An Adoption of AI in Architectural Education through an Analysis of Stable Diffusion Practice-Based Lectures

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This study investigates the pedagogical potential of integrating Stable Diffusion, a generative AI model, into architectural design education. Over two consecutive years, a practical design course incorporating AI-based tools was conducted with undergraduate architecture students. In Course 2023, students explored image generation using Stable Diffusion primarily as a novel visualization tool. In Course 2024, improvements in both the learning environment and curriculum enabled students to engage more creatively and strategically, integrating Stable Diffusion with existing design tools such as Rhino and Photoshop. Comparative analysis of student outcomes and course evaluations indicates that generative AI can enhance creative thinking, design expression, and engagement in the architectural studio. However, the study also highlights the importance of educational strategies in maximizing AI's value as a design partner. The findings suggest that effective implementation of generative AI in architectural education requires not only technological access but also curriculum frameworks that foster exploratory and reflective learning.

Keywords: *AI in Architecture, Stable Diffusion, Architectural Image Generation, Architectural Education*

INTRODUCTION

Research Background & Aim

The field of architectural design has continuously evolved alongside advances in digital technology, and recently, generative artificial intelligence (AI) has begun opening new possibilities in the design process. In particular, image-generating AI models such as Stable Diffusion (SD) have emerged as valuable tools for rapidly visualizing architectural forms and exploring diverse design scenarios (Hong et al., 2024). Carpo (2023) referred to this technological shift as "the second coming of AI," and Altman (2025) noted that the spread of AI is progressing at a pace far exceeding Moore's Law.

Leading architectural firms such as Zaha Hadid Architects and MVRDV have already adopted AI in practice, and platforms like ARCHITEChTURES, PromeAI, and LookX are creating accessible environments where general users can participate in the design process (Leach, 2022). Beyond practice, the integration of AI into architectural education is now gaining research attention. Leach (2022) predicted that AI would not only become an essential collaborator in architectural practice but also a formal component of architectural school curricula.

However, the actual implementation of generative AI in architectural education presents a range of pedagogical challenges beyond the technological capabilities alone. In studio-based courses, multiple factors come into play—including students' learning curves, how creativity is expressed, and how AI connects with existing design thinking. Rather than merely introducing a new support tool, it is crucial to understand and evaluate how such technologies are adopted and established within the educational context.

Therefore, this study analyzes the practical implementation process of generative AI by examining two years of experience operating a design studio using SD. The research focuses on student responses and the effects of pedagogical adjustments, comparing the challenges and limitations identified in the first year with the improvements and instructional interventions introduced in the second. Ultimately, this study aims to offer empirically grounded insights into how generative AI can be effectively integrated into architectural design education and proposes strategic directions for adopting AI as a creative and sustainable design tool in future curricula.

Research Scope & Method

The scope of this study focuses on a studio course conducted with third- to fifth-year students in a five-year architecture program at a national university. A total of 97 students participated—45 in the first year (2023) and 52 in the second year (2024). The version of SD used in the course differed by year: SD Automatic1111 (A1111) via Google Colab in Course 2023, and a locally installed version, SD Forge, in Course 2024.

The research methodology consists of the following steps. First, the study reviews the theoretical background of AI adoption in architecture and prior research on AI integration in architectural education. Second, it compares the overall structure of the course—including the learning environment and instructional content—between the two academic years. Third, it analyzes student outcomes and course evaluations to explore the implications of incorporating AI into architectural education.

THEORETICAL BACKGROUND AND PRE VIOUS STUDIES

Theoretical Background of AI Adoption in Architecture

In architectural design, digital technologies have long served as tools to support and extend human thinking. In 1962, Douglas Engelbart proposed a vision for computer-assisted design in his work Augmenting Human Intellect, presenting a scenario in which digital devices could augment the intellectual work of architects (Engelbart, 1962). Figure 1 visualizes this scenario using an image generated by ChatGPT-4o, depicting an architect interacting with a computer to perform design tasks.

