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Reframing Architectural Pedagogy Within AI Supported Personalized Learning Experiences

Yapay Zekâ Destekli Kişiselleştirilmiş Öğrenme Deneyimleri Bağlaminda Mimarlik Pedagojisinin Yeniden Çerçevelenmesi

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Abstract

This study examines how artificial intelligence (AI)-supported tools can contribute to personalized learning in architectural education through an integrative literature synthesis. Rather than treating AI as a purely technical layer, the study positions it as a pedagogical actor that reshapes feedback practices, design judgment, authorship, and studio culture. The studio-centered and interdisciplinary nature of architectural education often struggles to address learner diversity through uniform curricula and limited feedback systems. Drawing on recent studies of AI-supported personalization, adaptive learning, design education, and architectural studio pedagogy, the article develops a conceptual framework that links learner needs with pedagogical safeguards. The framework organizes AI-supported practices into four functional clusters: generative AI, analytical-tectonic tools, visualization and presentation tools, and learning-guidance systems.
Keywords: Architectural education, AI in Education, Personalized learning, Student-centered learning, Learning Experience

Öz

Bu çalışma, yapay zekâ (YZ) destekli araçların mimarlık eğitiminde kişiselleştirilmiş öğrenmeyi nasıl destekleyebileceğini entegratif bir literatür sentezi aracılığıyla incelemektedir. Çalışma, YZ'yi yalnızca teknik bir araç olarak değil; geri bildirim süreçlerini, tasarım yargısını, yazarlık anlayışını ve stüdyo kültürünü dönüştüren bir pedagojik aktör olarak ele almaktadır. Mimarlık eğitiminin stüdyo merkezli ve disiplinler arası yapısı, öğrenen çeşitliliğini tek tip müfredat ve sınırlı geri bildirim mekanizmalarıyla her zaman karşılayamamaktadır. Eğitimde YZ destekli kişiselleştirme, adaptif öğrenme, tasarım eğitimi ve mimarlık stüdyosu pedagojisine ilişkin güncel çalışmalar temel alınarak öğrenen ihtiyaçlarını pedagojik güvencelerle ilişkilendiren kavramsal bir çerçeve geliştirilmiştir. Bu çerçeve; üretken yapay zekâ, analitik-tektonik araçlar, görselleştirme ve sunum araçları ile öğrenme rehberliği sistemlerinden oluşan dört işlevsel küme etrafında yapılandırılmıştır.
Anahtar Kelimeler: Mimarlık Eğitimi, Eğitimde Yapay Zeka, Kişiselleştirilmiş Öğrenme, Öğrenci merkezli Öğrenme, Öğrenme Deneyimi

1. INTRODUCTION

Architectural education is a studio-centered learning system that requires problem solving, multidimensional thinking, interdisciplinary association, and creative production under the same pedagogical framework, beyond the mere integration of aesthetic sensitivity and technical knowledge. In heterogeneous student groups that differ in learning pace, prior knowledge, and modes of production, this system often remains insufficient in addressing learner diversity through uniform pedagogy and limited feedback loops. The need for personalized learning, which offers individual pathways for learners, emerges precisely from this tension (Göçen & Aydemir, 2020). The design studio already entails an individualized journey of production; however, timing, space, and assessment practices may not render this journey equally visible for all students. The issue is not simply a question of "which software" should be used; rather, the flexibility of the learning environment and the student-centeredness of pedagogy must be addressed together. The content taught in architectural education is also multidimensional. It includes design knowledge, technical skills, spatial configuration, aesthetic production, and material knowledge, as well as competencies such as emotional intelligence. This diversity increases the need for differentiated feedback and pacing. Systems that provide personalized feedback may enable students to identify and correct errors earlier in the production process. AI-supported systems can also make process traces visible, creating a basis for discussing tool use and decision traces beyond traditional assessment practices that are often compressed into exams and final projects (Bond et al., 2024; Kofinas et al., 2025). Through adaptive systems, it appears possible for students to gain experience by working on their own projects, receive data-informed feedback, and benefit from guiding recommendations (Göçen & Aydemir, 2020; Aly et al., 2025). This potential becomes meaningful when considered together with the digital restructuring of the studio's signature pedagogy. Crowther (2013) discusses the technological enhancement of the design studio, while Montenegro (2024) examines the pedagogical innovation dimension of text-to-image systems in architectural design education, thereby opening a common ground for today's generative and multimodal tools. The evidence base informing this discussion has been steadily growing. Systematic reviews on AI-supported personalization and adaptive learning in education point to the reshaping of feedback, interaction, and adaptive pathways (Farhood et al., 2025; Inuwa et al., 2025). The thematic visibility of AI in educational discourse is also reinforced through machine-assisted mappings (Kaur & Pavlova, 2026). Hariyanto et al. (2025) review the role of techniques such as supervised learning, pattern discovery, and reinforcement-based sequencing in adaptive instructional systems.

