Public Space Design enabled by Artificial Intelligence Generative Tools

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ABSTRACT: This paper discusses the integration of generative artificial intelligence (AI) tools in the conceptual phases of the design of a public space. It raises the question of how AI tools can enhance the design process and how the integration of AI tools in a design process may affect the interactions between architects and clients. The investigation uses a collaborative project between academia and a major art institution to transform a vehicular street into a pedestrian event space supporting art and community programs.

The methodology was framed around generative AI platforms, such as Dall-E 2, Midjourney, BlueWillowAI, DreamStudio, Lexica, and Stable Diffusion utilizing both text-to-image and image-to-image functionalities. The approach followed the reiterative process of developing design variations, evaluating outputs, identifying desired traits in imagery/designs, and exploring new possible designs based on desirability. The study demonstrated (1) accelerated idea formations in the early stages of the design process and (2) an enhanced ability to communicate with a broad audience.

KEYWORDS: public space, artificial intelligence (AI), design education

INTRODUCTION

Generative artificial intelligence (AI) is a rapidly advancing technology transforming design practice and education (Newton 2021). How AI technology interacts with human creativity—whether through collaboration, reliance, or mutual dependence—will define the conversation about AI in the upcoming years (Newton 2019, Huang et al. 2021). This necessitates the formulation of strategies for creative partnerships and joint authorship with AI.

This paper demonstrates an approach for an AI-enhanced architectural design process that empowers students while letting them maintain intentionality and authorship. Specifically, this paper is investigating (1) how AI applications can change a design process (2) how AI can impact design education, and (3) how AI applications can impact the interaction between architects and clients.

The research uses an urban project as a case study and framework to test the potential of AI applications in terms of enhancing design processes, streamlining creativity, and engaging a larger community. Through a series of experiments that test AI applications from context analysis and idea generation to the refinement of the design, the research intent is to establish best practices for AI-facilitated design processes. The project also identifies the advantages and disadvantages of AI tools while demonstrating a strategy for applying AI tools in practice and architectural education.

1.0 TECHNOLOGY CONTEXT

Applications of generative AI in design and visual arts are a relatively recent phenomenon. Several researchers explore the analysis and creation of two- and three-dimensional designs (Newton 2019) considering particular cultural contexts and identities (Huang et al. 2021). AI research in architecture addresses Useful Daylight Illuminance (UDI) optimization for buildings at an urban scale (Canli et al. 2023) or building frameworks to design energy-conscious buildings (Aman et al. 2023). Text-to-image applications can also be used in urban planning to engage a larger community in new ways in a design process, synthesize emotional responses of citizens in a design process (Riether & Narahara 2023) or allow all project stakeholders, both professionals and the public to directly participate by visualizing their design proposals for future urban landscapes (Mugita et al. 2023).

However, the field of architecture has not benefited from AI developments to the same degree as other disciplines (Özerol et al. 2023). This points to a slow adoption of these new technologies in creative disciplines. The emergence of stable diffusion tools is significantly changing the use of image-based AI in architecture. This is evident in some recent studies that apply AI in various curricular frameworks (Dortheimer 2023). Many of these studies operated semantically evoking poetic texts, such as Italo Calvino's "Invisible City". Others see AI technology as a one-for-one replacement of conventional design processes, not as a form of creative partnership. The question of intentionality and agency is rarely investigated (Terzidis 2023), yet it is fundamental to the future use of AI tools in design and particularly the role clients and other non-designers play in the formation and selection of design concepts. AI-driven design processes may be of a more collaborative nature, which will be addressed in the result section of this paper.

2.0 PROJECT CONTEXT

The topic of the studio project was the redesign of a Public Space for the Arts for the *Kunstmeile Krems*. Forty-three miles west of Vienna, Krems is located at the Danube River at the gate to the UNESCO World Heritage site Wachau, a well-known wine region in Austria. The town is rich in history with its cultural and architectural growth peaking during the Renaissance and Baroque periods. Today, it is the center of higher education and culture in the Lower Austria region. The *Kunstmeile Krems* is an umbrella organization for several museums, galleries, art foundations, and cultural events such as music festivals. Most of the venues are located along the Steiner Landstraße, currently, a one-mile-long monotonous two-lane street with street parking that connects the urban centers of Stein and Krems, two towns that are characterized by their medieval structure and that have during industrialization merged into a single urban entity (Figure 1).

