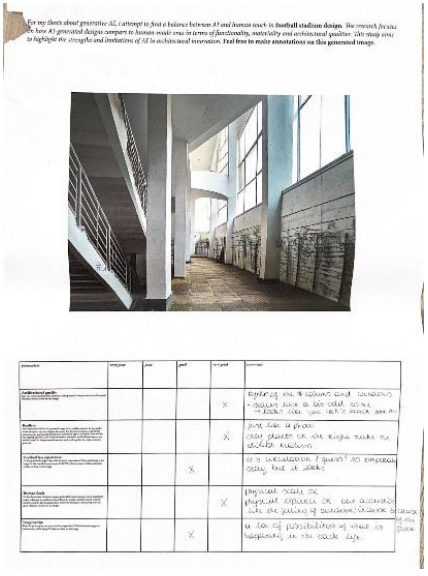

Figure 5
Example of a fiche used for the 1st survey, substage 3.2

Images were assessed using 'architectural quality', 'realism', 'football fan experience', 'human scale' and 'imagination' as criteria. The images perform well in architectural quality (65%) and imagination (70%). However, realism (40%) and football fan experience (46%) suggest that the designs are not yet fully optimised for functionality and fan engagement. Human scale (55%) received mixed feedback, implying that some images may not be entirely aligned with human proportions and spatial experience.

Substage 3.3 – Image evaluation by football fans – user perspective

The results from the 2nd survey varied significantly (see examples in Figure 6). Across all five comparisons, the preferences indicate that AI images are generally perceived as equally pleasant as real images, which makes them a potential replacement for real images. In some comparisons, AI images were strongly preferred (90.5% and 84.2%), while in others, the majority favoured the realistic image – with only 12.2% preference for AI in one case. This suggests that the perception of AI-generated images is highly dependent on the context, subject, or quality of the images. While AI has a clear advantage in certain cases, it is not always seen as the better option. This suggests that AI-generated images can be successful, but they do not consistently surpass realistic ones in all situations.

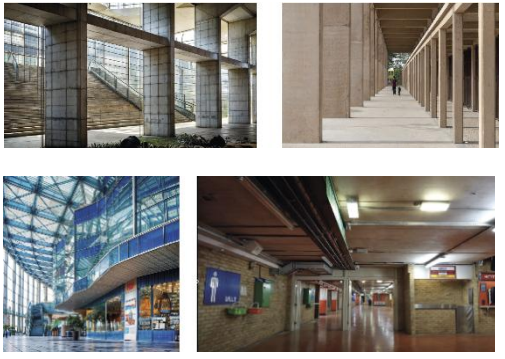

Figure 6
On the top row, the AI-generated image (left) was preferred by only 12% of the participants. On the bottom row, the AI-generated image (left) was preferred by 90,5% of the participants.

Substage 3.4 – Interviews with football fans – user perspective

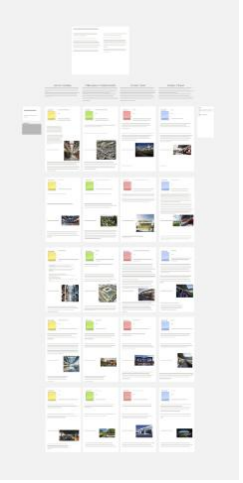

Figure 7
Screenshot of the Miro board where all interviews were conducted

The short interviews, as shown in figure 7, were conducted with 20 participants to gather general impressions of what they considered important in a football stadium. Before any images were generated, each participant received a textual description of a specific stadium area - interior, facade, public space, or stands - and was asked to identify key aspects they found important in that area.

After participants reported on their preferences, images were generated. Each image took an average of 3 minutes to generate using a text-to-image tool (see example Figure 8). The results show that the majority were satisfied with the AI-generated image. While 80% of the participants were satisfied with the generated image, 20% had minor criticisms, such as "I like it; it's beautiful, but it lacks life." (related to Figure 8) This last survey demonstrated how AI can facilitate participation effectively and quickly.