Reviews specific to design education place benefits and risks side by side. Song and Abdul Rabu (2025) emphasize gains in efficiency and communication while also pointing to overdependence and ethical concerns; this duality can be directly transferred to the architectural studio. Alshahrani and Mostafa (2025) demonstrate an adoption asymmetry between student enthusiasm and instructor caution, while Ma et al. (2025) frame AI literacy, modular curriculum, and instructor development as institutional prerequisites for generative AI. Consequently, the promise of personalization should not be read solely as algorithmic adaptability; it must also be interpreted through assessment ethics, stakeholder alignment, and institutional policies. Architecture-specific literature sharpens this broader picture through studio culture and design judgment. Karadag (2025) centers human-AI co-creativity, while Karadag and Ozar (2025) examine generative imaging and student perceptions in concept design-oriented studios together with ethical concerns. The systematic review by Alamasi and Asfour (2026), reported in accordance with guidelines for applications of generative AI in architectural design education, maps these applications according to design stages. Gunaydin Donduran, Kasali, and Dogan (2024) address the use of generative tools as pedagogical instruments and discuss co-authorship. A Turkish case on AI-supported learning in speculative spatial design is represented by Lekesiz and Muezzinoglu (2025). Atalay (2025) discusses new learning and design approaches, while Agarwal (2024) examines the pedagogical paradigm shift associated with computational design and generative algorithms. Jian (2023) summarizes the many dimensions of AI in personalized learning, including e-learning, virtual teachers, and ethics. Sharma et al. (2025) investigate AI-embedded workflows in personalized housing scenarios through user profiles and virtual reality, while Mehan et al. (2024) integrate spatial justice and digital production in XR-based making. Recent human-centered learning analytics studies further indicate that personalization quality depends on co-design with instructors and students, interpretability of analytics interfaces, and contextual adaptation during implementation (Alfredo et al., 2024; Alfredo et al., 2025). In parallel, policy-oriented guidance emphasizes that pedagogical innovation with generative AI should be aligned with institutional safeguards for equity, privacy, and accountable assessment design (Miao & Holmes, 2023).

In the architectural studio, artificial intelligence is not merely a technical tool that supports personalized learning. It is a multilayered pedagogical actor that requires the reorganization of feedback, design judgment, authorship, and studio pedagogy. While the existing literature mostly focuses on AI's capacity to accelerate production, facilitate visualization, or support feedback processes, this study proposes a holistic approach that reads these tools together with their transformative effects on design judgment, authorship, critical thinking, and instructor-student relations. Accordingly, the article reorganizes functional descriptions dispersed across the literature under four main clusters and repositions them along the axes of personalized learning, academic integrity, ethical responsibility, and institutional preparedness. In doing so, it develops a conceptual framework for studio practice and offers a practitioner-oriented bridge between the functional language of the literature and contemporary studio practice (Figure 1).

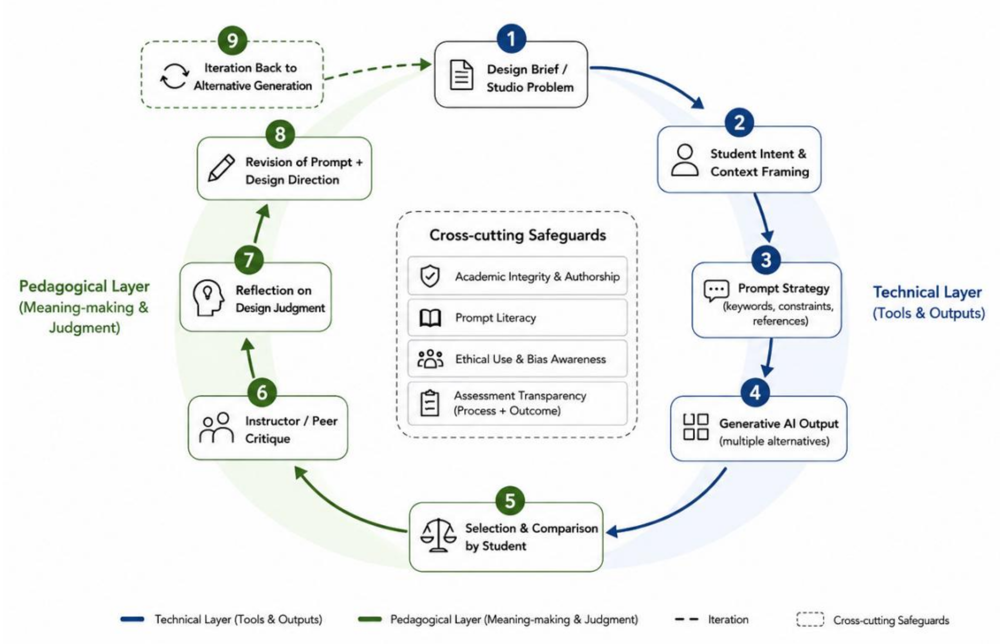

Figure 1: Pedagogical Interaction Loop for Generative AI in Architectural Studio *(Conceptual diagram developed by the author with the assistance of generative AI tools and subsequently edited, interpreted, and validated by the author for academic publication purposes.)*

