Integrating Generative AI in Architectural Education: A Comparative Study of Traditional, Stock LLMs, and Custom Tools

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Abstract: The rapid development of generative artificial intelligence (AI) is transforming architectural education by reshaping creativity, technical skills, and problem-solving approaches. This paper presents a comparative analysis of traditional methods, general-purpose AI tools like ChatGPT and Midjourney, and a custom-built Architecture AI Tool (ArchAI) tailored to the needs of architectural education. The study highlights the strengths and limitations of each approach, focusing on their impact on creativity, efficiency, and educational outcomes. The findings reveal that while general-purpose AI tools enhance accessibility and ideation, their domain-specific applications are limited. In contrast, custom AI solutions, integrated with architectural principles and tailored datasets, offer significant advantages by automating design tasks, providing real-time feedback, and fostering innovative learning experiences. This work underscores the need for a balanced integration of generative AI to optimize learning outcomes and prepare students for professional practice.

1 INTRODUCTION

The fast-paced advancement of artificial intelligence (AI) has introduced groundbreaking tools that are transforming various fields, with generative AI standing out as a key technology in creative industries. Using sophisticated computational methods such as large language models (LLMs), generative adversarial networks (GANs), and diffusion models, generative AI facilitates the automated creation of diverse content, including text, images, 3D models, and architectural designs. This technological leap carries significant implications for architecture a field traditionally dependent on human creativity, iterative processes, and extensive technical expertise. In architectural education, generative AI is not only challenging traditional learning frameworks but also reshaping how creativity, problem-solving, and technical skills are nurtured (Li et al., 2024a).

At its most accessible level, generative AI is represented in popular tools like ChatGPT or image generators such as Midjourney, designed for general-purpose use. These tools are user-friendly and versatile, making them valuable for early-stage ideation, content creation, and visual exploration in architectural projects (Ploennigs and Berger, 2023). For instance, ChatGPT has been used to craft narratives around architectural concepts or refine project descriptions, while platforms like DALL-E and Midjourney allow students to quickly visualize abstract ideas, streamlining the early design phase. By lowering the barrier to AI-driven creativity, these tools enable even beginners to experiment with sophisticated design ideas. However, the general-purpose nature of these tools often falls short in addressing the specialized demands of architecture. They may lack the precision, contextual awareness, or depth needed to tackle complex architectural challenges. Recent works have shown how targeted applications of generative AI can bridge this gap, as exemplified by its application in the building industry to improve workflows and enhance code compliance (Wan et al., 2024). In contrast, custom-built generative AI tools offer tailored solutions that align with the specific needs of architecture students and educators. These tools, designed with domain-specific datasets, architectural principles, and educational objectives in mind, can integrate seamlessly with Building Information Modeling (BIM) systems or provide design feedback consistent with professional standards (Li et al., 2024b).

Users generally favor tools that are user-friendly and customizable for visualizing and presenting diverse data types (Roshdy et al., 2018; Sharaf et al.,

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2014). This preference extends to architectural plans as well. Additionally, tools that enable new ways of interacting with these plans can be particularly beneficial. The potential of generative AI in architectural education goes far beyond automation. Research suggests that carefully integrating these tools can enhance creativity and improve time management. For example, studies have shown that architecture students often use generative AI during the concept development stage to visualize ideas and streamline workflows, leading to clearer concepts and greater efficiency (Kee et al., 2024). Moreover, AI-driven tools like ArchiGuesser have demonstrated the ability to make learning architectural history more interactive and engaging through gamified experiences (Ploennigs and Berger, 2023).Generative AI's capabilities extend further, as shown in its ability to generate multimodal outputs, such as text-to-image models, which have been explored for educational and design ideation purposes (Koh et al., 2023).

