AI-Based Tools and Applications: a Descriptive Mapping in the Architectural Design Process Stages

èkphrasis

46th International Conference
of Representation Disciplines Teachers
Congress of Unione Italiana per il Disegno

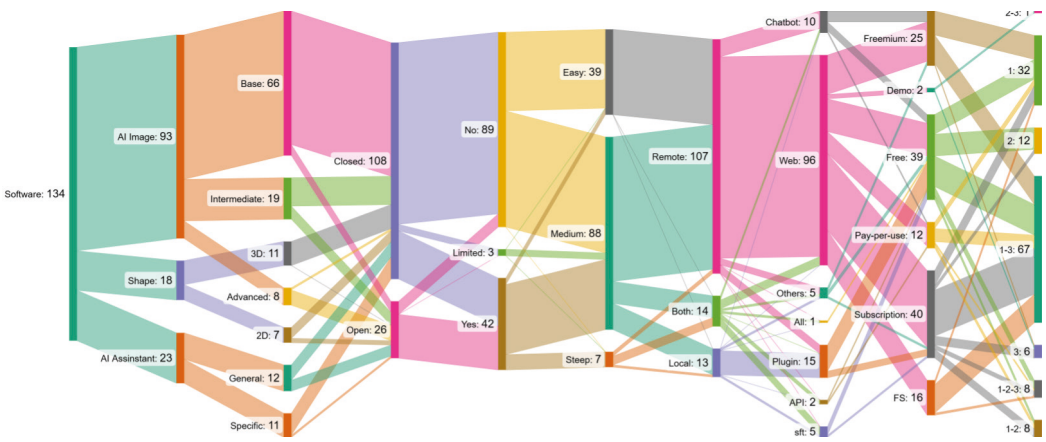
AI-Based Tools and Applications: a Descriptive Mapping in the Architectural Design Process Stages

Enrico Pupi
Andrea Tomalini

Abstract

The architectural design process, intrinsically linked to the discipline of representation, is articulated through progressive phases, each characterized by specific activities and objectives. This article reports the preliminary results of a study aimed at mapping Generative Artificial Intelligence (GenAI) tools currently available to support the design process and its representation, associating them with operational phases.
AI, where implemented, has demonstrated its capacity to introduce novel approaches by automating procedures and identifying unexplored solutions. In architectural design, GenAI redefines representation, modifying its objectives and the diachrony of design phases. Digital tools enhanced by AI shape design thinking, demodulating the sequence and interaction between phases.
Beyond mapping GenAI tools, the contribution is propaedeutic to future educational experiences (planned for the 2025/2026 academic year) to verify the applicability of AI tools in complex design processes.
The study offers a framework of AI potentialities in contemporary architectural design and representation, highlighting how GenAI provides new visual tools and triggers a paradigm shift in how we conceive and communicate architectural design.

Keywords
Generative artificial intelligence, digital representation, architectural Design, AI-based tools, comparative critical mapping.



Cover visualization depicting the classification and quantitative distribution of AI tools mapped across architectural design process stages, as presented in this study.

doi.org/10.3280/oa-1430-c921

Introduction

The history of architectural design is intrinsically linked to that of its representation tools. If, for centuries, canonical instruments have shaped thought, the advent of digital technology has progressively expanded the disciplinary vocabulary, introducing new design grammar and syntax [Carpo 2011; Carpo 2017]. Today, Generative Artificial Intelligence (GenAI) is not limited to automating existing processes. However, it is proposed as a catalyst for a paradigm shift capable of redefining the relationship between human intuition and computational capacity [Chaillou 2019]. This change extends to various fields of architectural design, including interior design [Spennato 2023]. Recent reviews meticulously analyze the application of various generative AI models across the different phases of the architectural design process, highlighting both the potential and the existing gap between technological advancements and their practical adoption in the field [Li *et al*. 2024; Bölek, Tutal, Özbaşaran 2023].

GenAI in the context of architectural representation tools

The evolution of architectural representation tools is a foundational element in the analysis of contemporary design. Historically, the primary objective of this technological progression has been process optimization and error minimization. The advent of Artificial Intelligence (AI) is progressively reshaping the landscape of architectural representation tools, introducing a transformation from pre-existing traditional and digital methodologies [Vissers-Similon *et al*. 2024]. This transition can be interpreted as part of a broader evolutionary trajectory of Computer-Aided Architectural Design (CAAD), as argued by Stojanovski *et al*. [2021], who traces the shift from generative algorithms to artificial intelligence in architectural and environmental design.
Historically, architectural representation has been a codified language specifically purposed for transmitting design ideas through representational artifacts characterized by disciplinary codes and conventions. The introduction of GenAI unveils unprecedented paths for visual artifact creation, enabling the generation of representations from diverse inputs. This approach automates complex procedures and can yield unexpected outcomes, fostering design exploration. Within this context, the intrinsic dialectic of *èkphrasis* is reactivated. At the same time, historically, the word evoked and interpreted the image; AI now presents a significant inversion, leveraging language as a generative matrix. The algorithm, trained on vast datasets of images and texts, learns semantic and formal correlations, translating textual descriptions into visual representations. The capacity to generate synthetic architectural artifacts from linguistic inputs is extensively explored in studies investigating the potential of language-image models to produce complex and qualitatively relevant architectures [Koehler 2023; Chen *et al.* 2023].
Constituent linguistic units, termed tokens, function as intrinsic elements of the generated image, evoking atmospheres, architectural styles, and spatial configurations. Notably, while directly influenced by the training dataset, the quality and pertinence of the output remain intrinsically linked to the precision and richness of the linguistic input, underscoring the centrality of the user's descriptive and conceptual competence. AI transcends a mere transformation of architectural representation tools. Instead, it modulates the interrelation between language and image. This evolution prompts an in-depth reflection on the modalities through which design ideas are represented in the digital age. Suppose the practice of ékphrasis traditionally conferred upon the word the power to narrate the visual. In that case, AI reveals the generative capacity of language, inaugurating new frontiers for architectural communication and visualization [Bernhard *et al*. 2021].

Definition of considered design phases

A precise definition of the design phases under analysis is necessary to structure this research. While professional practice conventionally articulates the design process into macro-phases of technical-economic feasibility, definitive design, and executive design, the context of this study -primarily oriented towards mapping AI tools and their potential integration into educational design and representation laboratories- necessitates a simplified re-interpretation of this subdivision. Specifically, the following macro-phases will be considered:

- *Phase 1*: conceptualization and generation (Low degree of conditioning). This phase is defined as a moment of conceptual ideation dedicated to establishing the project's guiding principles and generating initial formal and spatial hypotheses. In this phase, AI tools can support the architect in exploring a wide range of solutions, automating form and planimetric configuration generation processes, and stimulating creativity by identifying unexpected relationships between programmatic data and design constraints [Mancini and Menconero 2023]. This phase partially correlates with the preliminary phase of professional practice projects but with a marked emphasis on alternative exploration and concept generation, allowing for a low degree of conditioning in model inference to promote transverse design exploration;
- *Phase 2*: development and optimization (intermediate degree of conditioning). This phase is dedicated to refining initial ideas, translating them into more defined spatial configurations, and integrating performance considerations (functional, environmental, structural). In this context, AI tools can facilitate the analysis of diverse design configurations, evaluate their performance against specific criteria, and support the decision-making process through complex data visualization and optimized solution identification. This intermediate phase is comparable to a simplified version of the definitive design, focusing on spatial and performance definition. This phase witnesses a progressive increase in AI conditioning, supporting more informed design choices through analysis and optimization;
- *Phase 3*: representation and communication (high degree of conditioning). This final phase centers on project formalization through graphic elaborations and detailed models to communicate design choices to stakeholders. In this context, AI offers tools for automatic rendering generation or immersive visualization creation. Although chronologically assimilable to executive design, it is important to note that the investigated applications cannot emulate the documental output typical of an executive project. The contribution of AI in this phase is nonetheless characterized by a high degree of conditioning, as the generation of specific visual outputs requires more stringent parameters and constraints to ensure project coherence.
This subdivision can be considered eminently representative of the traditional design process, borrowing some fundamental aspects from it. Moreover, it is precisely calibrated to facilitate the analysis of AI tool contribution in the creative and decisional process. It enables thematic mapping and potential integration into an educational context, considering the variable degree of conditioning exerted in inference within the different phases.