2. METHOD

This study adopts an integrative and conceptually oriented literature synthesis approach to examine the relationship between AI-supported tools and personalized learning in architectural education. This approach aims to develop a new conceptual framework by bringing together theoretical and practice-oriented debates that have been addressed in dispersed ways across different disciplines. In this respect, the study differs from quantitatively oriented systematic reviews and focuses instead on recurring themes, conceptual convergences, and areas of pedagogical tension in the literature. Its aim is not to measure a specific effect size or produce empirical generalizations, but to develop a theory-building reading that enables the role of AI tools in the architectural studio to be reconsidered. Methodologically, this positioning is consistent with review typologies that distinguish integrative synthesis from full counted systematic reviews and allow the combination of heterogeneous evidence for framework development (Grant & Booth, 2009). The coding and thematic integration stages also follow updated guidance for integrative review rigour, especially in combining conceptual and empirical sources (Whittemore & Knafl, 2005).

The article foregrounds the possibility of thinking individual differences together with an AI-supported learning system oriented toward efficiency and performance. The diversification of AI tools in the studio makes visible the need to consider the discourse of personalized learning together with ethical and institutional safeguards. The synthesis follows AI not merely as a technical layer that provides individualized content, but at the level of pedagogical agency that transforms forms of feedback, the visibility of design judgment, authorship, and assessment systems. The study does not generate primary field data such as student products, surveys, or observations from a single institution. Instead, it is conducted as a documentary synthesis based on secondary sources, and its inferences are gathered into a conceptual mapping that can be adapted to studio-centered architectural pedagogy.

In this text, personalized learning is associated particularly with adaptive or formative feedback, differentiated learning pace, learner modeling, and recommendation or guidance mechanisms that shape learning pathways. Fully automated institutional adaptation or learning analytics-centered interventions are not excluded; however, they are not the primary focus. The main questions guiding the reading and synthesis process are as follows:

1. In the context of architectural and design education, with which personalization mechanisms, such as feedback, pacing, learner modeling, or resource recommendation, are AI tools associated in the literature?

2. How do the functions grouped as generative, analytical, visualization, and guidance functions meaningfully correspond to learners' needs?

3. Which pedagogical principles recur in discussions of ethics, academic integrity, authorship, and institutional preparedness?

4. When these components are read together, what kind of multilayered framework can be proposed for practitioners?

When the sources are read thematically, functional descriptions recur even if they appear under different interdisciplinary labels: variation generation, analytical calculation and optimization, communication and visualization, and learning support and feedback. These recurrences are aligned with tool roles commonly encountered in the studio and reduced to four functional clusters: generative AI, analytical-tectonic tools, visualization and presentation, and learning guidance. The question of "which learning need corresponds to which tool class" is answered not through classroom observation, but through a mapping derived from the functional language of the literature. Academic integrity, authorship, stakeholder alignment, and institutional preparedness are deliberately kept alongside this mapping as pedagogical safeguards. Thus, each functional cluster is inseparably linked to feedback and judgment practices that must be reorganized in the studio. The literature in this study is structured around three analytical axes:

1-debates on artificial intelligence and adaptive learning in higher education;

2-digital tool use and pedagogical transformation in architectural and design studios;

3-AI integration in relation to curriculum, ethics, and institutional preparedness. Source selection was limited to peer-reviewed studies located at the intersection of these axes and relating AI to learning processes. To reflect the current dynamics of the field, publications after 2020 were prioritized, and the rapid integration of generative AI and multimodal systems into educational environments was considered in this prioritization. Access to the literature was designed so as not to be reduced to a single automated query. A Boolean search string combining the learning context, such as architectural education, design education, and design studio; the technical core, such as artificial intelligence and generative AI; and the personalization-adaptation axis, such as personalized learning, adaptive learning, and student-centered learning, is proposed as an operationalization of the logic of the triple intersection. The time window of 2020-2026 was prioritized in order to cover the period in which generative and multimodal tools rapidly entered studio discourse. Earlier theoretical texts were used only sparingly and with justification to show the longer trajectory of studio pedagogy. The core evidence base consists mainly of peer-reviewed journal articles and institutional conference papers. A key eligibility expectation was that the sources address AI together with personalized feedback, pacing, or support in the instructional process, or propose an AI placement that is meaningful for the learning trajectory in design education. Commercial promotional materials, non-peer-reviewed personal publications, and software manuals detached from pedagogical purposes were excluded from the synthesis. In relation to curriculum and institutional preparedness, a similar problematization is reviewed globally by Sapawi and Yusoff (2025). This article does not tabulate a flow diagram showing record, screening, and inclusion counts after a full systematic search. Instead, it conducts a targeted integrative synthesis in line with the criteria above, and transparency is provided through explicit questions, criteria, and thematic codes. If a full search is conducted in a future revision, a counted flow diagram of the search and screening process may be added and compared with the methodologically detailed systematic review conducted by Alamasi and Asfour (2026) on generative AI in architectural design education. Full texts were coded thematically under the following categories: personalization mechanism, tool class, stakeholder adoption, ethics and integrity, institutional infrastructure, and instructor development (Table 1).