Figure 8
Example of an image generated after the interview in stage 3.4.

DISCUSSION

This research uses generative AI in creating user-centred designs for football stadiums and explores whether it can contribute to a more iterative design process between architects and end-users, with architects playing a crucial role in adapting AI-generated ideas. Based on the results of the three perspectives, we can conclude that there is potential to include generative AI for football stadium designs from a designer and user perspective. As the results in Substage 3.4 show, it is promising in the discussion between users and designers to translate user needs expressed in words into images.

The research encountered initial challenges due to the lack of control over the software's output, as the AI's interpretations of prompts were sometimes unpredictable. This variability made it difficult to achieve fully consistent results in the beginning. However, rather than posing significant obstacles, these unexpected outcomes proved beneficial, offering novel perspectives and opportunities for identifying valuable qualities. Over the course of the study, the software demonstrated strong overall performance, effectively supporting the research objectives.

Some **limitations** can impact the effectiveness of these AI-generated images. While AI can quickly generate images and design ideas, it **does not replace architects' decision-making**. Rather than producing fully finished designs, generative AI serves as a tool for ideation and exploring design possibilities. Human expertise remains essential to

ensure a final design that incorporates sensory, emotional, contextual, and social considerations. In football stadium design these multiple factors, such as environmental aspects, must be carefully balanced. AI can support this process by enhancing user-centric workflows, but it does not address the full spectrum of user needs. Stadium design must consider multiple aspects, and we cannot guarantee that AI can fully impact the entire spectrum of user needs. A second limitation is that assessing **user experience solely from images** also comes with limitations, as the experience of space is influenced by more senses than just the visual. A third limitation is that using AI in early design ideation does not guarantee that AI-generated concepts will be **directly implemented in the final stages of design**. Indeed, AI does not create fully finished designs and architects are still needed to make sure to finish the design and implement the needed adaptations.

Further research could go into the implementation of different user needs, as football stadiums would benefit from such a design. Additionally, the value of image generation in these design processes can be explored among other tools to implement the sensory needs that are not expressed visually. Many of the above described limitations – such as assessing user experience solely from images, and the impact on the architect's decision making and the final design – could be studied via a simulated case study in which the architect designs a football stadium using generative AI in a real context, for example in a competition or studio format.

As generative AI is a rapidly evolving field, the results of this research should be interpreted in the context of currently existing AI models. For example, at the time of conducting this research, multi-model models (such as OpenAI's Sora and ChatGPT v4o) were not commercially available yet. Therefore, as this research has shown the potential of using generative AI for user-centred design, further and ongoing research is necessary to ensure that both designers and users can make the most out of integrating generative AI into participatory processes.

Lastly, the triangulation method ensured that the findings within this research were observed by three perspectives – researcher, designer, and user. However, further research could study whether there are emerging patterns amongst different perspectives in order to develop strategies to maximize the benefits of integrating generative AI into the design process, and minimize the downsides (e.g. a quick additional Photoshop postproduction step by the designer could avoid the "lacks life" reaction of the user in the example of Figure 8).

CONCLUSIONS

This research aimed to explore the potential of generative AI - as a tool - in football stadium design, focusing on the fan experience. The results show that in all three perspectives at stage 3 of the study, AI can generate visually appealing and innovative designs that capture key aspects of user needs. Feedback from the participants confirmed the value of these AI-generated concepts in offering qualitative ideas. However, human designers remain crucial for refining these ideas into functional and contextually relevant designs that fully address the practical and aesthetic needs. This research explored avenues to demonstrate how AI-generated design images can support a user-centred approach by involving stakeholders early in the design process. By integrating AI-driven methodologies, it aims to contribute to the expanding role of AI in architectural innovation.

In conclusion, generative AI presents exciting possibilities for football stadium design, particularly in the early concept stages, with a human-centred approach. This should still involve human expertise to ensure designs that provide the optimal experience for fans. While AI tools offer significant potential in visualising user-centered experiences, their current limitations suggest that AI should be viewed as a complementary tool rather than a replacement for architects.

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