Despite these advantages, questions persist about the effectiveness and ethical implications of using generative AI in education. Comparisons between traditional methods and AI-supported workflows reveal striking differences in how creativity, human agency, and educational outcomes are approached. Traditional methods, rooted in manual drafting and iterative instructor feedback, often emphasize foundational skills and critical thinking. On the other hand, generative AI offers faster ideation and enhanced visualization, raising concerns about potential over-reliance on automation and the erosion of essential skills. Additionally, within the realm of generative AI, there is a great contrast between general-purpose tools like ChatGPT and specialized AI systems built for architectural applications. While the former prioritizes accessibility and ease of use, the latter delivers targeted solutions, supporting tasks such as sketch-to-model transformation, generative floor plans, and context-aware feedback tailored to architectural education (Li et al., 2024b).

This paper focuses on the contrasts between traditional methods, general-purpose generative AI tools, and custom AI solutions. By examining the impact of these approaches on architectural education, it aims to highlight the most effective ways generative AI can enhance learning outcomes.

2 METHODOLOGY

This study employs a qualitative framework to evaluate the role of generative artificial intelligence (GenAI) in architectural education. The methodology involves a comparative analysis of traditional non-AI approaches, generative AI tools, and the custom-built Architecture AI Tool (ArchAI), emphasizing their respective contributions to creativity, learning efficiency, and design workflows. Additionally, the study contrasts stock generative AI solutions, such as ChatGPT and Claude AI, with the custom tool to identify domain-specific advantages. Images from the Architecture AI Tool (ArchAI) and its outputs will be integrated for demonstrative purposes.

2.1 Comparative Framework: Generative AI vs. Non-Generative AI

The study examines the differences between generative AI-enabled workflows and traditional non-AI-supported methods. Generative AI offers significant advantages in automating repetitive tasks, providing real-time feedback, and enhancing visualization capabilities. These aspects are compared against non-generative approaches, which emphasize manual effort and critical thinking.

Firstly, in terms of *Automated Design Assistance*, generative AI tools, such as the Architecture AI Tool (ArchAI), automate blueprint analysis, layout suggestions, and design visualization, allowing students to focus on conceptual development. Non-generative methods rely on manual iterations and instructor-led feedback, which, while foundational, are less efficient for rapid prototyping. By manually adjusting layouts, students spend more time learning technical processes but less time innovating and exploring creative possibilities.

Secondly, regarding *Feedback and Iteration*, the Architecture AI Tool (ArchAI) provides actionable, data-driven feedback linked to uploaded blueprints, allowing immediate refinement. This is achieved by analyzing spatial layouts, identifying inefficiencies, and suggesting practical improvements based on its integrated architectural knowledge base. Traditional methods depend on instructor evaluations, which, while valuable for mentorship and guidance, are constrained by the availability of instructors and often lack scalability for larger cohorts. The reliance on periodic feedback slows the iteration process and reduces the agility of student workflows.

Thirdly, in the aspect of *Visual Outputs*, generative AI tools generate updated images and alternative layouts from user inputs, enhancing creativity through visual exploration. This visual immediacy enables students to evaluate multiple design iterations in real-time. Non-generative methods, though reinforcing manual drafting skills, require extensive effort to achieve comparable visual exploration. As a result, students are often limited to fewer iterations within constrained time frames.

By accelerating the design process and enhancing visual feedback, generative AI fosters a more dynamic learning environment while traditional methods build foundational skills critical for long-term expertise.

2.2 Comparative Analysis: Stock vs. Custom Generative AI Tools

A critical component of this study is the comparison between general-purpose generative AI tools (e.g., ChatGPT) and the custom Architecture AI Tool (ArchAI). The analysis highlights how customization enhances functionality for domain-specific tasks in architectural education.

Firstly, concerning **Blueprint Interaction and Processing**, the Architecture AI Tool (ArchAI) processes uploaded blueprints, allowing users to rename rooms, edit layouts, and generate updated visual outputs. These capabilities encourage students to interact directly with design materials, fostering a hands-on learning experience. Stock generative AI tools, such as ChatGPT, are limited to providing textual descriptions or conceptual advice. They cannot directly interact with visual inputs like blueprints, restricting their applicability in architectural education.