Table 1. Summary of the methodological framework

Component	Description
Study type	Integrative-conceptual literature synthesis; documentary synthesis based on secondary sources
Literature axes	(i) AI and adaptive learning in higher education; (ii) digital tools and pedagogical transformation in architectural/design studios; (iii) curriculum, ethics, and institutional AI preparedness
Source selection	Peer-reviewed studies; intersection of the three axes; relation of AI to learning processes
Temporal priority	Post-2020 priority; 2020-2026 in the sample index search; limited and justified use of earlier sources
Indexes	Scopus, Web of Science, ERIC
Functional organization	Four clusters: generative AI; analytical-tectonic tools; visualization-presentation; learning guidance
Thematic codes	Personalization mechanism; tool class; stakeholder adoption; ethics and integrity; institutional infrastructure and instructor development

Figures in this study are generated through a literature-to-diagram translation procedure rather than software screenshot selection. First, recurrent themes are identified in the coded corpus (feedback loop, decision trace, stakeholder interaction, and revision mechanism). Second, these themes are mapped into actor-process relations (student, AI tool, instructor, and critique environment). Third, the resulting diagrams are validated against the article's main claim that AI functions as a pedagogical actor in studio learning. This procedure is intended to ensure conceptual alignment between visual material and argument structure. The proposed organization does not claim to be an empirical taxonomy based on student outputs collected from a single institution. The four clusters are concretized through the following reading steps (Table 2).

Table 2. Derivation process of the functional clusters of AI tools

Step	Level of Analysis	Description	Conceptual Output	Example Tools / References
1	Function-based inquiry	Sources are read through the question "what does the tool do?": variation generation, performance analysis, visualization, learning support	Basic functional categories emerge	Production, analysis, presentation, guidance
2	Literature mapping	Functional distinctions emphasized in different studies are read together: generative versus analytical tools, adaptive feedback, guidance, and personalization	Recurrent functional clusters in the literature are identified	Interdisciplinary conceptual overlap
3	Cluster stabilization	The resulting functions are stabilized under four main clusters	Four functional clusters: generative AI; analytical-tectonic tools; visualization; learning guidance	Conceptual model formation
4	Studio correspondence	Each cluster is associated with concrete tools in the architectural studio context	Tools are read through their pedagogical functions	Midjourney / DALL-E as generative; ETABS / Ladybug as analytical; Lumion / Enscape as visualization; LLM-based systems as guidance
5	Conceptual chain	The question "where does the category come from?" is answered	Derivation chain: literature functions -> cluster label -> studio practice	Methodological basis of the model

3. AI-SUPPORTED TOOLS IN ARCHITECTURAL EDUCATION

The four functional clusters proposed in this study are not treated merely as a classification of technological tools. Rather, they constitute a pedagogical reading for understanding how learning processes are reorganized in the architectural studio. In this context, AI-supported tools are conceptualized as a system that transforms the studio learning experience through four main axes.

First, generative AI tools function as mechanisms of possibility generation that expand students' design horizons by multiplying alternatives in the early stages of the design process. These tools encourage thinking through multiple scenarios rather than reducing the design problem to a single solution.

Second, analytical and tectonic tools move the design process toward evidence-informed decision making by enabling design decisions to be evaluated through performance, data, and environmental conditions. This does not eliminate intuitive design thinking; instead, it relates intuition to measurable data and generates a hybrid mode of thinking.

Third, visualization and presentation tools transform modes of representation and create a communication and representation infrastructure that strengthens students' capacity to express, narrate, and open their ideas to discussion. These tools contribute to making studio critique culture more accessible and multilayered.

Finally, learning and guidance systems function as formative learning support by offering feedback mechanisms adapted to individual learning pace and enabling students to structure their own learning process. These systems do not eliminate the role of the instructor; rather, they operate as a complementary layer that diversifies and sustains feedback processes. When these four axes are considered together, AI tools appear in architectural education not merely as technologies that accelerate production processes, but as a holistic pedagogical system that reshapes learning modes, design judgment, and studio interactions. The following subsections elaborate this framework through concrete tool examples under the headings of generative AI, analytical-tectonic tools, visualization and presentation, and learning guidance. The examples should not be read simply as a list of software. They should be interpreted through traces of pedagogical agency, including feedback speed, where and how design judgment is produced, the boundaries of authorship and citation, and jury-rubric organization. This organization remains consistent with the functional distinctions found in Song and Abdul Rabu (2025), Montenegro (2024), Aly et al. (2025), and Hariyanto et al. (2025). The effect of generative tools on the early phases of design thinking in higher education design studios can be cross-read with Oh (2024); discussions of human-AI relations, collaboration, and assessment in the studio with Park (2025); and the framework of human-AI collaboration across the stages of the architectural design process with Alana et al. (2026).

