

Article

Technological Innovation in Architectural Design Education: Empirical Analysis and Future Directions of Midjourney Intelligent Drawing Software

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Abstract: This study investigates the role of Midjourney intelligent drawing software in architectural design education, particularly its impact on design efficiency and creativity among sophomore architecture students. While Midjourney serves as a powerful tool for rapid visual concept generation, it does not replace traditional design skills but complements them by enhancing the visualization process. The study also identifies some key limitations of Midjourney, especially in areas of functionality and sustainable design, which require students to integrate additional tools for a more comprehensive design approach. The recommendation to expand the use of intelligent drawing technologies like Midjourney in future research is supported by the observed improvements in student performance, including enhanced creative expression and efficiency in design processes. These conclusions are based on qualitative data derived from student feedback, as well as quantitative measurements of their design outcomes before and after using the software. Furthermore, it highlights the need to broaden the scope of studies to include a wider variety of educational contexts and source materials to improve understanding of the software's potential in design education.

Keywords: architectural design education; intelligent drawing software; technology in design education; empirical research in design education; technology-enhanced learning



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1. Introduction

In the context of the digital age, global education systems are undergoing a technology-driven transformation. Especially in the field of architectural design, this transformation is characterized by a shift from traditional design methods to more modernized and technologically advanced teaching and practice approaches. Artificial intelligence (AI), as one of the core technologies in this transformation, is redefining the scope and boundaries of design through its applications in design generation, data analysis, and the creation of simulated environments. Recent studies by Kasneci [1], Chiu [2], and Dwivedi [3] emphasize how AI tools, particularly in education, have reshaped the way students interact with design technologies. These tools not only enhance the design generation process but also provide innovative educational support, highlighting the growing role of intelligent systems in transforming both professional practice and education [4].

Intelligent drawing software, such as Midjourney (v.1.4.10), utilizes advanced image generation algorithms to enable users to create complex images from simple text descriptions. This technology not only speeds up the workflow for designers but also, as Buelinckx noted [5], computer-aided design (CAD) has enabled architects to generate design solutions using algorithms. Terzidis further explored, in his 2006 work, how parametric and algorithmic design can bring unprecedented flexibility and innovation to architectural design [6]. Importantly, these technologies provide a new perspective in design education,

enabling teachers and students to instantly explore and implement design ideas, which was unimaginable in traditional education models.

However, while the professional application of these technologies is increasing, their potential and effectiveness in educational settings remain relatively under-researched. The application of AI in architectural design education is still limited. Most existing research focuses on the potential of technology and its application in professional practice, with a lack of in-depth discussion on how to effectively integrate these technologies into the teaching process, particularly in enhancing students' learning experiences and creativity. Moreover, opinions within the academic community vary regarding the real impact of AI technologies on fostering students' innovative thinking, with some researchers suggesting that over-reliance on technology might suppress creativity. There is still widespread discussion and controversy in academia and industry about whether these technologies can truly enhance students' design skills and creativity.

This study aims to explore, through empirical research, the effects of Midjourney intelligent drawing software on sophomore architecture students, specifically examining its impact on students' design abilities and innovative thinking. The main objectives of this study are to analyze how the Midjourney software enhances students' creative expression, improves their technical skills, and facilitates design process efficiency. The study also aims to provide insights into the software's limitations, such as its ability to address functionality and sustainability concerns, and how these limitations can be overcome by combining traditional and AI-assisted design approaches. By analyzing the students' design works before and after using Midjourney, this study seeks to verify whether intelligent drawing technology can serve as an effective design-aid tool to enhance the quality and efficiency of architectural design and education.

Furthermore, the study will examine the practicality and acceptance of Midjourney in the process, assessing its potential value as a support tool. In this way, the research not only provides a new technological perspective for the field of architectural design education but also supports the further development of architectural design.

The main objective of this paper is to thoroughly analyze the application of Midjourney intelligent drawing software in architectural design education and to evaluate its specific impact on students' design thinking and technical skills. The results are expected to show that students using Midjourney perform better in terms of creative expression, technical mastery, and design understanding compared to those who do not use such tools.