AI-based tools: identified categories and classification criteria

An AI model constitutes a computational system engineered to emulate specific human cognitive capacities through data processing and learning. These models operate via mathematical algorithms, calibrating during a pre-training phase on large-scale datasets. An AI model's primary objective lies in identifying patterns and correlations within data and making elaborate predictions or decisions in response to novel inputs.
The classification of AI tools proposed herein is structured according to distinct categories, reflecting the diversity of underlying architectures and specific applications. The principal categories, with their respective subcategories, encompass:
AI Image Generators: Tools specialized in generating images from textual and/or visual inputs:
- *Base*: Offer fundamental text-to-image generation functionalities, ideal for conceptual prototyping and initial stylistic exploration;
- *Intermediate*: Feature advanced functionalities such as inpainting (filling missing areas in an image) and outpainting (extending image borders), enabling more sophisticated manipulation and greater creative control;
- *Advanced*: Offer complex user interfaces, such as Automatic1111 and ComfyUI, which allow for highly detailed control over generation parameters and the implementation of personalized workflows;
Shape Generation: Tools for creating geometries that automate modeling processes and facilitate the exploration of design variants. These tools are often based on architectures such

as Generative Adversarial Networks (GANs), pioneering models introduced by Goodfellow *et al*. [2014] that marked a breakthrough in the field of GenAI:
- 2D: Tools dedicated to generating planimetries and distribution schemes.
- 3D: Tools focused on creating three-dimensional architectural models, frequently with optimization functionalities based on specific parameters.
AI Assistants: AI systems providing support in various phases of the design process.
- *General Purpose*: Models applicable to tasks ranging from information retrieval to pattern identification within data.;
- *Specific Purpose*: Tools focused on specific tasks within the architectural domain, such as spatial data analysis (e.g., *Aino.World*) or BIM model interrogation and management (e.g., *Archie*).
The comparative analysis of AI tools necessitates the adoption of evaluation criteria of diverse natures. The parameters utilized in this analysis, accompanied by a concise description, are detailed below:
- *Category*: The principal classification of the AI tool (AI Image Generator, Shape Generation, AI Assistants);
- *Subcategory*: A more specific classification within the principal category (e.g., AI Image Generators: Base, Intermediate, Advanced);
- *Application Name*: The commercial name of the AI tool;
- *Web Resource*: The official URL address of the AI tool;
- *Key Aspects*: A brief description of functionalities and principal characteristics;
- *Open/Closed*: Indicates whether the tool's source code is open and accessible for modifications (Open) or proprietary (Closed). It is necessary to clarify that the term 'open' has also been used in cases involving only an open-weight model;
- *Fine-tuning*: Specifies whether the user can customize the AI model with proprietary data to adapt it to specific needs;
- *Learning Curve*: Evaluates the difficulty of learning and using the tool for a new user (Easy, Medium, Steep);
- *Where it Computes*: Indicates where data processing occurs (remote or locally executable computation);
- *User Interface*: Describes the type of interface through which the user interacts with the tool (Web-Based, Software, Plugin, Chatbot, API, etc.);
- *Compatible Environments*: Lists the operating systems and software with which the tool is compatible (e.g., Web Browsers, Windows, macOS, Linux, CAD, BIM);
- *Cost/License*: Indicates the cost model or license type of the tool (e.g., Freemium, Subscription, Pay-per-use, Free);
- *Project Phase*: Specifies the phases of the design process in which the tool is most applicable (indicated numerically as defined previously).

Critical mapping of AI tools in the design process

The findings of this investigation represent an initial census of AI-based applications potentially integrated into architectural design processes (tabs. 1,2,3). In contrast to other studies analyzing the broader AEC sector [Onatayo *et al*. 2024], the identified applications specifically focus on the ideation phase of the design process.
The classification of tools, structured into three functional macro-categories, identified 134 available tools and applications (survey conducted until January 31, 2025). It is important to emphasize that this reconnaissance does not aspire to exhaustiveness, instead representing a snapshot of a continuously and rapidly evolving technological landscape.
The quantitative analysis of the tabulated data, illustrated in the histograms of Figure 1, reveals a distinct predominance of image generator tools, which constitute the majority (93 out of 134, or 69.4% of the total). Generic AI assistants represent a smaller fraction (23 tools, 17.16%), while 3D modelers constitute the least numerous category (18 tools, 13.43%). A further observation concerns the prevalence of tools classified as 'Closed' and characterized by a 'Simple' or 'Medium' operational pipeline. This data suggests a maturation phase of AI tools within

Category: AI Image Generator

Subcategory	Application Name	Web Resource	Key aspects	Open/Closed	Fine-tuning	Learning Curve	Where It Computes	User Interface	Compatible environments	Cost/License	Project Phase
Base	AI Image Generator	https://deepai.org/machine-learning-model/text2img	Basic text-to-image generation.	C	N	E	R	W-B	Web Browsers	Freemium	z
	Archicad AI Visualizer	https://graphisoft.com/it/solutions/innovation/archicad-ai-visualizer	AI-powered feature within Archicad for generating design ideas from prompts.	C	N	E	R	Plugin	Archicad	Free with Archicad Subscription	I - 3
	ArchiVinci	https://www.archivinci.com/	Specializes in architectural visualization from text prompts.	C	N	M	R	W-B	Web Browsers	Subscription	I
	Artbreeder	https://www.artbreeder.com/	Combines and morphs images.	C	Y	M	R	W-B	Web Browsers	Freemium	I - 3
	ArtGuru AI Art Generator	https://www.artguru.ai/	Basic text-to-image generation.	C	N	E	R	W-B	Web Browsers	Freemium	I
	BasedLabs	https://www.basedlabs.ai/	Platform for access to many models, also to Flux Dev and Schnell.	C	Y	M	R	W-B	Web Browsers	Freemium	I - 3
	BlueWillow	https://www.bluewillow.ai/	Free alternative to Midjourney, accessible via Discord.	O	N	M	R	Discord Bot	Discord	Free	I - 3
	Canva's AI Image generator	https://www.canva.com/ai-image-generator/	Integrated image generation within a broader design platform.	C	N	E	R	W-B	Web Browsers	Subscription	I
	CF Spark	https://studio.creativefabrica.com/flow/	Part of a creative asset platform, focuses on generating visuals for design projects.	C	N	E	R	W-B	Web Browsers	Subscription	I - 3
	Clipdrop by Jasper	https://clipdrop.co/	Collection of AI tools for image editing and generation.	C	N	M	R	W-B	Web Browsers	Freemium	I - 3
	CrAIyon	https://www.craiyon.com/	Basic and widely accessible text-to-image generator.	C	N	E	R	W-B	Web Browsers	Freemium	I
	DALL·E 3	https://openai.com/index/dall-e-3/	Advanced text-to-image model known for its understanding of complex prompts and stylistic control.	C	L	M	R	W-B, API	Web Browsers, Integrations	Pay-per-use	I
	DaVinci	https://davinci.ai/	General purpose AI platform with image generation capabilities.	C	N	M	R	W-B	Web Browsers	Pay-per-use	I
	DeepAI	https://deepai.org	Suite of AI tools including image generation and editing.	C	N	M	R	W-B	Web Browsers	Freemium	I - 3
	Deep Dream Generator	https://deepdreamgenerator.com/	Transforms images using neural networks to create artistic effects.	C	N	E	R	W-B	Web Browsers	Freemium	I
	Diffusion Bee	https://diffusionbee.com/	A user-friendly application for running Stable Diffusion locally on macOS.	O	Y	M	R/L	Software	macOS	Free	I - 3
	DomoAI	https://domoai.app/	AI-powered video creation tools with image generation capabilities.	C	N	M	R	W-B	Web Browsers	Subscription	I - 3
	Drawthings	https://drawthings.ai/	iOS application for on-device Stable Diffusion image generation.	C	N	M	L	MA	macOS	Freemium	I - 3
	Dreamlike.art	https://dreamlike.art/	Offers a range of AI art generation tools with a focus on quality and style control.	C	N	M	R	W-B	Web Browsers	Freemium	I
	Dream Studio	https://beta.dreamstudio.ai/generate	The official platform for Stable Diffusion, offering various generation and editing options.	C	N	M	R	W-B	Web Browsers	Credit-based system	I - 3
	D5	https://www.d5render.com/	Real-time rendering software with integrated AI features for asset generation and enhancement.	C	N	M	R/L	Software	CAD, BIM	Subscription	3
	EasyDiffusion	https://easydiffusion.github.io/	User-friendly installer and interface for running Stable Diffusion locally or on remote computing services.	O	Y	M	R/L	Software	Windows, macOS, Linux	Free	I - 3
	FlairAI	https://flair.ai/	Focuses on generating branded content and product mockups.	C	N	E	R	W-B	Web Browsers	Freemium	I - 3
	Fliki	https://fliki.ai/tools/ai/image-generator	Primarily a text-to-video platform with image generation capabilities.	C	N	E	R	W-B	Web Browsers	Subscription	I - 3
	Flux AI	https://flux1.org/	Credit-based platform for access all the Flux models.	C	N	E	R	W-B	Web Browsers	Subscription	I
	Flux AI Image Generator	https://fluxaiimagegenerator.com/	Credit-based platform for access all the Flux models.	C	N	E	R	W-B	Web Browsers	Subscription	I - 3
	Fotor	https://www.fotor.com/	Online photo editor with integrated AI image generation features.	C	N	E	R	W-B	Web Browsers	Freemium, Subscription	I
	Freepik	https://www.freepik.com/ai/image-generator	Part of a stock asset platform, offering AI image generation for creative content.	C	N	E	R	W-B	Web Browsers	Subscription	I
	Fusion Brain	https://fusionbrain.ai/en/	AI image generation platform with different models and styles.	C	N	E	R	W-B	Web Browsers	Free	I
	GetIMG	https://getimg.ai/	Suite of AI tools for image generation, editing, and upscaling.	C	Y	M	R	W-B	Web Browsers	Freemium, Subscription	I - 3
	Getty Images	https://www.gettyimages.it/ai	AI image generation integrated into a premium stock image platform, emphasizing commercial use.	C	N	E	R	W-B	Web Browsers	Pay-per-image	I - 3