Artificial intelligence models selected aspects of human intelligence through programs that imitate cognitive functions such as learning, problem solving, reasoning, and decision making (McCarthy et al., 1955; Turing, 1950). Machine learning and deep learning strengthen the capacity for personalization and monitoring by making inferences from patterns in large datasets (Montenegro, 2024).

3.1. Generative Artificial Intelligence Tools

Generative AI tools are systems capable of producing new content in response to input. In architectural education, they accelerate the production of alternatives in the early stages of design. Midjourney, DALL-E, and Adobe Firefly transform textual prompts into visual scenarios, while vision-capable ChatGPT supports idea and narrative generation in multimodal concept development (Gunaydin Donduran et al., 2024). In conceptual architecture, the language layers and prompt logic of text-to-image generative chains are detailed within a design-research framework by Horvath and Pouliou (2024). Bakir and Alsaadani (2022) discuss the role of generative tools in supporting creative strategies in the studio environment. Figure 2 presents this mechanism as a conceptual process diagram rather than a software showcase. The model frames generative AI as part of a recursive studio loop: design brief interpretation, prompt construction, alternative generation, critique, and reflective revision. In this framing, the pedagogical value does not derive from image novelty alone, but from how students externalize and revise design judgment through iterative comparison.

Figure 2: AI-Supported ideation in architectural studio: from open prompt to multiple AI-generated alternatives, critique and sythesis for design development (a) Midjourney (URL-1), (b) Dall-E(URL-2), (c) ChatGPT (URL-3)

3.2. Analytical and Tectonic AI Tools

Structural and environmental analysis is an integral part of architectural education. ANSYS and ETABS provide simulations of load distribution and structural behavior. The Ladybug plugin supports the analysis of climate data, solar exposure, and energy performance. Rhino-Grasshopper and Galapagos combine parametric form generation with performance optimization (Başarır, 2022). AI-supported platforms such as ANSYS (Figure 3.a), ETABS (Figure 3.b), and Ladybug (Figure 3.c) provide students with the ability to evaluate design proposals through simulations that integrate structural behavior, environmental factors, and HVAC systems. These capabilities enrich students' design narratives with data-informed insights, bridging the gap between form-making and performance evaluation. Beyond technical validation, analytical outputs actively mediate students' critical and aesthetic decision making. When students compare alternative schemes through structural, environmental, and energy metrics, they are required to articulate why one option is preferable, what trade-offs are accepted, and how performance constraints reshape formal intent. In this sense, simulation becomes a pedagogical device for argumentation: students move from "producing a form" to "defending a design decision" with explicit evidence. This process also deepens aesthetic judgment, because visual and spatial preferences are tested against measurable consequences and then reinterpreted through iterative redesign.