Additionally, the conclusions of this study will provide important insights into how to effectively integrate emerging technologies into design education, offering strategic recommendations for using AI tools to educators and policymakers, thereby promoting further innovation and development in educational practices. Through these findings, the study not only enhances the understanding of the application of AI technology in education but also provides new perspectives and recommendations for the future direction of architectural design education. By systematically researching and assessing the application of Midjourney software in teaching, this study aims to provide insights for educators into how to effectively integrate emerging technologies into design education. These insights not only help optimize teaching strategies but also facilitate the students' understanding of complex design concepts and enhance their creativity. Moreover, the research findings will also provide feedback for the development of intelligent drawing technology, promoting its better service to educational purposes. Furthermore, research has shown that AI tools are not only essential for automating and enhancing the technical aspects of design but also for fostering creativity and improving pedagogical outcomes [2]. AI-driven platforms like Midjourney enable students to experiment with new ideas, iterate quickly, and gain immediate feedback, making the design process more interactive and collaborative. These developments point to a significant shift in design education, where AI systems complement traditional methods to produce more holistic learning experiences [7].

2. Literature Review

Intelligent drawing technology, particularly AI-based image generation tools, has begun to demonstrate its unique value in the educational field. These technologies, utilizing machine learning algorithms, can generate detailed images from simple text descriptions, providing unprecedented visual support and innovative approaches for teaching. For instance, AI drawing tools like OpenAI's DALL-E and Midjourney use deep learning models to interpret and visualize text descriptions. This capability not only stimulates creative thinking in the fields of art and design but is also applied in science, engineering, and humanities, helping students better understand complex theories and concepts.

Chronis has noted that intelligent technology is used to simulate and generate more complex and innovative structural forms, enhancing design efficiency and new degrees of freedom [8]. In his book, "Creative Ecosystems", McCormack discussed the application of AI in simulating natural ecosystems, how it affects students' cognition and practice of the design process and proposed a new model for design education [9,10].

The effectiveness of intelligent drawing technology has been validated in multiple studies, showing it can enhance student engagement and motivation. In "Journal of Educational Technology", Smith, J. and Johnson, K. [11] showcased how researchers demonstrated the capability of these tools in experimental learning settings to help students concretize abstract concepts, thereby gaining a deeper understanding and mastery of subject knowledge. Intelligent drawing technology also impacts teaching methods, allowing educators to design curricula and educational activities more effectively. They use customized images to match teaching objectives, thus providing a richer and more personalized learning experience [12,13]. Furthermore, through intelligent drawing technology, teachers can create content with a strong visual impact, playing a crucial role in enhancing students' attention and comprehension [14,15].

The current discussions on the applications of generative AI (GenAI) in education mainly focus on ChatGPT and Midjourney. For example, how should teachers plan their assignments, and what policies should educational institutions revise or implement? Some teachers remain cautious about allowing students to use AI applications to complete assignments, while others have embraced these tools and adjusted their assessment methods [1]. GenAI enables users to generate new content, including text, images, audio, video, and 3D models, by inputting simple requests [3]. ChatGPT is one such GenAI application that generates human-like conversations [16]. Another example is Midjourney, which has made a significant impact on art education. These tools can function as teachers, tutors, clerks, and designers, and they are transforming the way students learn, teachers teach, and educational institutions develop policies [3]. For instance, students can use ChatGPT to write a 1000-word essay, solve math problems, or compose music in less than 30 s. By curating information in a storytelling format, ChatGPT enhances students' learning capabilities. This tool can (i) enable students to learn more quickly and in diverse ways, (ii) offer teachers new perspectives to grow, and (iii) simplify institutional administrative work [17]. However, AI applications like ChatGPT are not entirely reliable and can produce errors and inaccurate outputs. Are students equipped to judge the appropriateness and trustworthiness of these outputs? Do they understand ethical issues like copyright? Many academic institutions have yet to address the use of generative AI in their academic dishonesty policies [3].

The use of generative AI in education is still in its early stages. Many educators and policymakers are still exploring its capabilities and limitations [18]. Most studies and discussions have centered around higher education. However, compared to university students, younger students in primary and secondary schools are still developing their cognitive and emotional intelligence [19]. Their self-regulated learning skills are less mature, and classroom learning is often under the supervision of teachers [19]. This highlights the critical role teachers play in supporting learning through technology. To date, no empirical studies have been conducted to explore how GenAI is impacting school education. Therefore, this qualitative study aims to investigate the impact of GenAI on

school education from the perspectives of teachers and school leaders. The study uses ChatGPT and Midjourney as tools to gather data from educators and school leaders.

In architectural design education, the application of visual expression techniques has gradually transitioned from traditional hand-drawing [20] and physical models to a strong reliance on modern technologies such as computer-aided design (CAD), three-dimensional modeling, and virtual reality (VR) [21]. These technologies not only enhance the precision and efficiency of designs but also greatly improve the ability to express design intentions. Modern visual expression techniques enable students to explore and experiment with various possibilities of architectural design within a virtual environment, significantly expanding their creativity and problem-solving capabilities. According to Sanders and Peterson in the “Architectural Education Journal” [22], these technologies can break the limitations of traditional architectural design approaches as noted by Oxman [23]. The integration of design thinking with AI tools can inspire creativity and critical thinking in design students [24,25].