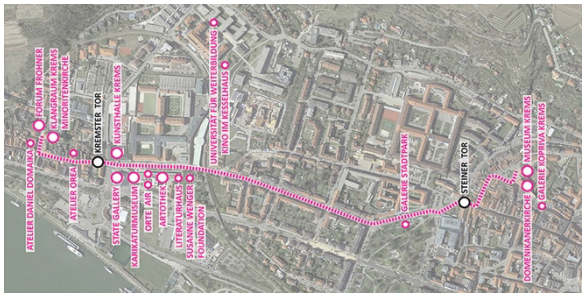

Figure 1: Art Institutions affiliated with and located on the *Kunstmeile Krems*. Source: (Gernot Riether, the author 2024)

The project was conducted within an architecture design studio comprising 16 upper-year undergraduates (B.Arch) during the summer of 2023. The first part of the studio (3 weeks) was held at NJIT's campus in Newark, and the second part (3.5 weeks) took place at the actual site in Krems, Austria, where the studio was set up in the Artist of Residence Program (AIR), located directly at the site of the project. This living and working arrangement allowed students to observe the site over an extended period while they were refining their projects. Due to time constraints, the project used tools that can expedite design ideation and communications, which included generative AI tools, image processing (Adobe), and rapid 3D modeling software that facilitates free-form designs (Rhinoceros 3D). Between the time in Newark and Krems, students went to Vienna for a week where they toured many examples of public spaces, relevant to the studio's project. One of the spaces examined more closely was the Museums Quartier (MQ), a public space shaped by a diverse array of cultural organizations that has in recent years transformed cultural activity in Vienna by attracting a growing number of cultural initiatives to its surrounding area. (Roodhouse & Mokre 2004)

3.0 CASE STUDY - FRAMEWORK

3.1. Project goals

Goals for the redesign of the *Kunstmeile Krems* were established in discussions with the stakeholders of the project, which included directors, curators, and artists from the institutions of the *Kunstmeile Krems*, city officials, and residents of Krems and Stein. The following goals were agreed upon: (1) Transform a part of the Steiner Landstraße into a public space that spatially connects the art venues of the *Kunstmeile Krems*; (2) Develop a spatial identity for the *Kunstmeile Krems* that will facilitate wayfinding and place-making (public readings, performances, workshops, and outdoor exhibitions); (3) Integrate programs that promote social interactions by introducing design-quality urban furniture, sun shading through greenery and shading devices.

To achieve these goals additional strategies were identified: (1) The development of modular action platforms for temporary and permanent initiatives by the institutions located on the *Kunstmeile Krems*; (2) The transformation of sealed surfaces currently used for streets, parking, and sidewalks into permeable, green spaces that reduce heat island effects and mitigate stormwater runoff; (3) The Reduction of traffic on Steiner Landstraße by prioritizing pedestrian and bike use. (4) The development of strategies for changing the traffic pattern to improve the connection of the *Kunstmeile Krems* with remote parking and the town's train stations.

3.2. Course structure

The studio was structured into four main parts that will be described in detail below: (1) Context and Site Analysis, (2) Conceptual Explorations, (3) Contextualized Concepts and (4) Schematic Design. Each of these parts was structured around the use of AI applications. During each of these milestones, meetings and visits were conducted with stakeholders to learn about the institutional needs and gain inside perspectives. In addition, reviews were set up that provided opportunities to engage with the residents, the artist community, and city officials (Figure 10).

3.3. Methods

The studio facilitated an open experimentation culture encouraging students to adopt a wide range of generative AI tools and models. These included Dall-E 2, Midjourney, BlueWillowAI, DreamStudio, Lexica, and Stable Diffusion. Some students would run implementations of stable diffusion locally but a majority used available services, free or paid. Initial work was done utilizing text-to-image functionality with some image-to-image in combination with text prompts. The methodology relied on the reiterative process of developing design variations, evaluating outputs, identifying desired traits in imagery/designs, and exploring new possible designs based on desirability. Prompt engineering strategies involved contradictory requirements and ambiguity in the early stages to ensure a diverse and unprescribed set of solutions. In late design process stages prompts, and occasionally in/out-painting, became more focused and prescriptive to maintaining chosen traits/features over generations of variations.