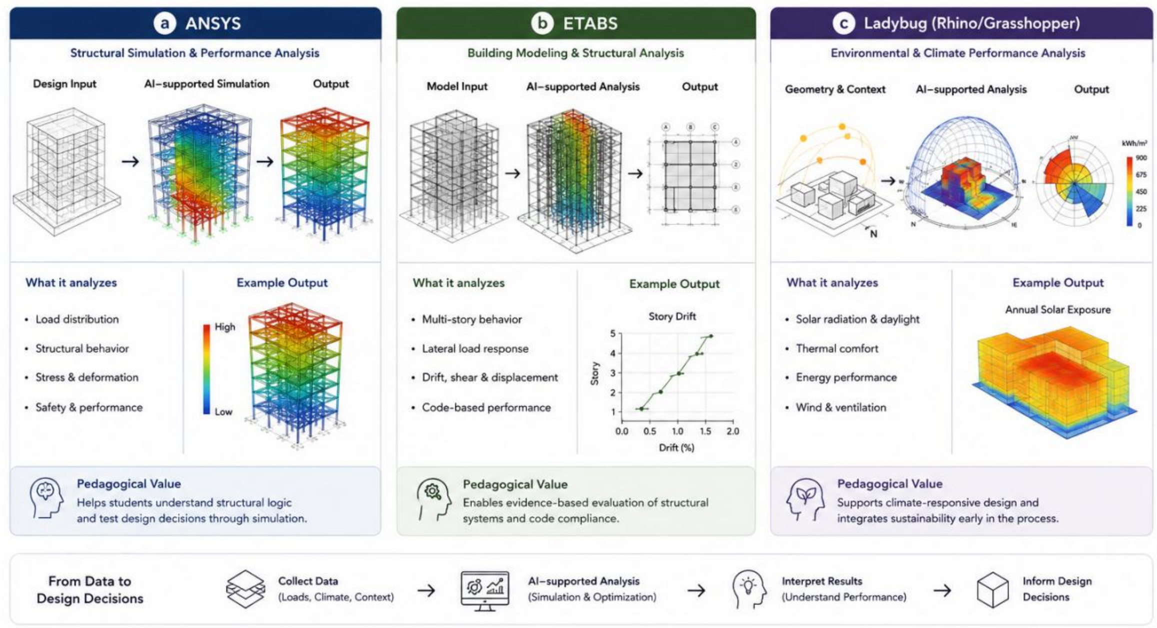

Figure 3: AI supported tools for data and environment analysis: structural simulation with (a) ANSYS (URL-4), building analysis with (b) ETABS (URL-5), and environmental performance analysis with (c) Ladybug (URL-6). These tools enable data-information and support evidence-based decisions in architectural education.

3.3. Visualization and Presentation Tools

Visual presentation skills are essential for effectively communicating design concepts in architectural education. AI-supported visualization tools enable students to present their projects with photorealistic quality, dynamic interaction, and expressive clarity.

Lumion, Enscape, Twinmotion: These programs allow students to render architectural projects in real-time with photorealistic visuals. Features such as lighting and shadow analysis, material realism, and immersive spatial experiences enhance the communicative power of the design.

Genera.So, ArchitectGPT: These AI-driven tools generate rapid renderings and animations based on user inputs, offering significant advantages in both time efficiency and output quality during project presentations.

These tools are particularly valuable in design studios, where quick and effective visual output is often required. They help students articulate their ideas more clearly and creatively, enhancing the overall comprehensibility of their projects. By conducting visualization studies, architecture students can better explain their design intentions and reinforce the narrative quality of their projects. Figure 4 is organized as a communication-process map rather than a software gallery. The map demonstrates how representational choices (camera, material, lighting, sequencing) affect critique readability, stakeholder interpretation, and subsequent design revisions. Accordingly, visualization is treated as a pedagogical medium that structures argumentation and feedback quality, not merely as an output-polishing step.

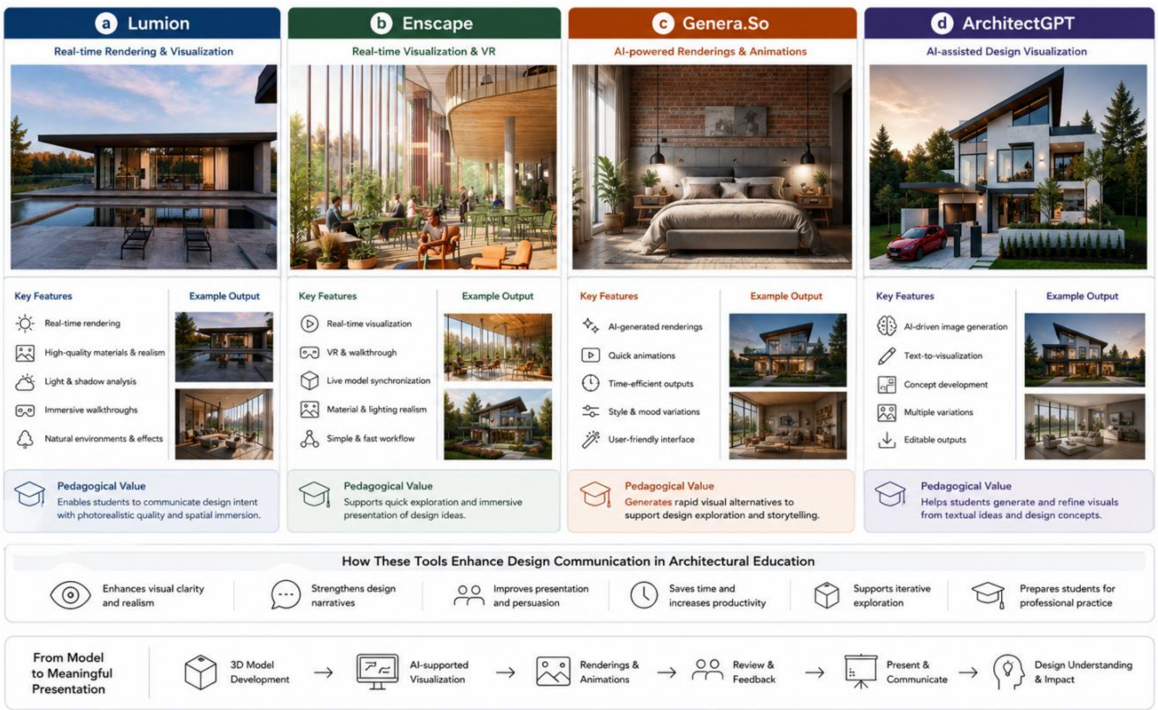

Figure 4: AI-Supported visualization tools in architectural education: (a) Lumion (URL-7), (b) Enscape (URL-8), (c) Genera.So (URL-9), (d) ArchitectGPT (URL-10)