Secondly, in terms of **Domain-Specific Knowledge Integration**, the custom tool incorporates a curated architectural knowledge base, offering precise, contextually relevant responses to queries. This enables the tool to address specific design challenges, such as spatial optimization or material selection, with tailored recommendations. Generic AI tools rely on broad datasets, which, while versatile, often lack the depth needed for specialized applications. As a result, their responses are less accurate and may require significant interpretation by the user.

Thirdly, regarding **Visual Design Suggestions**, the custom tool generates precise, visually accurate layouts based on user inputs, ensuring alignment with architectural principles. For instance, students can request improved layouts and receive tailored visual outputs that incorporate lighting, spacing, and functional zoning considerations. Stock generative AI tools, while capable of generating images (e.g., using DALL-E), lack architectural accuracy. These tools often produce outputs that are visually appealing but fail to adhere to practical design constraints. Moreover, they struggle with understanding domain-specific queries.

Fourthly, considering **Ease of Use and Adaptability**, the Architecture AI Tool (ArchAI) integrates seamlessly into architectural workflows, providing features such as targeted feedback and interactive editing. Its user-centric design ensures accessibility for both novice and advanced users. Stock AI tools,

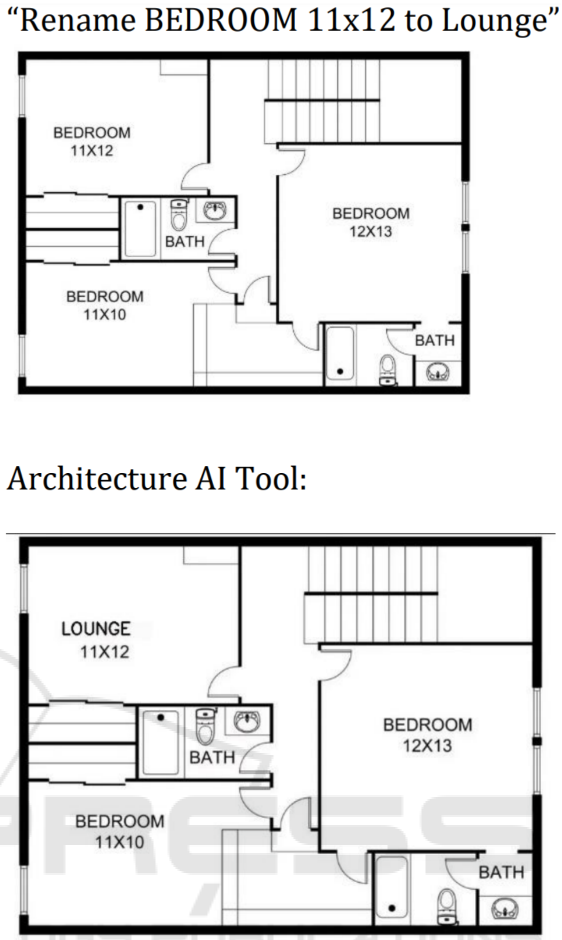

Figure 1: Tool output when asked to rename Lounge 11x12.

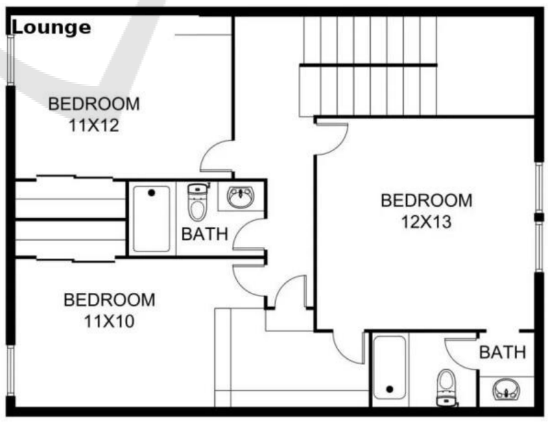

Figure 2: GPT output when asked to rename Lounge 11x12.