4.0 CASE STUDY - RESULTS

In each of the 4 parts of the design process students explored different strategies to utilize AI applications in different ways. In the context analysis students developed prompts to match a specific outcome, in the conceptual phase students developed prompts to provoke surprising results and in the final phase of the project AI applications were used to create variations.

4.1. Digital wachau: cultural context explorations

As part of the site analysis and to develop a good understanding of the unique characteristics of the Wachau region students were asked to develop prompts that described the Wachau Valley without using the word “Wachau” and compare the resulting images to pictures of the actual valley. Early prompts such as “wine region in Central Europe” sometimes got close but triggered a discussion about how images would compare to the Rhine Valley in Germany or Tuscany in Italy. Successful prompts were combining characteristics of wine terraces with crystalline rock formations, hills, rivers, medieval urban structures, and elements of Renaissance and Gothic architecture.

Figure 2: Digital Wachau, AI-generated images representing what DALL-E model considers central European historical context. While closely showing the landscape and urban characteristics of the Wachau Valley, the prompts were rather general (prompt: “scenic overlook over a vine valley with castles and ruins and urban architecture” (far left) and prompt: “castles and ruins and urban architecture with pedestrian on cobblestone roads” (left) Source: (Loc Nguyen 2023), Capturing the mood and environmental aura of the region with an expressive image style. Prompts: “Wachau Valley, alongside river, populated with people, small houses at far distance with terracotta roofs, green landscape, town church” (right) and “Wachau Valley at night, illuminated with streetlights, town homes with terracotta roofs, town church, town reflected on Danube River” (far right) Source: (Karla Vasquez 2023).

This exercise also illustrated how generative AI can synthesize a diverse set of qualities to produce images with identity and authenticity. The resulting images were evaluated against the actual characteristics of the valley. The more feedback students received by using AI tools the more detailed and precise the prompt became. A close match of the prompt outputs to the actual Wachau Valley scenery speaks to the visual and landscape characteristics between a broader range of locations that follow a similar spatial continuum. This is evident in Figure 2 when compared to the left and far left to the images on the right and far right where the locality was specifically included in the prompt. Students also experimented with various visual representation styles (Figure 2) to convey a more ephemeral and elusive feel for the region. This initial exercise achieved two objectives by allowing students to (1) explore cultural and scenic genius loci of the Wachau Valley and (2) develop preliminary understanding and skills associated with generative (text-to-image) AI. The former was particularly important since this phase of the course was conducted remotely. Additionally, these AI explorations were an important element of student immersive experiences with the local heritage.

4.2. Conceptual explorations

From the previous exercise, students gained the ability to develop prompts and produce expected outcomes. Since they were free to experiment with diverse AI platforms, they also learned how to navigate various stable diffusion models and how to apply them for the desired effects as seen in stylized imagery. This broader evocative use of AI-generated imagery was a critical part of the creative layer of the design process. Since the goal of the studio was to develop highly engaged and experientially memorable (iconic) public spaces students conducted case studies and identified important precedents. However, unlike in the traditional design process where precedents serve as a springboard to design explorations, here the precedents were used to produce text-based descriptive prompts that were fed into AI (Figure 3).

Figure 3: From precedents to mental and textural notes, and to AI prompts. Transcending precedents and exploring design space of prompts: “pedestrian street, with lots of modern urban furniture, people interacting with one another, wooden pavilion” (left) and “pavilion filled with mirror and glass on pedestrian street, people interacting with one another, vivid lights reflecting of pavilion” (right) DALL-E. Source: (Karla Vasquez 2023).