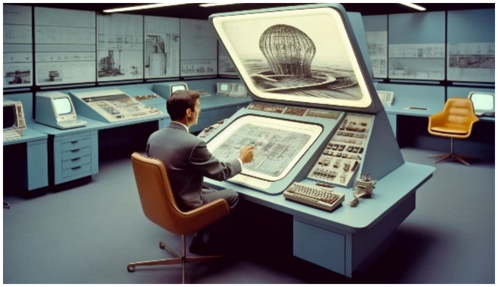


Figure 1 Engelbart's 'Augmented architect at work'.

Later, in 1970, Nicholas Negroponte expanded on this idea in The Architecture Machine, introducing the concept of a design system in which humans and machines interact, learn, and generate designs collaboratively (Negroponte, 1970). This concept laid the theoretical foundation for the human-AI collaborative design systems that have emerged in recent years.

Building on this background, various AI technologies are now being actively used as decision-making tools in architectural practice. A prominent example is Spacemaker, which analyzes site conditions, zoning regulations, sunlight access, and other data to automatically generate residential design proposals. Architects can review and adjust these proposals through an interactive interface. Spacemaker was acquired by Autodesk in 2020 and later became a core technology for AI-based design platforms like Autodesk Forma.

Generative AI is also proving valuable in the early phases of design. Shin (2024) demonstrated how tools like ChatGPT and DALL·E can contribute to generating conceptual ideas, visualizing them, and even assisting in 3D interpretation. Chang & Han (2024) explored the use of prompt-based design techniques to position AI as a potential co-designer in the creative process.

In this way, AI has evolved from a tool for automation to a system that supports creative exploration and design decision-making. This marks a critical turning point in our studio context, where digital technologies had previously been treated primarily as auxiliary tools. As such, discussions on integrating generative AI into the design process—moving beyond CAD- and BIM-centered instruction—have become increasingly necessary.

Review of Previous Studies on AI-Based Architectural Education

Recent studies on the use of generative AI Recent studies on generative AI in architectural education have focused on its potential to support students' creative thinking and its role as a practical tool within the design process.

Kavakoglu et al. (2022) analyzed a studio project using StyleGAN2-ADA for façade design and found that AI had a positive influence on students' creativity. However, they noted the limitation that algorithmic thinking and dataset construction skills must be developed in parallel to maximize AI's effectiveness.

Alymani (2024) highlighted that AI rendering technologies can enhance design expression and encourage intuitive approaches. At the same time, the study warned of potential drawbacks such as limitations to creativity and the risk of stylistic homogenization.

Hong et al. (2024) examined the use of various generative AI tools, including ChatGPT, MidJourney, and PromeAI, in design studios. Their findings showed that while AI supports exploration and visual representation, it falls short in delivering detailed resolution. They concluded that AI is best suited as a supplementary tool in the early stages of conceptualization and idea development.

Lee (2024) implemented an AI-integrated curriculum based on the ADDIE model, using ChatGPT and Bing Image Creator in architectural theory education. The results indicated that AI effectively supported students' conceptual understanding and creative thinking. However, the study also emphasized the need for structured instructional strategies due to challenges in prompt precision and the difficulty of maintaining control over outcomes.

Collectively, these studies suggest that generative AI has strong potential as a tool to foster creative design in architectural education. Nonetheless, concerns remain that overreliance on AI or its use without thoughtful integration may lead to a reduction in creativity or overly standardized thinking. Therefore, effective AI-based architectural education must adopt pedagogical strategies that expand students' creativity while supporting their design thinking processes.

SD-BASED DESIGN COURSE: ENVIRONMENT AND CONTENT

Studio Environment

In Course 2023, due to hardware limitations—specifically a system with a CPU: i7-9700, RAM: 16GB, and GPU: GT 730 1GB—Stable Diffusion could not be run locally. Instead, the WebUI Automatic1111 interface was accessed via Google

Colab Pro. In Course 2024, with upgraded hardware (CPU: i9-13900, RAM: 16GB, GPU: RTX 3060 12GB), Stable Diffusion WebUIForge was run locally using the Stability Matrix setup. In other words, the first year utilized a web-based environment, while the second year operated in a locally installed environment.

Objectives & Structure of the Course

The aim of the studio course in this study was to explore the role and applicability of AI in the architectural design process using SD and ChatGPT. The course was structured to combine theoretical instruction with hands-on practice, providing students with both a foundational understanding of AI technologies and practical experience in applying these tools within real-world design activities (Figure 2).