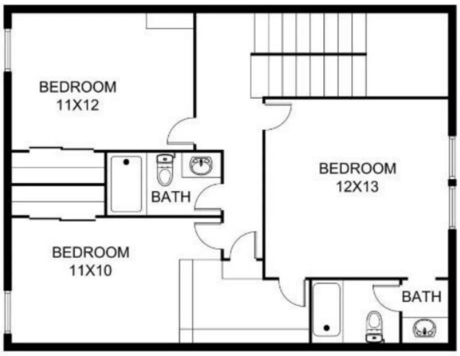

Figure 3: Original Blueprint Query.

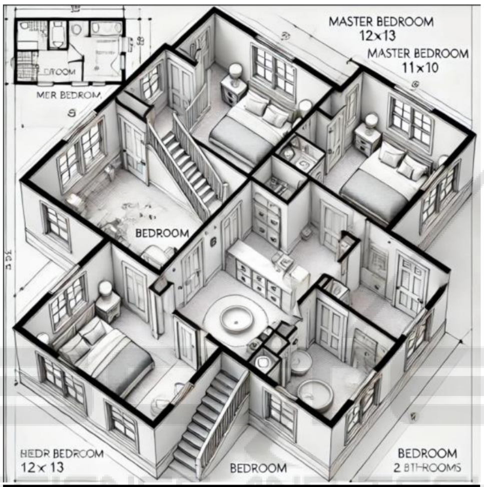

Figure 4: GPT output when asked to provide a better layout based on the original blueprint.

Figure 5: Tool output when asked to provide a better layout based on the original blueprint.

though flexible and broadly applicable, require significant adaptation to align with the specific needs of architecture students. This gap limits their usability for domain-focused tasks.

Lastly, in terms of **Actionable Feedback and Metadata Analysis**, the custom tool offers metadata analysis of blueprints, providing insights into dimensions, zoning, and other structural elements. This level of detail supports advanced educational objectives, such as teaching students to evaluate design metrics effectively. Stock tools lack the ability to interpret or analyze such data, making them unsuitable for tasks requiring detailed architectural insight.

The customization of the Architecture AI Tool (ArchAI) enables it to address the unique demands of architectural education, surpassing the capabilities of generic AI tools in delivering targeted, actionable insights.

2.3 Educational Applications of the Architecture AI Tool (ArchAI)

The Architecture AI Tool (ArchAI) offers transformative potential in architectural education by enhancing student engagement, creativity, and learning outcomes. Key applications include:

Firstly, *Interactive Blueprint Analysis*: Students can upload blueprints, receive targeted feedback, and refine their designs interactively. This fosters active learning by allowing students to experiment with layouts and assess the impact of changes in real time.

Secondly, *Accelerated Design Processes*: The tool automates repetitive tasks such as renaming rooms, generating layouts, and evaluating spatial efficiency. By reducing the time spent on manual processes, students can dedicate more effort to conceptual development and innovation.

Thirdly, *Knowledge Retrieval*: Leveraging its domain-specific knowledge base, the tool provides precise answers to complex queries. For example, students can inquire about optimal materials for sustainable designs or efficient zoning strategies and receive contextually relevant insights.

Fourthly, *Creative Exploration*: The tool's ability to generate new layouts and design suggestions encourages experimentation. Students are encouraged to explore unconventional ideas and develop innovative solutions without the constraints of traditional workflows.

Lastly, *Enhanced Visual Learning*: By generating visual outputs tied to specific design principles, the tool supports visual learners in grasping complex architectural concepts. This enhances comprehension and retention, particularly for students who benefit from diagrammatic representations.

The integration of these applications into architectural education equips students with practical skills and a deeper understanding of design principles, preparing them for future professional challenges.

3 RESULTS

This section compares Generative AI tools with traditional non-generative methods in architectural design, highlighting the enhancements in speed, creativity, and effectiveness. We also assess the capabilities of specialized tools like the Architecture AI Tool (ArchAI) against standard generative AI tools. Insights are derived from practical evaluations with architecture students, focusing on usability and System Usability Scale (SUS) scores, to demonstrate the transformative impact of Generative AI in architecture.