The driving keywords of this image series were sunshade, stained glass, vivid colors, and hanging mirrors, which respond to the key design goals identified earlier. This approach allowed students to develop the vocabulary necessary to communicate design intent. It provided additional layers of translation and abstraction facilitating the transcendence of the original precedents and producing novel outcomes. This can be seen in Figure 4 where visual and evocative logic (abstracted creativity) is privileged over technical and constructability, which is critical in the early stages of the design process. While prompts emphasized visual and experiential qualities, they also pursued the key project goals, such as interactive and immersive engagements, and family-friendly spaces.

Figure 4: Explorations of public art in public spaces. Prompts included: “contemporary art installation that transforms a road into a public plaza into a realm of immersive experiences, sensory wonder, avant-garde design, creativity and engagement, tactile experiences, playful, family-friendly, both striking and harmonious, captures the essence of urban life” (left) and “Create a digital representation of an interactive contemporary art installation set in a public setting that showcases a future vision of a multifunctional and interactive public space in the style of Gabriel Dawe” (right). Source: (Isabella Gil 2023)

An important part of the conceptual explorations was the development of variations, the selection of promising outputs, and the continuation of selected design alternatives through subsequent variations (Figure 5). This allowed students to explore a broader class of design solutions in effortless yet focused ways and gave students a deeper insight into tectonic and programmatic solutions possible. This can be achieved by (1) maintaining the same prompt while changing the seed, (2) slight variation to the prompt, (3) using the output image as an input partially weighted with the changed prompt, or (4) using in-painting and out-painting tools. This range of techniques allows for a close and/or localized control of the images. Guiding variations is one of the most important steps in the AI-enabled design process as it brings back the agency and authorship to designers, and in this case to students. It also facilitates the development of critical visual thinking and mitigates the designer’s fixation with initial AI outputs, also known as automation bias (Zarzycki 2023).

Figure 5: Variations as an exploration of possible design space. Source: (Albina Zhaku 2023).

4.3. Contextualizing concepts

Once a broad array of idealized designs was formulated, students were asked to evaluate these conceptual designs for their fit with program, project goals and the immediate urban context. To address contextual relationships students used site images (Google Street View) and fed them into an AI platform with prompts describing social and functional requirements, such as seating or shading. Combining diverse and usually competing parameters resulted in images that were sometimes prosaic but more often inspiring and meaningful.

At this stage, the overall feel and mood of the image were deprioritized, and the focus was shifted to details and fidelity. Students followed a similar exploration, variation, and refinement process as outlined in the section above. Since one of the goals of the project was to transform a street into a pedestrian space, elements such as parking, traffic signs, and cars were removed from the Google Street View. Using the same base images students conducted three types of studies:

Experiment 1: Use prompts that describe the project such as “Public Space with seating and shading” Part of the prompt also had to define the type of outcome “eye-level view of an outdoor space with many pedestrians, highly detailed, photorealistic, V-Ray rendering.”

Experiment 2: Use a prompt without terms that directly describe functions or the type of spaces such as “Public space with a café” but instead trigger surprising ideas for a new type of public space by describing the qualities of the space such as “colorful, happy, immersive, dreamlike space” describing qualities from the site such as “wine terraces or floodplain forest” and add descriptions of artwork or artists’ names such as “Media art, James Turrell.”

Experiment 3: Add elements to the prompt that are entirely foreign to the prompts from the second round such as “soap bubbles” These prompts should avoid words that describe architectural or urban typologies such as “insect wing” or “rolling hills.” At the same time, students were asked to consider negative prompts to filter out undesirable elements, such as “cars, ugly, sad.”

These experiments allowed students to progress work from defined and prescriptive to open-ended and imaginary transcending obvious design associations and solutions. The range of outcomes from these three experiments (Figures 6).

Figure 6: A design scheme showing a full conversion from the vehicular to pedestrian street and enhancing it with seating, greenery, and water features. (left) Source:(Josh Pledger 2023). A high-energy event space with pavilions and street furniture. Prompt: “nighttime cinematic, surreal origami public space, surreal public plaza space, futuristic, colorful, lights, cinematic, paper, fun, interactive, origami pavilions, professional color photograph, immersive experiences, colorful spectrum, lit up ground, projections, technology, futuristic, style of Daan Roosegaarde“. Source: (Layla Neira 2023). Umbrella-like structures provide shading and visual interest. Prompt: “professional color photograph, full with large scale people, awe-inspiring anamorphic art, realm of interactive experiences and sensory wonder, outdoor, high pedestrian transit, dreamlike world, distorted geometry, unexpected juxtapositions”. Source: (Isabella Gil 2023).