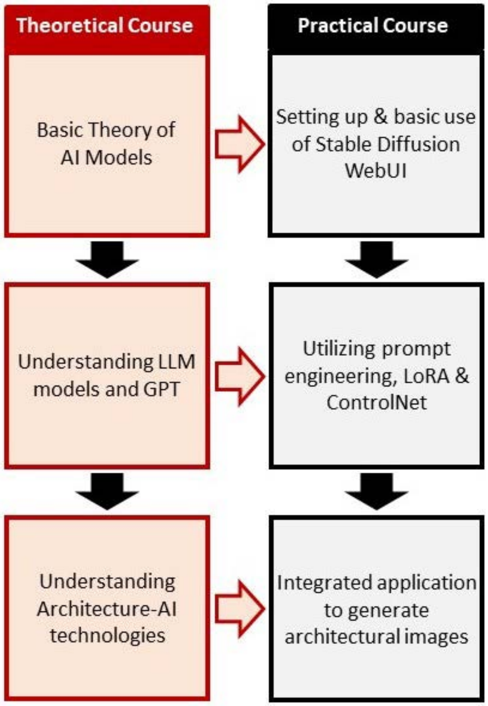


Figure 2
Framework of SD-based architectural design course

In the theoretical portion of the course, students learned about the principles of AI models, including diffusion models, natural language processing (NLP), large language models (LLMs), and the development of GPT, along with case studies on the application of AI in architectural design. The practical component involved step-by-step exercises such as installing SD and using the WebUI, generating images through prompt engineering techniques, refining outputs using LoRA and ControlNet, and conducting post-processing with image editing tools to simulate real-world design applications.

As shown in Table 1, the studio course spanned 15 weeks and included several key differences between Course 2023 and Course 2024. In Course 2024, improvements in the technical environment and the adoption of a more advanced SD model enabled a deeper and more practice-oriented curriculum.

The midterm evaluation (Week 8), which in Course 2023 focused on image generation based on textual prompts, evolved in Course 2024 into a task that required visualizing each student's individual design project. The later weeks of the course (Weeks 12–14) also expanded in the second year to include the integration of traditional design tools and the use of 3D generative AI via Unreal Engine, broadening the application scope of SD. Finally, the final evaluation (Week 15) in the second year was organized as a design competition task centered on a Serpentine Pavilion, emphasizing the practical implementation potential of AI-assisted design.

These year-to-year differences reflect not only the evolution of AI technologies but also the combined impact of increased student engagement and improvements in the studio environment. They suggest that generative AI–based design education can lead to more practical and creatively enriching learning experiences.

Table 1
Comparison of yearly curricula

	Course 2023	Course 2024
Week 1-4	- Introduction to AI, Deep Learning, Diffusion Models, LLMs, and GPT fundamentals - Practice installing and using SD WebUI	- Introduction to AI, Deep Learning, Diffusion Models, LLMs, and GPT fundamentals - Practice installing and using SD WebUI
Week 5-7	- Generating architectural images using SD WebUI - Prompt engineering using ChatGPT	- Generating architectural images using SD WebUI - Prompt engineering using ChatGPT - Basic practice with img2img, LoRA, and ControlNet
Week 8 Mid-term Exam	- Evaluation of architectural image generation based on provided architectural texts and references	- Evaluation of interior and exterior perspective images based on each student's individual design project
Week 9-11	- Application of prompt engineering - Basic use of img2img, LoRA, and ControlNet	- Advanced prompt engineering - Deepened practice using LoRA and ControlNet via ComfyUI
Week 12-14	- Case studies and practical exercises on applying SD to architectural design workflows	- Advanced design process workshop using Stable Diffusion integrated with existing architectural design software, including a 3D generative AI session.
Week 15 Final Exam	- Final evaluation of perspective images based on individual architectural design projects	- Final evaluation through the design and A3 panel production of a Serpentine Pavilion using SD

REFLECTIONS THROUGH STUDENT WORK AND COURSE EVALUATION

Evaluation and Analysis of Student Work

Mid-term Evaluation. The mid-term evaluation was conducted in Week 8 to assess students' ability to generate images using SD and their understanding of prompt engineering. The results are summarized in Table 2.