Table 1 (continuing at pages 6, 7, 8). Descriptive mapping of AI Image Generator tools for architectural design, categorized by subcategory (Basic, Intermediate, Advanced) and characterized by key aspects, accessibility, learning curve, computational location, user interface, compatible environments, cost/license, and project phase applicability. Regarding the table, in the 'Open/Closed' column the individual letters mean: C, Closed; O, Open.
In the 'Fine-tuning' column: Y, Yes; N, No.
In the 'Learning Curve' column: E, Easy; M, Medium; S, Steep.
In the 'Where It Computes' column: L, Locally; R, Remote; W-B, Web Based.
In the 'Compatible environments' column: MA, Mobile App.

Category: AI Image Generator

Subcategory	Application Name	Web Resource	Key aspects	Open/Closed	Fine-tuning	Learning Curve	Where It Computes	User Interface	Compatible environments	Cost/License	Project Phase
Base	HeyGen	https://www.heygen.com/	Primarily a text-to-video platform with avatar creation and potentially image generation features.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Hotpot AI	https://hotpot.ai/	Collection of AI tools for graphic design, image editing, and generation.	C	N	E	R	W-B	Web Browsers	Pay-per-use, Subscription	1 - 3
	Ideogram	https://ideogram.ai/	Focuses on generating images with high-quality typography and text integration.	C	N	M	R	W-B	Web Browsers	Freemium	1
	Image fx	https://labs.google/fx/tools/image-fx	Experimental AI tools from Google, including image generation and manipulation.	C	N	E	R	W-B	Web Browsers	Free	1
	Imagen 3	https://deepmind.google/technologies/imagen-3/	Google's advanced text-to-image model, known for photorealism and prompt understanding.	C	N	M	R	W-B	Web Browsers	Free	1
	Img2go	https://www.img2go.com/it/ai-creator-studio	Online image editing suite with AI image generation capabilities.	C	N	E	R	W-B	Web Browsers	Freemium	3
	Kive	https://kive.ai/	AI-powered platform for creative workflows, including image generation.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Leonardo.Ai	https://leonardo.ai/	Platform offering various AI models for generating visuals, including architecture.	C	Y	M	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Lexica	https://lexica.art/aperture	AI image search engine that also offers image generation capabilities.	C	N	E	R	W-B	Web Browsers	Freemium	1
	LookX AI	https://www.lookx.ai/	AI-powered platform for generating visuals, potentially including architectural applications.	C	N	M	R	W-B	Web Browsers	Freemium	1
	Meta AI	https://www.meta.ai/	Meta's research into AI, including generative models for images.	C	L	M	R	W-B	Web Browsers	Free	1
	Microsoft Designer	https://designer.microsoft.com/	AI-powered graphic design tool integrated into the Microsoft ecosystem.	C	N	E	R	W-B	Web Browsers	Free	1
	Neighborbrite	https://neighborbrite.com/#hero	AI-based online software. Upload a photo of the actual state and then customize it	C	N	E	R	W-B	Web Browsers	Freemium	1
	OpenJourney	https://openjourney.art/	Text-to-image diffusion model that makes AI art images in the style of Midjourney.	O	Y	M	R/L	Various	Web Browsers	Free	1 - 3
	Photosonic	https://photosonic.pro/	AI image generator from Writesonic, focusing on marketing and creative content.	C	N	E	R	W-B	Web Browsers	Subscription	1 - 3
	Picsart	https://picsart.com/ai-image-generator/	Mobile and web-based photo and video editing platform with AI image generation.	C	N	E	R	W-B, MA	Web Browsers, iOS, Android	Freemium, Subscription	1 - 3
	PicLumen	https://www.piclumen.com/	AI-powered image generation with a focus on creating realistic and high-quality visuals.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Playground.com	https://playground.com/	Platform offering a user-friendly interface for AI-based art models.	C	N	M	R	W-B	Web Browsers	Freemium, Subscription	1
	Polycam	https://poly.cam/tools/ai-texture-generator	Focuses on generating textures from text prompts for 3D models.	C	N	E	R	W-B	Web Browsers	Subscription	3
	Recraft AI	https://www.recraft.ai/	Focuses on generating vector graphics and illustrations using AI.	C	N	M	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Runway	https://runwayml.com/	Comprehensive AI creative platform with various generative tools, including image and video.	C	Y	M	R	W-B	Web Browsers	Subscription	1 - 3
	Scribble Diffusion	https://scribblediffusion.com/	Generates images from user-drawn sketches.	O	N	E	R	W-B	Web Browsers	Subscription	1
	SeaArt AI	https://www.seaart.ai/it	AI art generation platform.	C	Y	M	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Shutterstock	https://www.shutterstock.com/it/ai-image-generator	AI image generation integrated into a large stock asset platform.	C	N	E	R	W-B	Web Browsers	Pay-per-image, Subscription	1
	Sinkin	https://sinkin.ai/	AI-powered platform for creating photorealistic images.	C	N	M	R	W-B	Web Browsers	Pay-per-use	1 - 3
	SketchUp Diffusion	https://help.sketchup.com/it/sketchup-labs/sketchup-diffusion	AI-powered feature within SketchUp for generating design ideas from prompts.	C	N	E	R	Plugin	SketchUp	Free with SketchUp Subscription	1
	Skybox AI	https://skybox.blockadelabs.com/	Generates 360° skyboxes and environments from text prompts.	C	N	E	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Stable Diffusion Online	https://stablediffusionweb.com/	Web-based interface for running Stable Diffusion models.	C	N	M	R	W-B	Web Browsers	Freemium	1
	Starry AI	https://starryai.com/	AI art generator with a focus on community.	C	Y	E	R	W-B, MA	Web Browsers, iOS, Android	Freemium, Subscription	1 - 3