4.4. Schematic design

The designs from the previous exercise were grouped based on themes associated with design scenarios’ materiality or formal effects. Then, students discussed the potential of each of the themes and interpreted the AI perspectives against functional and practical requirements. Based on these discussions four themes were selected and four teams formed.

Arriving at the site it became clear that working with Google Street View images made students underestimate the scale of the site. Projects required adjustments to meet the actual scales as seen in the comparison between Figures 6 and 7. There was also a similar situation with several programmatic requirements. Students’ experience of the site on a hot summer day translated quickly into an increase of shading devices in their projects.

The initial AI images were translated into viable 3D environments that responded to functional requirements while maintaining the characteristics and identities that they evoked. Plans (Figure 7) were used to resolve key functions of the projects such as seating and shading. Plan drawings were also used to evaluate traffic flows, accessibility, and location of common facilities, such as information booths, bathrooms, or private tenant spaces (restaurants, café, bars, museum stores, and galleries). This part of the process took most of the time on site, as expected, as AI imagery was effective in stimulating initial creative thinking but still similar to those ‘napkin-like sketches’ needed to be fully thought through and resolved. However, having multiple variations of design proved to add to the flexibility of the refinement stage. While developing schematic design continue using AI tools for variations that were later used as more finalized renderings. In this stage, students used the image-to-image feature, which allowed them to maintain the overall character but provided imagery that was articulated differently in terms of mood, detail, and materiality (Figure 8). All four projects followed the same process: DON-AU (Figures 7), TERRACES (Figure 8),

URBAN BASKET (Figure 9), and SONNENDACH (Figure 9), with titles referencing initial AI prompts (with the word ‘Au’ representing floodplain forest in German).

DON-AU (Figures 7) used prompts that combined fabric effects, the vein structure of local insect wings to create lightweight fabric trees growing from a landscape of seating and plants that was generated by a prompt that combined landscape effects of meadow and floodplain forests that occupied the site before the Danube River was regulated. The fabric trees were developed into shading systems that could also be used as surfaces to project information from the museum’s exhibitions.

Figure 7: DON-AU: The continuation of the umbrella-like structures with added programmatic elements, such as greenery and gathering places, Rendering and Site Plan of final project. Source: (Isabella Gil, Valeria Gomez and Karla Vasquez 2023).

TERRACES (Figure 8) used prompts that described the terraced vineyards of the Wachau Valley. The terraces were developed into a system for seating and shading. The terraces were shaped for people to mingle and accommodate different scales of groups of people and arrangements that could be utilized for events by the bordering art organizations such as public readings, screenings or public debates. The terraced shading system also acted as planting pods and was optimized to maximize the green surfaces in the public space.

Figure 8: Using Image-to-image AI applications to generate variations for final renderings, Terraces. Source: (Angela Evangelista, Kennedy Pfeifer, Mona Pandaya 2023).

URBAN BASKET (Figure 9) used prompts describing the woven structure of a Zistel, a traditional basket made from osier stake in this region to harvest apricots. The woven structure was used to integrate seating and shading devices into a single complex urban furniture that could vary in size to accommodate social gatherings of different sizes.

SONNENDACH (Figure 9) divided the public space into horizontal layers reminiscent of the time before the Danube River was regulated and this area was regularly flooded. The layers function as a large roof that interacts with the existing trees and provides shade for the entire public space and projects shadow patterns at different scales onto layers below. Other layers maximized green spaces or served as seating devices.

Figure 9: Urban Basket (left) Source: (Project by Project by Angelica Valinoti, Loc Nguyen, Mateo Fuentes 2023). Sonnendach (right) Source: (Project by Albina Zhaku, Josh Pledger, Layla Neira, Dillon Imes 2023)

All projects emerged from the AI images transforming the streetscape into a pedestrian place with different identities. Each of the projects successfully responded to functionality by creating a space to socialize and a space open to cultural activities, such as public readings, performances, workshops, and outdoor exhibition spaces. All projects also responded successfully to requirements of un-sealing surfaces and maximizing green spaces.