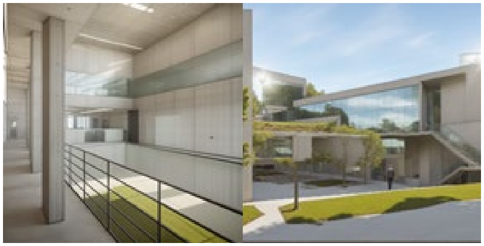
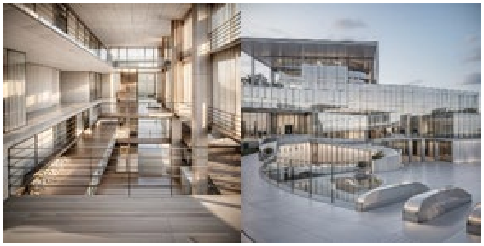
In Course 2023, the midterm task was to generate interior and exterior perspective views of a neighborhood facility to be built on a designated site in Daegu. Students were provided with a textual prompt and reference images. While they utilized SD's basic functions along with img2img and inpaint features, some outcomes showed limitations, including blurred edges, unclear material textures, and a lack of integration with the surrounding environment. Although the generated images conveyed an overall sense of architectural massing and structure, they fell short in representing detailed elements and spatial qualities.

In contrast, Course 2024 expanded the scope for interpretation and creative autonomy by allowing students to generate interior and exterior perspectives based on their individual design projects. In addition to img2img and inpaint, students utilized advanced features such as LoRA and ControlNet to produce images with strong conceptual clarity. The results exhibited clearer material textures, shadowing, natural lighting effects, and improved harmony with the surrounding context, resulting in more effective visual communication of architectural concepts. Notably, some of the outputs achieved a level of quality comparable to professional renderings.

As a result, even under the same evaluation criteria, Course 2024 outcomes showed marked improvement over Course 2023 in terms of image quality, representation of design intent, and the sophisticated use of AI tools.

Final Evaluation. The final evaluation was designed to comprehensively assess students' AI-based design capabilities developed throughout the semester, based on criteria such as alignment with architectural intent, effectiveness of prompt application, and overall visual quality including control over noise and image clarity. As shown in Table 3, Course 2023 task required students to generate perspective images based on their individual architectural design projects. In Course

Table 2
Results of mid-term exam

Course 2023 Mid-term Exam (Week 8)	Course 2024 Mid-term Exam (Week 8)
	
	
	

2024, however, students were tasked with designing a Serpentine Pavilion using SD and presenting the outcome in the form of an A3 design panel.

Course 2023 submissions demonstrated an overall improvement in image quality compared to the midterm, but still revealed limitations in detail expression. While the basic spatial configurations for both interior and exterior scenes were conveyed, fine architectural elements such as railings, lighting fixtures, and ramps often appeared blurred or distorted due to noise. Background figures and landscape elements were frequently awkwardly rendered, and material representations tended to appear flat. The image resolution was moderate, and students' use of SD largely remained at a basic level.

In contrast, Course 2024 outcomes combined SD-generated architectural imagery with traditional editing tools (e.g., Photoshop) to produce high-quality presentation panels. The spatial concepts and design intentions of the pavilion were effectively integrated through images and text. Complex architectural elements—including timber louver structures, organic curvilinear forms, and natural lighting—

Table 3
Resutls of final exam

Course 2023 Final Exam (Week 15)	Course 2024t Final Exam (Week 15)
	
	
	

were rendered with high visual fidelity. Contextual elements such as surrounding environments, people, and vegetation were presented with a realism comparable to professional renderings, and the atmospheric and material qualities were clearly expressed. This demonstrates the potential of AI not only as an image-generation tool, but also as a means of design communication that visualizes and conveys design intent.

In conclusion, the final evaluation clearly confirmed that Course 2024 students' ability to utilize SD and their capacity for visual expression had significantly improved compared to those of Course 2023.

Comprehensive Analysis of Student Outcomes
A comparative analysis of the midterm and final evaluation results from Course 2023 and 2024 revealed not only improvements in image quality but also notable shifts in students' attitudes toward generative AI and their approaches to design. While Course 2023 students primarily focused on adapting to SD as a new image-generation tool, Course 2024 students demonstrated more creative efforts to integrate AI into their design thinking and processes.