Category: AI Image Generator

Subcategory	Application Name	Web Resource	Key aspects	Open/Closed	Fine-tuning	Learning Curve	Where It Computes	User Interface	Compatible environments	Cost/License	Project Phase
Base	Synthesys X	https://synthesys.io/x/	Primarily a text-to-video and AI voiceover platform with image generation capabilities.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Thinkdiffusion	https://www.thinkdiffusion.com/	Cloud-based platform for running Stable Diffusion, offering pre-configured setups.	C	Y	M	R	W-B	Web Browsers	Subscription	1 - 3
	Vieutopia	https://vieutopia.com/	AI-powered platform for interior design visualization and concept generation.	C	N	M	R	W-B	Web Browsers	Freemium	1 - 3
	Vizcom	https://www.vizcom.ai/old-home	AI tool that transforms sketches into photorealistic renderings, particularly for product design.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Wombo Dream	https://dream.ai/create	Mobile app focused on artistic and abstract image generation from text prompts.	C	N	E	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Wonder AI	https://wonderai.app/	Mobile app offering various AI art styles and generation options.	C	N	E	R	MA	Web Browsers	Freemium, Subscription	1 - 3
Intermediate	Black Forest Labs	https://huggingface.co/black-forest-labs	Hugging Face inference spaces by Black Forest Lab for Flux-based tools.	C	N	E	R	W-B	Web Browsers	Free	1 - 3
	Deepinfra	https://deepinfra.com/	Platform for run many AI models also for image generation.	O	N	M	R	W-B	Web Browsers, API	Pay-per-use	
	Dezgo	https://dezgo.com/text2image/sdxl	Platform offering many tools and models for image generation and advanced editing.	O	N	M	R	W-B	Web Browsers	Pay-per-use	1 - 3
	Fal	https://fal.ai/	Platform offering a wide range of tools, also state-of-the-art models for image generation.	O	Y	M	R	W-B	Web Browsers	Subscription	1 - 3
	Firefly	https://www.adobe.com/products/firefly.html	Adobe's generative AI for image creation and manipulation, integrated into Creative Cloud.	C	N	M	R	W-B	Web Browsers, Adobe Apps	Subscription	1 - 3
	Flux.1 AI	https://flux1.ai/	Platform offering a wide range of Flux-based tools.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Hyperbolic	https://app.hyperbolic.xyz/	Platform for access a wide range of models, also for image generation.	O	Y	M	R	W-B, API	Web Browsers	Subscription	1 - 3
	Krea AI	https://www.krea.ai/	AI-powered visual ideation platform with real-time generation and upscaling.	C	Y	M	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Krita AI	https://kritaaidiffusion.com/	Plugin for the open-source Krita painting software, enabling Stable Diffusion integration.	O	N	M	L	Plugin	Krita	Free	1 - 3
	MidJourney	https://www.midjourney.com/	Leading AI art generation tool known for its distinctive artistic style.	C	L	M	R	Discord Bot	Discord, Web Browsers	Subscription	1 - 3
	NightCafè	https://creator.nightcafe.studio/	Platform offering various AI art generation methods and community features.	C	Y	M	R	W-B	Web Browsers	Subscription	1 - 3
	OpenArt	https://openart.ai/	Platform aggregating various AI art models and offering tools for generation and exploration.	C	Y	M	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Poe	https://poe.com/	Platform giving acces to a wide range of models for image generation.	C	N	M	R	W-B, API	Windows, MacOS, iOS, Android	Freemium, Subscription	1 - 3
	PromeAI	https://www.promeai.pro/it	AI-powered design and retouching tools for visualization.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Rendair	https://www.rendair.ai/	AI-powered platform for generating realistic visualizations.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 3
	Replicate	https://replicate.com/collections/text-to-image	Platform for running and deploying various AI models, including image generation.	O	Y	M	R/L	API	Web Browsers	Pay-per-use	1 - 3
	ReRender	https://rerenderai.com/	AI-powered platform for generating visualizations.	C	N	M	R	W-B	Web Browsers	Freemium, Subscription	1 - 3
	Spacely AI	https://www.spacely.ai/	AI-powered platform for interior design and space planning, including visualization.	C	N	M	R	W-B	Web Browsers	Subscription	1 - 2 - 3
	Veras	https://www.evolvelab.io/veras	AI-powered plugin for Revit and SketchUp for generating conceptual design options.	C	N	M	L	Plugin	Revit, SketchUp	Subscription	1
Advanced	Automatic1111	https://github.com/automatic1111	Popular web UI for Diffusion Models, offering extensive customization and control.	O	Y	S	R/L	W-B	Web Browsers	Free	1 - 2 - 3
	ComfyUI	https://github.com/comfyanonymous/ComfyUI	Node-based interface for AI-based workflows, offering highly flexible and complex customization.	O	Y	S	R/L	W-B	Web Browsers	Free	1 - 2 - 3
	Fooocus	https://github.com/lllyasviel/Fooocus	Streamlined and user-friendly interface for Diffusion Models, focusing on ease of use and quality.	O	Y	M	R/L	W-B	Web Browsers	Free	1 - 3
	Forge	https://github.com/lllyasviel/stable-diffusion-webui-forge	Optimized and community-focused distribution of Diffusion Models.	O	Y	S	R/L	W-B	Web Browsers	Free	1 - 2 - 3
	Invoke	https://github.com/invoke-ai/InvokeAI	Unified creative platform for AI image generation, offering various models and tools.	O	Y	S	R/L	Software	Web Browsers	Free	1 - 2 - 3

Category: AI Image Generator

Subcategory	Application Name	Web Resource	Key aspects	Open/Closed	Fine-tuning	Learning Curve	Where It Computes	User Interface	Compatible environments	Cost/License	Project Phase
Advanced	RunDiffusion	https://rundiffusion.com/	Cloud-based platform providing access to powerful GPUs for running Diffusion Models.	C	Y	M	R	W-B	Web Browsers	Pay-per-use	I - 2 - 3
	TensorOpera AI	https://tensoropera.ai/	All-in-one foundations to build own generative AI applications.	O	Y	S	R	W-B	Web Browsers, API	Freemium, Subscription	I - 2 - 3
	Together.ai	https://www.together.ai/	Platform for train, fine-tune-and run inference on AI models.	O	Y	S	R	W-B	Web Browsers	Freemium, Subscription	I - 3

architectural design, characterized by the diffusion of applications developed for a heterogeneous audience not necessarily possessing advanced digital skills. The reduction in the learning curve renders such tools accessible to a broader user base, facilitating adoption. Furthermore, the prevalence of services processing calculations remotely highlights a market trend towards further democratization of access to these technologies, not only in terms of user interface but also concerning the hardware requirements necessary for utilization. Finally, analyzing the design phase in which applying these tools is most agile reveals a prevalent concentration in the initial phases. This imbalance could be attributed to the greater ease of use of tools with consolidated pipelines for input data analysis, typical of preliminary phases, and the increasing demand for tools supporting design idea generation and visual exploration in the conceptual phase.

Figure 2 presents three heat maps comparing image generation tools with four key parameters: fine-tuning capability, accessibility (open/closed), learning curve, and computation location (local/remote). The fine-tuning parameter assumes particular relevance within the context of architectural design. A frequently raised critique regarding these tools concerns the potential homogenization of generated design solutions, often deemed devoid of specific contextual references and potentially eroding the stylistic identity of individual designers. However, through fine-tuning operations, it is hypothesized that each architect can preserve and personalize their design language, adapting AI tools to their distinctive style [Kim *et al.* 2023]. The analysis of heatmaps specific to image generators reveals that only a minority offer this level of customization. It is also significant to note that a minority of tools are classified as 'Steep' about fine-tuning, suggesting that customization options, when available, are quite accessible and do not always necessitate particularly advanced skills.