TERRACES for example uses the shading device as large planting pots (Figure 13). All projects could have developed further to provide additional programs, such as restaurants, café, or bars to activate the space all year round.

4.5. Client interactions

Kunstmeile Krems served as the main client. Other stakeholders included museum and gallery directors, curators, and artists, the residents of Krems and the Local Government Officials and the Public. During the first online meeting with the CEO and other representatives from the *Kunstmeile Krems*, students presented AI renderings of 50 different future public spaces. All images were produced within the first few days of the studio. Images were selected based on the responds from stakeholders and ideas that students saw in them. Traditionally an architect would show abstract diagrams or sketches at a first meeting with the client. This presentation allowed for the client to evaluate if they could identify with the characteristic or mood of an image rather than how the architect responds to function in a floorplan. It allowed for the client to interpret the image their own way and find new possibilities in the images that the student has not thought about. The discussion was used to narrow down the number of images. This initial meeting was also used to gain insight on the recent history of the site and to find out what the needs of the stakeholders and the larger community are.

Figure 10: Review after the first week on site with representatives from the *Kunstmeile Krems*, Günter Herz, Head of City Planning and Elisabeth Kreuzhuber, Municipal Councilor. Source: (Gernot Riether, the author 2023)

Once the studio relocated to Austria students visited the museums and galleries that make up the *Kunstmeile Krems* and asked curators and museum directors about their ideas and needs for a public space in front of their venues. After one week at the site the studio presented work in progress. This time to representatives from the *Kunstmeile Krems* and to the Head of City Planning from the City of Krems (Figure 10). The use of AI generated perspectives made it easy for an audience that were not architects to relate and understand the different projects. AI tools were used to generate multiple variations for each project (Figure 5), which provided choices. Projects were presented as systems that could be used to only transform small parts of the site or take over the entire site. Instead of presenting a final project the presentation led to an open-ended discussion about new opportunities. Aspects that were discussed were permanent versus temporary programs, venues in the public space by private tenants such as restaurants, café, bars and surfaces that could be unsealed and transformed into natural landscape.

During the last week on site each team refined their projects and developed another presentation (Figure 7). ORTE, the Architecture Center of Lower Austria invited the public to join a final review of the studio. Stakeholders were excited to see how each of the projects created spaces that connect to art and context and have the potential to draw people to the art venues. Projects also received very positive feedback regarding their unique spatial identity for the *Kunstmeile Krems*. But most importantly the studio had successfully helped to connect different stakeholders, trigger a discussion between stakeholders and city officials and generate an appetite to see more.

CONCLUSION

The paper presents generative AI-driven alternatives to the conventional design process with a focus on fast-paced idea generation and close interactions with a broad range of stakeholders. It demonstrates the requirement for a new form of literacy, a shift in thinking from sketch to text. It also demonstrates a short learning curve and quick technology adoption by both students and clients as well as the ease of interacting (interface) with new modes of creativity and high-quality of produced outcomes. Seeing how AI tools change the pace and frameworks of conversations between architects and clients also raised questions about the authorship and intentionality of designs.

This case study also provides an opportunity to evaluate curricular methodologies in architecture education, especially for the design studio. Generally, the AI-generated work outperformed other visualization and conceptualization skills students brought into projects. Understandably, this helped to garnish enthusiasm for the toolset and projects. Prompt-based interface (text-to-image) with image-to-image refinements also changed the

way one would think about the progression from abstract to more refined ideation, the use of evocative representations, and context-minded solutions. It changes the types of presentations, requires new formats of interaction, and provides new opportunities.

Students also discovered limitations of generative tools that may impede creativity: an ease of outcomes may reduce an inquisitive drive resulting in early gratification without a transformational use of creative/design tools. Other challenges may include the difficulty of transitioning from high-quality and high-fidelity AI-generated imagery to 3D models and conventional modes of architectural representation, which initially may feel under-defined. Finally, it is worth future studies to better understand emerging relationships between an image, a drawing, and a 3D model, and how this relationship be affected by generative AI.

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