This shift cannot be attributed to technical upgrades alone, but also reflects refinements in pedagogy. Course 2024 adopted project-based assessments, structured prompt writing, and integration with conventional tools, leading to deeper engagement. Students in both years generated images through Stable Diffusion using individually constructed prompts without standardized terminology. In Course 2023, the process focused on basic prompt-to-image generation with some use of *inpaint*. Course 2024 students developed iterative workflows using *ControlNet*, *LoRA*, and post-processing with Photoshop and Rhino, forming feedback loops that connected modeling, SD generation, and editing. This helped them perceive AI as an active collaborator rather than a static tool.

Additionally, Course 2024 students became more adept at integrating SD with software such as Rhino, Revit, SketchUp, and Photoshop, resulting in outcomes that were more aligned with professional standards. This demonstrates their growing ability to perceive the design process as a continuous flow, integrating AI as part of a creative experimentation and feedback loop—an indicator of increased educational maturity.

In conclusion, the two-year comparison clearly suggests that the success of AI-based design education cannot be guaranteed by technological infrastructure alone. Rather, its effectiveness is maximized when accompanied by well-structured pedagogy and learner-centered strategies. The integration of AI into architectural education should therefore be discussed not simply as a matter of technical training, but as part of a broader curricular shift toward design thinking and creativity.

Analysis of Course Evaluations and Reflections on AI Integration in Architectural Education

Course Evaluation Analysis. Course evaluations were conducted with a total of 97 students—45 from Course 2023 and 52 from Course 2024—and were analyzed by categorizing responses into positive feedback and areas for improvement.

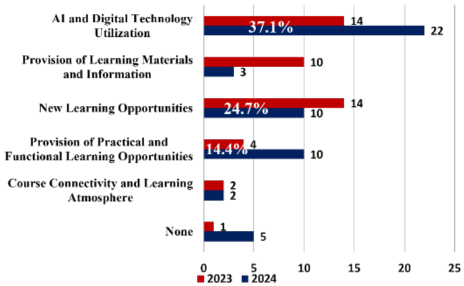
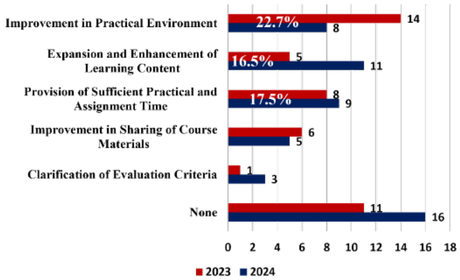


Figure 3
Positive course evaluation

According to the positive feedback categories shown in Figure 3, the highest proportion was attributed to "Utilization of AI and digital technologies" (37.1%), followed by "Provision of new learning opportunities" (24.7%) and "Practical and functional design content" (14.4%). These results indicate that students perceived SD not merely as an image generation tool, but as a meaningful resource applicable to real architectural design processes. Furthermore, they suggest that AI technologies provided students with opportunities to engage in design thinking experiences distinct from those offered in conventional architectural education.

Figure 4
Suggestion for improvement



In contrast, the improvement areas shown in Figure 4 reveal a high percentage of responses calling for "Enhanced studio environments" (22.7%), "Expanded training in diverse AI technologies" (17.5%), and "Extended hands-on studio time" (16.5%). These results suggest that while students demonstrate strong interest in the educational use of AI technologies, they also express a clear demand for more structured and diverse learning environments.

Taken together, the positive feedback and requests for improvement indicate that AI technologies in architectural education should move beyond being framed merely as "supportive tools" or as part of technical training. Instead, they must be implemented alongside learner-centered experience design and real-world design applicability.

Reflections on AI Integration in Architectural Education. A comprehensive analysis of student outcomes and course evaluations suggests that the effectiveness of AI implementation cannot be attributed solely to technical advancements. While improvements such as the transition from SD 1.5 to SDXL and upgraded PC hardware contributed to better performance, more critical were changes in instructional design and shifts in student engagement.