Analogously, figure 3 presents heatmaps comparing generic AI assistants based on the same four parameters considered previously. In this instance, a slightly more balanced distribution is observed among tools enabling fine-tuning operations between Open and Closed applications. Furthermore, a single tool classified as 'Steep' is noted by potentially more consolidated and task-specific operational pipelines. Another significant similarity to image generators lies in the computation location: for generic AI assistants, most processing occurs remotely.

Regarding 3D model generators for architectural design in the project phase, illustrated in figure 4, it is notably complex to identify tools enabling output customization. Furthermore, the category exhibits a marked prevalence of Closed applications compared to Open ones. Analogous to image generators, most 3D modelers execute calculations remotely, presenting user interfaces that are relatively simple and accessible, suited to a user base possessing foundational skills in the field of architectural design.

Criticalities and opportunities in architectural educational applications

It is reiterated that this collection provides a limited perspective on the panorama being mapped. The sector's dynamism is evidenced by the recent introduction of models such as *DeepSeek R1*, the stable release of *Gemini 2.0* by *Alphabet*, the release of *Mistral* AI's mobile application, and the release of Grok 3 developed by XAI. After the table's compilation (January

Category: Shape generation

Subcategory	Application Name	Web Resource	Key aspects	Open/Closed	Fine-tuning	Learning Curve	Where It Computes	User Interface	Compatible environments	Cost/License	Project Phase
2D	A-space	https://www.a-space.ai/	AI-based platform for interior design and furnishing.	C	N	M	R	W-B	CAD Softwares	Free (Beta)	1 - 2
	Graph2Plan	https://github.com/HanHan55/Graph2plan	Tool for generating floor plans from graphs.	O	Y	M	L	Software	None	Free	2
	Magnetizing Floor Plan Generator	https://www.food4rhino.com/en/app/magnetizing-floor-plan-generator	Application for the generation of 2D layouts of public buildings	C	N	M	L	Plug-in	Grasshopper	Free	2
	Marmot	https://github.com/yannickmacken/marmot	It is a plug-in for Grasshopper which allows the user to create and deconstruct graphs representing rooms, connections and areas, and can generate a plan layout from a graph.	O	N	M	L	Plug-in	Grasshopper	Free	2
	Planfinder	https://www.planfinder.xyz/	It is a software plugin for Rhino and Grasshopper and is designed to accelerate the design of floor plans of apartments.	C	N	M	R	Plug-in	CAD and BIM Softwares	Subscription	2
	Swapp	https://www.swapp.ai/	AI platform for drafting executive project drawings from models.	C	N	M	R	W-B	BIM Softwares	Contact for pricing (Demo available)	3
	Vitruvius	https://iconbuild.com/vitruvius	Chatbot interface for defining 2D floor plans and conceptual photorealistic interior views	C	N	E	R	W-B	None	Free (Beta)	1
3D	Architechtures	https://architechtures.com/en	Generate optimal building designs in real time. Architechtures is an AI-Powered building design web tool for the residential sector to help you improve decision-making and reduce design time from days to minutes.	C	N	M	R	W-B	CAD and BIM Softwares	Subscription	1 - 2
	ArkDesign.AI	https://arkdesign.ai/#home	AI-Powered Design & Feasibility Studies for Multi-Family & Mixed-Use Projects	C	N	M	R	W-B	CAD and BIM Softwares	Subscription	1 - 2
	CADwithAI	https://www.cadwithai.com/	Chatbot interface for creating 3D models.	C	N	E	R	W-B	CAD Softwares	Pay-per-use	1 - 2
	Finch3D	https://www.finch3d.com/	Cloud-based generative design tool for architecture.	C	Y	M	R	Plug-in	CAD and BIM Softwares	Subscription	1 - 2 - 3
	Forma	https://www.autodesk.com/products/forma/overview?term=1-YEAR&tab=subscription	Cloud platform for conceptual planning and design.	C	N	M	R	W-B	CAD and BIM Softwares	Free (Beta)	1
	Hypar	https://hypar.io/	Cloud-based collaborative platform for office environment design	C	N	M	R	W-B	CAD Softwares	Free (Beta)	1 - 2
	Hektar	https://www.parametric.se/	Advanced generator of housing solutions based on inputs related to area, context, building typology	C	Y	M	R	W-B	CAD Softwares	Subscription	1 - 2
	Plooto	https://iamplooto.com/plooto-app-hidden.html	Housing solution generator based on inputs related to area and building typology	C	N	M	R	W-B	None	Free (Beta)	1
	Skema	https://www.skema.ai/	A BIM Knowledge Reuse Engine that combines the power of AI and full Revit Integration to generate up to LOD 350 BIM models in minutes not weeks by directly leveraging the work from your previous BIM projects.	C	Y	M	R	W-B	CAD and BIM Softwares	Subscription	2
	Spacio	https://app.spacio.ai/	The all-in-one tool for designing buildings. Spacio is a cutting-edge building design tool in the browser. Built for architects and engineers.	C	N	M	R	W-B	CAD and BIM Softwares	Subscription	1 - 2
	Testfit	https://www.testfit.io/	Advanced interface to generate housing solutions based on inputs related to area, context, building typology	C	N	M	R	W-B	CAD and BIM Softwares	Contact for pricing (Demo available)	2 - 3

Table 2. Descriptive mapping of Shape Generation tools for architectural design, categorized by subcategory (2D, 3D) and characterized by key aspects, accessibility, learning curve, computational location, user interface, compatible environments, cost/license, and project phase applicability.
Regarding the table, in the 'Open/Closed' column the individual letters mean: C, Closed; O, Open.
In the 'Fine-tuning' column: Y, Yes; N, No.
In the 'Learning Curve' column: E, Easy; M, Medium; S, Steep.
In the 'Where It Computes' column: L, Locally; R, Remote; W-B, Web Based.
In the 'Compatible environments' column: MA, Mobile App.

31, 2025), these significant events highlight the highly complex period the research world is experiencing. Consequently, two key aspects emerge: the urgency to define methodologies for census and mapping of these tools to maintain a constantly updated overview and the necessity to define novel validation and interpretation protocols for algorithmically generated outputs, moving beyond a merely superficial or aesthetic reading and investigating the conceptual and design implications intrinsic to these computational architectures.

Integrating AI-based applications in educational settings presents an initial challenge concerning 'computational thinking' instruction to students lacking specialized training in computer science.