3.4. Educational and Guiding Support Systems

AI-supported chatbots and software assistants facilitate students' comprehension of concepts, support written content production, and provide constructive feedback throughout the individual learning process. These systems not only enhance independent learning but also play a complementary role in teacher-student interaction. ChatGPT, Copilot for Design: These tools assist with concept clarification, language support, and content generation. They are widely utilized for research reports, project summaries, and conceptual descriptions, contributing to the development of students' academic writing skills. Perplexity AI aids in resource discovery by providing access to current, reliable information, fostering informed and evidence-based knowledge production. Such AI systems offer personalized and formative feedback tailored to students' individual learning paces, supporting academic writing and critical thinking (Kerimbayev et al., 2025). In architectural education, where both theoretical and practice-based courses are fundamental, AI tools aligned with course content and appropriate writing standards help build the foundation for academic and sectoral research. The integration of such tools into educational processes prepares students for the expectations of contemporary architectural practice (Tabrizi et al., 2023, p. 648). Applications like Copilot for Design and Turnitin AI Writing offer project-based feedback, helping students detect errors and improve both their designs and academic outputs (Figure 5).

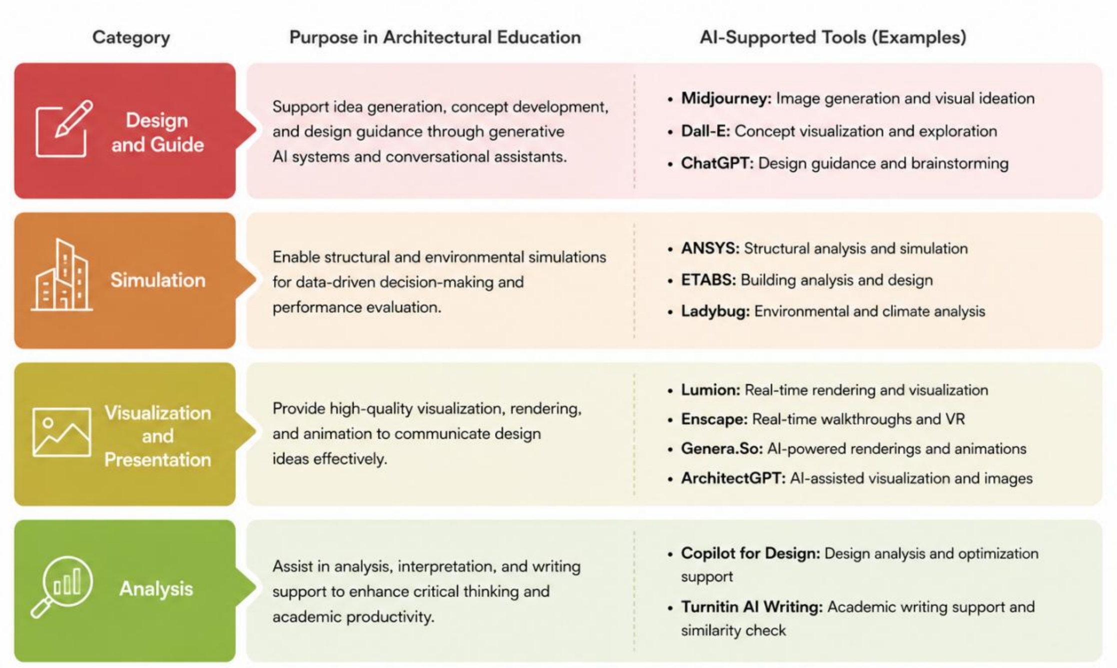

Figure 5: AI-supported tools and their pedagocial function in architectural education (*Conceptual diagram developed by the author with the assistance of generative AI tools and subsequently edited, interpreted, and validated by the author for academic publication purposes.)*

4. SYNTHESIS OF LITERATURE THEMES

Section 4 reorganizes the tool-level functions introduced in Section 3 into pedagogical themes. This thematic synthesis reinforces the thesis of AI as a pedagogical actor, not as a technical solution that simply enables personalization, but as an actor defined through the reorganization of feedback, design judgment, authorship, and studio culture. This section does not claim to present primary field findings; it brings together recurring literature themes in the context of the architectural studio. Personalized learning pathways and differentiated support are evindent in the early stages of the design process, where generative AI tools such as Midjourney and DALL-E have been associated with accelerated idea generation and the stimulation of creativity. This has been linked to increases in students' motivation and engagement in the learning process. Adaptive content and feedback constitute the backbone of personalization in heterogeneous learner profiles (Farhood et al., 2025; Inuwa et al., 2025). Sharma et al. (2025) exemplify the reconfiguration of workflows in personalized housing studios through user profiles and immersive tools. Increased design diversity, creativity, and critical judgment are reported, as students produce a broader range of design alternatives compared with traditional methods. AI-supported visualization tools enable more variations to be generated both qualitatively and quantitatively, improving not only aesthetic diversity but also technical accuracy. Reviews in design education also note that while AI accelerates alternative generation, it may weaken original judgment (Song & Abdul Rabu, 2025).