Course 2024 students made more sophisticated use of advanced AI tools such as LoRA, ControlNet, and ComfyUI, and were better able to integrate these with existing architectural software like Rhino, Revit, SketchUp, and Photoshop. As a result, they produced outcomes that closely resembled professional design workflows. This shift reflects not just improved technical proficiency, but a deeper internalization of AI as a creative design tool within students' thinking processes.

Leach (2022), referring to the early adoption of CAD, noted that once a new technology becomes widespread, it transitions from being perceived as "innovative" to being seen as a "standard tool." A similar shift appears to be occurring with AI in architectural education, as students increasingly view it not as a "specialized" technology but as an integrated part of the design process.

In conclusion, this study suggests that the successful integration of AI in architectural education relies not only on technological infrastructure but also on the reconfiguration of pedagogical strategies and learner-centered approaches. Moving forward, the development of AI-based curricula, interdisciplinary design studios, and diversified evaluation methods will be essential for building a sustainable educational framework for AI in design education.

CONCLUSION

This study analyzed how generative AI technologies, particularly SD, can be integrated and developed within architectural design education through a two-year case study of a studio course. By comparing student outcomes and course evaluations, the findings indicate that not only improvements in technological infrastructure but also strategic adjustments in pedagogy significantly contributed to enhancing students' design capabilities.

Course 2024 students moved beyond viewing SD as a mere image generation tool, instead utilizing it as a creative design support system. By applying advanced AI functions in combination with traditional design software, they were able to produce results approaching professional-level outputs. These outcomes demonstrate that changes in instructional design—such as project-based evaluations, guided prompt writing, and software-integrated exercises—effectively increased student engagement with AI technologies.

While this study is limited by its focus on a single model (SD), it provides empirical evidence that AI can serve as a practical and creative tool in architectural education. Future research should involve comparative studies across multiple AI models and long-term assessments of educational effectiveness, in order to explore the broader potential of establishing AI-based curricula in architectural design education.

ACKNOWLEDGEMENT

This work is supported in 2025 by the Korea Agency for Infrastructure Technology Advancement (KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant RS-2021-KA163269).

REFERENCE

Altman, S. (2025, February 10). *Three observations.* Sam Altman's Blog. https://blog.samaltman.com/three-observations

Alymani, A. A. (2024). Integrating artificial intelligence rendering tools in design: Integrating AI as teaching methods in architectural education. in *Proceedings of the 42nd Conference on Education and Research in Computer Aided Architectural Design in Europe (eCAADe)* [Volume 2], 629-638.

Carpo, M. (2023). *Beyond digital: Design and Automation at the End of Modernity.* MIT Press.

Chang, Z. Y., and Han, J. W. (2024). `Exploring the Impact of AI-based Prompt Design Method on Architectural Design Process and Designers' Role. *Journal of the Architectural Institute of Korea,* 40(5), 41-52.

Engelbart, D. C. (1962). *Augmenting human intellect: A conceptual framework (Summary Report AFOSR*-3223). Stanford Research Institute.

Hong, S. K., Park, C. K., Lee, K. H., and An, E. H. (2024). 'A Case Study on Architectural Design Education for Lower-year University Students Using Generative AI'. *Journal of the Korean Institute of Interior Design*, 33(5), 57–74.

Kavakoglu, A. A., Almaç, B., Eser, B., and Alaçam, S. (2022). 'AI Driven Creativity in Early Design Education: A pedagogical approach in the age of Industry 5.0'. *in Proceedings of the 40th International Conference on Education and Research in Computer Aided Architectural Design in Europe (eCAADe)* [Volume 1], 133-142.

Leach, N. (2022). *Architecture in the Age of Artificial Intelligence: An Introduction to AI for Architects.* Bloomsbury Visual Arts.

Lee, S. (2024). `Innovation and performance analysis of architectural theory education using generative AI'. Journal of the Korean Institute of Interior Design', 33(5), 45-56.

Negroponte, N. (1970). *The Architecture Machine: Toward a More Human Environment.* Cambridge, MA: MIT Press.

Shin, D. (2024). `The role and application of AI: An integrated approach to architectural design using ChatGPT and DALL-E'. *Journal of the Architectural Institute of Korea,* 40(2), 67-76.