Category: AI assistant

Subcategory	Application Name	Web Resource	Key aspects	Open/Closed	Fine-tuning	Learning Curve	Where It Computes	User Interface	Compatible environments	Cost/License	Project Phase
General purpose	Aria	https://huggingface.co/rhymes-ai/Aria	General-purpose language model, chatbot capabilities.	O	Y	M	R	Chatbot, API	Windows, macOS, Linux	Free	1 - 3
	ChatRTX	https://www.nvidia.com/it-it/ai-on-rtx/chatrtx/	Local LLM chatbot utilizing RTX GPUs.	O	Y	M	R/L	Application	Windows	Free	1 - 3
	Claude	https://claude.ai/	Advanced language model focused on helpful conversations.	C	Y	M	R	Chatbot, API	Web Browsers, API	Freemium	1 - 3
	CoPilot	https://copilot.microsoft.com/	AI companion providing assistance across various tasks and applications.	C	Y	E	R	Chatbot	Web Browsers	Freemium	1 - 3
	Falcon	https://huggingface.co/tiiuae	Open-source large language model for research and development.	O	Y	M	R/L	API	Windows	Free	1 - 3
	Gemini	https://gemini.google.com/app?hl=it	Multimodal AI model for text, code, images, audio, and video understanding.	C	Y	M	R	Chatbot, API	Web Browsers, API	Freemium	1 - 3
	GPT	https://chatgpt.com/	Powerful language model for conversations, content generation, and more.	C	Y	M	R	Chatbot, API	Web Browsers, API	Freemium	1 - 3
	Groq	https://groq.com/	High-performance language model with a focus on speed, based on Meta's models.	C	Y	M	R	Chatbot, API	Web Browsers, API	Free	1 - 3
	Llama	https://www.llama.com/	Open and accessible large language model by Meta.	O	Y	M	R/L	Chatbot, API	Web Browsers, API	Free	1 - 3
	Mistral	https://chat.mistral.ai/	Open, efficient, and high-performing language models.	O	Y	M	R/L	Chatbot	Web Browsers	Free	1 - 3
	OpenRouter	https://openrouter.ai/	Platform providing access to various language models through a unified API.	C	N	M	R	Chatbot, API	Web Browsers, API	Pay-per-use	1 - 3
	Perplexity	https://www.perplexity.ai/	AI-powered search engine providing answers with source citations.	C	Y	E	R	Chatbot, API	Web Browsers, API	Freemium	1 - 3
Specific purpose	Aino.World	https://aino.world/	AI for spatial data analysis that transforms data questions into interactive maps, charts, and graphs.	C	N	E	R	W-B	CAD Softwares	Subscription	1
	Archie	https://www.archiecodes.com/	Tool to query a 3D model via chatbot	C	N	E	R	W-B	CAD and BIM Softwares	Subscription	3
	Archilogic	https://www.archilogic.com/	Spatial intelligence platform that gives the power to make informed decisions, and optimize the space	C	N	E	R	W-B	Web Browsers, API, CAD Softwares	Pay-per-use, Subscription	3
	Crow - Artificial Neural Networks	https://www.food4rhino.com/en/app/crow-artificial-neural-networks	This component offers two different kinds of operation:- Supervised Learning through Backpropagation Networks; Unsupervised Learning through Self-Organizing Maps.	C	Y	S	L	Plug-in	Grasshopper	Free	2
	Dodo	https://www.food4rhino.com/en/app/dodo	It is a collection of tools for machine learning, optimization, and geometry manipulation.	C	N	M	L	Plug-in	Grasshopper	Free	2
	Giraffe	https://www.giraffe.build/post/urban-ai	AI-powered urban planning platform.	C	N	M	R	W-B	CAD Softwares	Freemium	1
	LunchBoxML	https://provingground.io/2017/08/07/machine-learning-with-lunchboxml/	It is a plug-in for Grasshopper for exploring mathematical shapes, paneling, structures, and data management. LunchBox also includes a set of machine learning components	O	Y	M	L	Plug-in	Grasshopper, Dynamo	Free	2
	Octopus	https://www.food4rhino.com/en/app/octopus	It allows the search for many goals at once, producing a range of optimized trade-off solutions between the extremes of each goal.	C	N	M	L	Plug-in	Grasshopper	Free	2
	Opossum	https://opossum-optimizer.com/	It uses the best-performing optimization algorithms to enhance your projects in Grasshopper for Rhinoceros	C	N	M	L	Plug-in	CAD Softwares	Free	2
	Tunny	https://tunny-docs.deno.dev/	It is Grasshopper's optimization component using Optuna, an open source hyperparameter auto-optimization framework.	C	N	M	L	Plug-in	CAD Softwares	Free	2
	Wallacei	https://www.wallacei.com/	Rhino Plug-in for generating & optimizing design options	C	N	M	L	Plug-in	CAD Softwares	Free	2

Table 3. Descriptive mapping of AI Assistant tools for architectural design, categorized by subcategory (General Purpose, Specific Purpose) and characterized by key aspects, accessibility, learning curve, computational location, user interface, compatible environments, cost/license, and project phase applicability.
Regarding the table, in the 'Open/Closed' column the individual letters mean: C, Closed; O, Open.
In the 'Fine-tuning' column: Y, Yes; N, No.
In the 'Learning Curve' column: E, Easy; M, Medium; S, Steep.
In the 'Where It Computes' column: L, Locally; R, Remote; W-B, Web Based.
In the 'Compatible environments' column: MA, Mobile App.

Fortunately, the market is cognizant of this complexity and offers various user-friendly applications. Beyond this initial phase, the criticality related to application learning emerges as these applications rapidly reveal their limitations after an initial phase of student appreciation. These limitations manifest through imprecise or misaligned outputs, a circumscribed personalization margin, highly standardized processes, and limited compatibility with tools conventionally

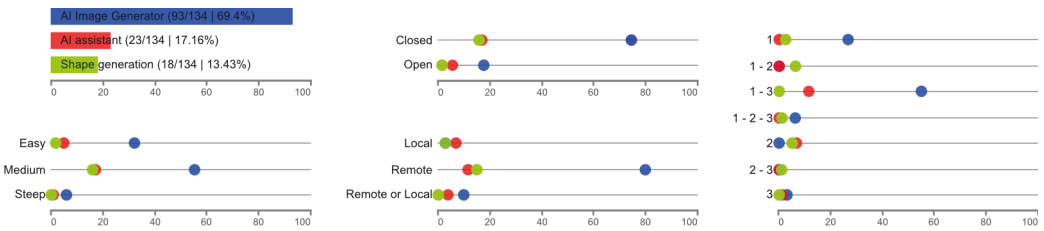


Fig. 1. Quantitative distribution of AI tools across functional categories and key parameters. Histograms show the prevalence of AI Image Generators and tools with medium learning curves, remote computation, and applicability in early design phases.

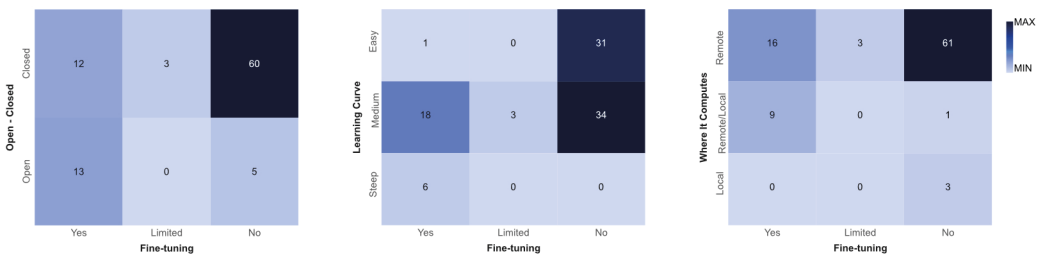


Fig. 2. Heatmaps comparing AI Image Generator tools based on (left) Open/Closed accessibility and Fine-tuning capability; (center) Learning Curve and Fine-tuning capability; (right) Compute Location and Fine-tuning capability. Heatmaps highlight the limited availability of fine-tuning options across different accessibility and complexity levels.

employed in the design process. However, as evidenced by recent studies [Paananen *et al.* 2023], despite these limitations, the guided use of image-generation tools can enrich the educational experience, stimulating creativity and facilitating the exploration of novel design methodologies. Semantic AI models for guiding ideation in architectural design courses have been proposed and evaluated [Vermisso 2022], suggesting specific pedagogical approaches to integrate AI into the early phases of the design learning process. Consistent with this evidence, further research investigates the use of AI diffusion as a design vocabulary in the initial phases of architectural design and education [Bank Stigsen *et al.* 2023; Hanafy 2023], confirming the potential of these tools to enrich the ideation process.

The role of the teaching staff is to guide students toward the most appropriate application, mitigating the risks of an incongruous approach. The informed introduction of this technology within architecture faculties is highly advisable to prepare students for a rapidly transforming professional landscape.