3.1 Generative AI vs. Non-Generative AI Approaches

Generative AI tools demonstrated a significant advantage in accelerating the iterative design process. These tools reduced the time required for revisions compared to manual methods, enabling students to visualize and refine multiple iterations in real time. In contrast, traditional methods, while reinforcing core design skills, constrained students to fewer iterations due to the manual nature of the workflow and time limitations.

The use of Generative AI workflows also enhanced creativity by providing real-time feedback and actionable suggestions. This allowed students to explore innovative layouts and optimize designs with greater confidence. On the other hand, manual methods relied heavily on instructor feedback, which, although valuable, was less scalable and often delayed due to instructor availability.

Additionally, tools such as the Architecture AI Tool (ArchAI) provided enhanced visual feedback that enabled students to experiment with a wide range of design variations. This immediacy encouraged exploration and iterative improvement. In comparison, non-generative methods required external tools for visualization, which limited both the immediacy and scope of design exploration.

3.2 Stock Generative AI vs. ArchAI

ArchAI, such as the Architecture AI Tool (ArchAI), offered superior performance compared to stock generative AI tools, particularly in their ability to process and edit blueprints. This functionality provided students with a hands-on learning experience that stock tools, limited to textual interactions, could not replicate.

The custom tool also outperformed stock AI in terms of domain-specific knowledge. By leveraging its architectural knowledge base, the tool provided precise and actionable insights for specific design challenges. In contrast, stock tools often produced generalized outputs that required additional interpretation to be useful in a practical context.

Finally, design accuracy and visualization were significantly improved with custom tools. These tools generated contextually accurate layouts aligned with architectural standards, offering practical applicability. In comparison, stock tools, while visually appealing, frequently lacked adherence to design constraints, reducing their utility for architectural tasks.

3.3 Usability Testing and SUS Scores Results

To conduct the results, we conducted usability and SUS tests for the Architecture AI tool (ArchAI). The evaluation involved 31 students, primarily students from architecture, to evaluate ArchAI's functionalities. The users were first asked about their experience with similar tools, such as ChatGPT, Claude AI, and PlanFinder. Among the 31 users, 11 had advanced experience, 10 had intermediate experience, 9 were beginners, and 1 had no prior experience with similar tools. They tried out the tool and its complete features and were then asked to give feedback on its usability.

Users were asked various questions, including how easy it was to use some features of the tool, which they gave an average score of 4.6 out of 5, as well as how easy it was to use the tool. The processes of renaming a room and their overall satisfaction with the enhanced layout both received average scores of 4.4 out of 5.

None of the users encountered issues or errors while using the tool, they all successfully renamed and updated the floorplan without difficulties. Additionally, 96.8% of them said that the tool responded with a helpful and enhanced floorplan. As for the feedback of the uploaded floorplan, all the users agreed that the feedback was clear and actionable. When asked about the likelihood of using the tool again, the majority of the users expressed high interest, with many responding *"Very Likely."*

Regarding the SUS scores, ArchAI achieved a high average SUS score of 86.69, with a standard deviation of 21.56, which corresponds to an *"excellent"* usability rating based on established benchmarks. Users gave an average score of 4.68 for wanting to use the tool frequently, 4.74 for ease of use, and

4.87 for confidence when using the system. Furthermore, the tool was rated highly for being well integrated (4.77) and quick to learn (4.77). Meanwhile, scores for negative aspects, such as perceived complexity (1.81), inconsistency (1.87), and cumbersome processes (1.74), were very low, indicating minimal issues in these areas. These results reflect a very positive user experience overall, with high usability and confidence ratings, and low scores for complexity and inconsistency. This metric shows the system's effectiveness and that it is user-friendly.

4 CONCLUSION

This study demonstrates that generative AI, particularly custom-built solutions like the Architecture AI Tool (ArchAI), can revolutionize architectural education. These tools enhance creativity, streamline workflows, and provide targeted feedback, allowing students to focus on conceptual innovation. Compared to traditional methods and generic AI solutions, the custom tool excels in addressing domain-specific challenges, offering superior interactivity, precision, and contextual relevance.

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