Real-time feedback and process traceability: AI-based analytical tools such as ANSYS, ETABS, and Ladybug can provide immediate technical evaluation of student projects, shorten revision cycles, and improve process management. In addition, stages of the learning process can be documented in a data-oriented manner and made traceable for both students and instructors. The adaptive learning literature regards real-time feedback and process tracing as key mechanisms of personalization (Hariyanto et al., 2025). In architecture, such traces do not replace the studio jury; rather, they should be interpreted as complementary data. Park (2025) also emphasizes the need for process-based assessment and documentation in generative studio education.

Instructor-student interaction and asymmetric adoption: Educational support systems such as ChatGPT, Copilot for Design, and Turnitin AI Writing can contribute to students' academic writing, conceptual clarity, and project presentation skills. These tools may also allow instructors to provide more targeted and timely feedback. Alshahrani and Mostafa (2025) demonstrate the tension between student enthusiasm and instructor caution, indicating the need for shared policies and rubrics. Recent higher-education evidence also shows that detection-oriented approaches are insufficient on their own; therefore, process evidence, authorship transparency, and staged assessment design should accompany AI-supported writing and design production (Kofinas et al., 2025; Gabay et al., 2026).

Prompt literacy as an emerging competency: Students need to develop the ability to formulate accurate, purposeful, and context-sensitive prompts in order to obtain effective results from AI tools. This competency represents a multidimensional academic skill set that includes creative thinking, technical precision, and linguistic clarity. Jian (2023) highlights the risks of data privacy and bias. The Erasmus+ analysis published on Zenodo (Alonso de Castro & Bueno, 2025) demonstrates that instructor development and tool selection at the institutional scale are linked to policy. This policy layer is also compatible with UNESCO's human-centered guidance, which prioritizes equitable access, age-appropriate use, and pedagogical validation in institutional GenAI adoption (Miao & Holmes, 2023).

5. CONCLUSION AND RECOMMENDATIONS

This study has examined the relationship between AI-supported tools and personalized learning in architectural education not through their technical capacities alone, but through the transformations they produce in studio pedagogy. The functions of generation, analysis, visualization, and learning support, which are discussed in dispersed ways in the literature, have been reframed through their pedagogical counterparts and integrated under a four-axis holistic framework. This framework shows that artificial intelligence is not merely a tool that supports learning processes, but an active pedagogical component that reshapes design thinking, feedback dynamics, and studio interaction. This perspective requires the central concept of the "studio" in architectural education to be reconsidered. With AI, the studio is no longer only a physical environment for production and critique. It becomes a multilayered and partially digitalized learning ecosystem that continuously produces feedback. This transformation turns the student from a passive recipient of knowledge into an active subject who manages their own learning process, while repositioning the instructor from a transmitter of information to a pedagogical guide who establishes the critical framework and directs the process. Nevertheless, this transformation also brings significant pedagogical risks. The superficialization of design judgment, issues of originality and authorship, tool dependence, and ethical uncertainty indicate that AI integration is not sustainable without a critical framework. For this reason, personalized learning should not be understood merely as support for individual differences; it must also be considered together with academic integrity, critical thinking, and pedagogical responsibility.

In conclusion, this study argues that the integration of AI into architectural education should be evaluated not as a technical innovation, but as a pedagogical paradigm shift. Future studies should test this conceptual framework with empirical data and reveal how it operates in different studio contexts. They should also evaluate its effects on learning justice, critical depth, and creative autonomy. In this context, AI should be positioned not as a final decision-making system in architectural education, but as a partner that stimulates critical thinking, generates alternatives, and enriches the learning process. The following recommendations summarize how these conclusions can be concretized at studio and institutional levels:

- Prompt and AI literacy should be gradually embedded into studio learning outcomes.

- Student process traces and jury assessment should be used together without conflating them; where possible, process-based evidence systems including prompts, reflective journals, and decision rationales should be prioritized.
- Shared ethical and integrity principles, as well as sample rubrics, should be developed for instructors.
- AI should be framed not as an autonomous designer that makes decisions, but as a guide and generator of variation. However, this framing requires juries and rubrics to be redefined through authorship and judgment.

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DECLARATIONS

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