Within this evolving technological panorama, AI joins digital tools already introduced into education, such as VPL and computational design [Lo Turco *et al.* 2024]. Experience gained

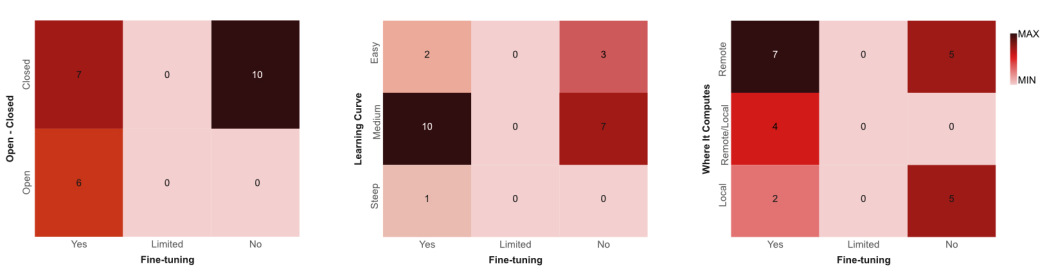


Fig. 3. Heatmaps comparing Generic AI Assistant tools based on (left) Open/Closed accessibility and Fine-tuning capability; (center) Learning Curve and Fine-tuning capability; (right) Compute Location and Fine-tuning capability. Heatmaps indicate a slightly more balanced distribution of fine-tuning options than image generators.

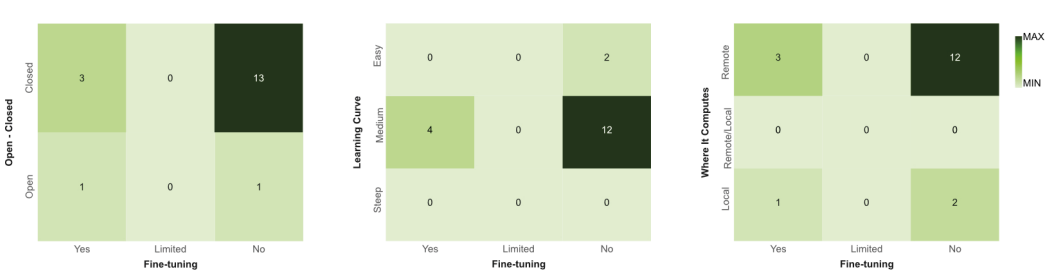


Fig. 4. Heatmaps comparing 3D Model Generator tools based on (left) Open/Closed accessibility and Fine-tuning capability; (center) Learning Curve and Fine-tuning capability; (right) Compute Location and Fine-tuning capability. Heatmaps illustrate the scarcity of fine-tuning options and the prevalence of closed-source 3D model generators.

with these approaches can guide the educational integration of AI [Sebestyen *et al*. 2024], fostering a critical and conscious understanding of the novel technologies.
Despite initial difficulties, employing these tools can significantly expand the student learning experience, offering the opportunity to explore innovative methodologies of representation, simulation, and design analysis. The capacity to rapidly generate images, forms, or design scenarios accelerates both the creative process and the capacity for critical self-evaluation. The continuous activity of reviewing automatically generated solutions promotes the development of a critical sense that can be readily transposed to the analysis of one's project. The necessity for a critical approach to AI is also highlighted by recent research [Kwon, Ahn 2024], which urges a critical reflection on the potential implications of AI in architectural design, including concerns regarding the erosion of design identity.
This process is further enhanced by applying tools dedicated to data analysis. These, when implemented in the preliminary phases of the design process, contribute to developing a deeper understanding of the reference context [Ampanavos and Malkawi 2022], while when applied in later phases, they can guide specific design strategies [Huang *et al*. 2022].

Conclusions

The mapping of AI-based tools for architecture reveals a rapidly evolving panorama, with a growing offering of applications supporting diverse design phases. Quantitative analysis reveals the predominance of image generators, characterized by accessibility and ease of use, indicating democratizing access to these technologies. However, the limited possibility of fine-tuning represents a critical aspect, suggesting a potential trend toward stylistic homogenization of generated outputs.
The educational integration of these tools presents challenges related to computational thinking literacy and the management of applicative limitations. Notwithstanding these challenges, significant opportunities emerge: AI can accelerate the creative process, foster critical self-evaluation, and expand design representation and analysis modalities. Educational efficacy resides in the capacity to guide students towards a conscious and critical utilization, avoiding an uncritical dependence on generated outputs.
Future research should focus on developing dynamic methodologies for census and validation of AI tools. Concurrently, it is necessary to define innovative pedagogical protocols that integrate AI to enhance design thinking rather than as a substitute.
This perspective of GenAI integration with design thinking is supported by studies such as that of Sreenivasan and Suresh [2024], which explore the synergies between design thinking and artificial intelligence, underscoring AI's potential to amplify human creative capacities.
Finally, contributing to an epistemological reflection on the impact of AI on the architectural discipline [Gallo *et al*. 2020; Del Campo *et al*. 2019; Giordano *et al*. 2024] becomes indispensable to delineate future scenarios in which artificial and human intelligence can coexist and collaborate effectively [Mance 2025]. The principal challenge lies in preparing future architects to operate in a professional context profoundly transformed by AI [Jaruga-Rozdolska 2022], preserving the centrality of critical thinking and human creativity.

Acknowledgements

The authors thank prof. Roberta Spallone and prof. Massimiliano Lo Turco for the opportunity to carry out this innovative research on AI. Part of the research will be further developed within a course in next academic year available at Politecnico di Torino.
The authors jointly wrote *Abstract*, *Introduction*, *Criticalities and opportunities in architectural educational applications* and *Conclusions*. The authors jointly developed the tables 1, 2 and 3.
PhD Candidate Enrico Pupi wrote *Definition of considered design phases* and *AI-based tools: identified categories and classification criteria*.
PhD Tomalini wrote *GenAI in the context of architectural representation tools* and *Critical mapping of AI tools in the design process*.

Reference List

Ampanavos, S., Malkawi, A. (2022). Early-Phase Performance-Driven Design Using Generative Models. In D. Gerber, E. Pantazis, B. Bogosian, A. Nahmad, C. Miltiadis (Eds.). *Computer-Aided Architectural Design. Design Imperatives: The Future is Now.* Proceedings of the 19th International Conference, CAAD Futures 2021, Los Angeles, CA, USA, July 16-18, 2021, vol. 1465. Springer: Singapore. https://doi.org/10.1007/978-981-19-1280-1_6 .

Bank Stigsen, M., Moisi, A., Rasoulzadeh, S., Schinegger, K., Rutzinger, S. (2023). AI Diffusion as Design Vocabulary - Investigating the use of AI image generation in early architectural design and education. In W. Dokonal, U. Hirschberg, G. Wurzer (Eds.). *Digital Design Reconsidered.* Proceedings of the 41st Conference on Education and Research in Computer Aided Architectural Design in Europe (eCAADe 2023), Graz, September 20-22, 2023, vol. 2, pp. 587-596. https://doi.org/10.52842/conf.ecaade.2023.2.587 .

Bernhard, M., Smigielska, M., Dillenburger, B. (2021). Augmented Intuition. Encoding Ideas, Matter and Why It Matters. In I. As, P. Basu (Eds.). *The Routledge Companion to Artificial Intelligence in Architecture*, pp. 405-419. London: Routledge. https://doi.org/10.4324/9780367824259-26 .

Bölek, B., Tutal, O., Özbaşaran, H. (2023). A systematic review on artificial intelligence applications in architecture. In *Journal of Design for Resilience in Architecture and Planning*, 4(1), pp. 91-104. https://doi.org/10.47818/DRArch.2023.v4i1085 .

Carpo, M. (2011). *The Alphabet and the Algorithm, Writing Architecture*. Cambridge: The MIT Press.

Carpo, M. (2017). *The second digital turn: Design beyond intelligence*. Cambridge: The MIT Press. https://doi.org/10.2307/j.ctt1w0db6f.

Chaillou, S. (2019). *AI & Architecture | An Experimental Perspective*. Harvard: Harvard University Press.

Chen, J., Wang, D., Shao, Z., Zhang, X., Ruan, M., Li, H., Li, J. (2023). Using Artificial Intelligence to Generate Master-Quality Architectural Designs from Text Descriptions. In *Buildings*, 13(9), 2285. https://doi.org/10.3390/buildings13092285 .

Del Campo, M., Manninger, S., Sanche, M., Wang, L. (2019). The Church of AI - An examination of architecture in a posthuman design ecology. In M. Haeusler, M. A. Schnabel, T. Fukuda (Eds.). *Intelligent & Informed.* Proceedings of the 24th CAADRIA Conference. Atti del 24th CAADRIA Conference, Victoria University of Wellington, Wellington, New Zealand, April 15-18, 2019, vol. 2, pp. 767-772. Wellington, New Zealand. https://doi.org/10.52842/conf.caadria.2019.2.767 .

Gallo, G., Tuzzolino, G. F., Wirz, F. (2020). The role of Artificial intelligence in architectural design: conversation with designer and researchers. In M. Soellner (Ed.). *Conference proceedings of the 7th International Conference on Architecture and Build Environment S.ARCH.* Proceedings of the 7th International S.ARCH Conference, Tokyo, April 7-9, 2020, pp. 1-8. Erlangen: S. Arch.

Giordano, A., Russo, M., Spallone, R. (2024). Preface: Introducing the Relationships Between Digital Representation and AR/AI Advanced Experiences. In A. Giordano, M. Russo, R. Spallone (Eds.). *Advances in Representation. New AI-and XR-Driven Transdisciplinarity,* pp. ix, xvi. Cham: Springer. https://dx.doi.org/10.1007/978-3-031-36155-5 .

Goodfellow, I. J., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A., Bengio, Y. (2014). Generative adversarial nets. In *Proceedings of the 28th International Conference on Neural Information Processing Systems*, vol. 2, Montreal, Canada, pp. 2672-2680. Cambridge: The MIT Press. https://doi.org/10.5555/2969033.2969125 .

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

Huang, C., Zhang, G., Yao, J., Wang, X., Calautit, J. K., Zhao, C., An, N., Peng, X. (2022). Accelerated environmental performance-driven urban design with generative adversarial network. In *Building and Environment*, 224, 109575. https://doi.org/10.1016/j.buildenv.2022.109575 .

Jaruga-Rozdolska, A. (2022). Artificial intelligence as part of future practices in the architect's work: MidJourney generative tool as part of a process of creating an architectural form. In *Architectus*, vol. 3, No. 71, pp. 95-104.

Kim, F. C., Johanes, M., Huang, J. (2023). Text2Form Diffusion: Framework for learning curated architectural vocabulary. In W. Dokonal, U. Hirschberg, G. Wurzer (Eds.). *Digital Design Reconsidered.* Proceedings of the 41st Conference on Education and Research in Computer Aided Architectural Design in Europe (eCAADe 2023), Graz, September 20-22, 2023, vol. 1, pp. 79-88. https://doi.org/10.52842/conf.ecaade.2023.1.079 .

Koehler, D. (2023). More than anything: Advocating for synthetic architectures within large-scale language-image models. In *International Journal of Architectural Computing*, 21(2), pp. 242-255. https://doi.org/10.1177/14780771231170455 .

Kwon, C., Ahn, Y. (2024). Critical views on AI (Artificial Intelligence) in building design. In *International Journal of Sustainable Building Technology and Urban Development*, 15(2), pp. 240-246. https://doi.org/10.22712/susb.20240017 .

Li, C., Zhang, T., Du, X., Zhang, Y., Xie, H. (2024). Generative AI models for different steps in architectural design: A literature review. In *Frontiers of Architectural Research*. https://doi.org/10.1016/j.foar.2024.10.001 .
Lo Turco, M., Tomalini, A., Bono, J. (2024). The teaching of parametric modeling in the School of Architecture at the Politecnico di Torino. In *20 Architecture Experience*. Proceedings of the International Conference of Architecture and Design. Bucarest (ROU), October 30-31, 2023, pp. 72-81. Bucarest: Accademia Adrianea Edizioni.

Mance, D. (2025). Architectural practice in the Digital Age: Balancing Adoption and Adaptation. In M. Barosio, E. Vigliocco, S. Gomes (Eds.). *School of Architecture(s) - New Frontiers of Architectural Education*, pp. 349-361. Cham: Springer. https://doi.org/10.1007/978-3-031-71959-2_38 .

Mancini, M. F., Menconero, S. (2023). AI-aided design? Text-to-image processes for architectural design. In *diségno*, n. 13, pp. 57-70.

Onatayo, D., Onososen, A., Oyediran, A. O., Oyediran, H., Arowoiya, V., Onatayo, E. (2024). Generative AI Applications in Architecture, Engineering, and Construction: Trends, Implications for Practice, Education & Imperatives for Upskilling. In *Architecture*, 4(4), pp. 877-902. https://doi.org/10.3390/architecture4040046 .

Paananen, V., Oppenlaender, J., Visuri, A. (2023). Using text-to-image generation for architectural design ideation. In *International Journal of Architectural Computing*, 22(3), pp. 458-474. https://doi.org/10.1177/14780771231222783 .

Sebestyen, A., Ozdenizci, O., Legenstein, R., Hirschberg, U. (2024). AI-Infused Design - Merging parametric models for architectural design. In O. Kontovourkis, M.C. Phocas, G. Wurzer (Eds.). *Data-Driven Intelligence*. Proceedings of the 42nd Conference on Education and Research in Computer Aided Architectural Design in Europe (eCAADe 2024), Nicosia, September 11-13, 2024, vol. 1, pp. 489-498. https://doi.org/10.52842/conf.ecaade.2024.1.489 .

Spennato, A. (2023). Design e Intelligenza Artificiale: Una nuova frontiera per l'interior design. In *AND*, 44, pp. 98-107. https://and-architettura.it/index.php/and/article/view/639 .

Sreenivasan, A., Suresh, M. (2024). Design thinking and artificial intelligence: A systematic literature review exploring synergies. In *International Journal of Innovation Studies*, 8(3), pp. 297-312. https://doi.org/10.1016/j.ijis.2024.05.001 .

Stojanovski, T., Zhang, H., Frid, E., Chhatre, K., Peters, C., Samuels, I., Lefosse, D. (2021). Rethinking Computer-Aided Architectural Design (CAAD)-From Generative Algorithms and Architectural Intelligence to Environmental Design and Ambient Intelligence. In D. Gerber, E. Pantazis, B. Bogosian, A. Nahmad, C. Miltiadis (Eds.). *Computer-Aided Architectural Design. Design Imperatives: The Future is Now*. Proceedings of the International Conference on Computer-Aided Architectural Design Futures, Singapore, July 2021, pp. 62-83. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-19-1280-1_5 .

Vermisso, E. (2022). Semantic AI models for guiding ideation in architectural design courses. In *Atti dell'International Conference on Innovative Computing and Cloud Computing*. https://computationalcreativity.net/iccc22/papers/ICCC-2022_paper_150.pdf .

Vissers-Similon, E., Dounas, T., De Walsche, J. (2024). Classification of artificial intelligence techniques for early architectural design stages. In *International Journal of Architectural Computing*, 0(0). https://doi.org/10.1177/14780771241260857 .

Authors
Enrico Pupi, Politecnico di Torino, enrico.pupi@polito.it
Andrea Tomalini, Politecnico di Torino, andrea.tomalini@polito.it

To cite this chapter: Enrico Pupi, Andrea Tomalini (2025). AI-Based Tools and Applications: a Descriptive Mapping in the Architectural Design Process Stages. In L. Carlevaris *et al.* (Eds.). *èkphrasis. Descrizioni nello spazio della rappresentazione/èkphrasis. Descriptions in the space of representation.* Proceedings of the 46th International Conference of Representation Disciplines Teachers. Milano: FrancoAngeli, pp. 3197-3210. DOI: 10.3280/oa-1430-c921.

ISBN 9788835182412