Furthermore, with the widespread adoption of augmented reality (AR) and virtual reality (VR) technologies, architectural education has begun to explore the application of these technologies in simulating complex architectural scenes and environments. This allows students to test and optimize their designs in a safe simulated environment, providing a more interactive and immersive learning experience [26,27]. While Midjourney allows rapid visualization of architectural concepts through text-to-image generation, it primarily focuses on visual aesthetics without immersive interaction. In contrast, VR and AR technologies provide a deeper level of engagement by allowing students to experience and interact with their designs in real-time, simulating the three-dimensional space of their projects. This immersive environment helps students understand the spatial dynamics, lighting effects, and user interaction more effectively than static images. Furthermore, VR and AR allow for real-time adjustments during the design process, offering a more dynamic design feedback loop. By using these advanced visualization tools, students can more accurately assess and realize their design concepts, thereby achieving greater academic and professional success [28]. Kharvari and Kaiser [27] discuss how modern educational tools such as virtual reality (VR) and augmented reality (AR) have begun to complement traditional architectural teaching methods, providing students with immersive environments for spatial exploration. Similarly, Midjourney facilitates rapid prototyping and concept validation, allowing students to visualize and modify their designs early in the process, which enhances creative problem-solving.

The application of intelligent drawing technology and visual expression techniques in education has been extensively explored through numerous studies. These include case studies that analyze how AI drawing tools are utilized in design courses to enhance students’ creative processes. Research indicates that students not only improve efficiency during the initial creative phases of design but are also able to rapidly make adjustments and improvements during the iterative design process [29].

The study also examines how digital tools are applied in landscape architecture education to improve students’ project planning and visual expression skills. It was found that by using 3D modeling software and virtual reality technology, students could gain a more comprehensive understanding and mastery of spatial layouts and ecological impacts in landscape design [30]. Similarly, integrating AI in the arts and design fields, despite the technical challenges, also brings educational opportunities as outlined in the section “Challenges and Opportunities” [31].

These case studies not only confirm the effectiveness of intelligent drawing and advanced visual expression technologies in enhancing the quality of education and student learning outcomes but also demonstrate the potential of these technologies to foster creative thinking and technical skills’ development among students. By deeply analyzing these studies, educators and technology developers can better understand how to optimize the educational applications of these tools to meet the evolving learning needs and educational goals. The main objective of this study is to conduct an in-depth analysis of the application

of Midjourney intelligent drawing software in architectural design education and to evaluate its specific impact on students' design thinking and technical skills. Through this research, we aim to reveal how technology changes educational methods and promotes innovation and technical advancement in students' architectural designs. The need to integrate AI tools like Midjourney into design education is becoming increasingly clear, as they offer enhanced capabilities in both visualization and creative exploration. However, further studies are needed to fully understand their potential, particularly when used alongside traditional pedagogical approaches [32].

3. Objectives

The paper aims to consider the following issues

1. From the perspective of architectural design education:
In the rapidly changing educational technology environment, how can intelligent drawing technology effectively enhance students' design capabilities and innovative thinking? The project comprehensively analyzes and assesses the practical application of the intelligent drawing software Midjourney in assisting architecture students to complete kindergarten design projects. The research will explore how the software helps students through various stages from concept ideation to the final design sketch, enhancing their design thinking, visual expression capabilities, and innovative thinking.
2. From the perspective of intelligent software application:
In terms of effectively integrating technology and traditional educational methods, how does Midjourney software provide innovative support to students and promote problem-solving strategies? This study plans to conduct a detailed case analysis to explore how Midjourney software provides innovation support and facilitates problem-solving strategies during students' design processes. Special attention is given to how the software impacts students' creative development and technical realization at different design stages, and how these tools help students overcome design challenges to achieve high-quality architectural design outcomes.
3. From the perspective of enhancing the quality of architectural design education:
The research aims to evaluate the potential impact of using intelligent drawing technologies like Midjourney on enhancing the quality of architectural design education. By comparing students' design works before and after using Midjourney, the study analyzes the effectiveness of implementing intelligent drawing technology in education, and how it changes students' design processes and outcomes. This objective includes assessing the technology's effectiveness in cultivating students' creativity, technical skills, and critical thinking.

4. Materials and Methods

4.1. A Pedagogical Framework for the Course

This study employs a mixed-methods research design, combining quantitative and qualitative analyses to comprehensively evaluate the effectiveness of the Midjourney intelligent drawing software in assisting second-year architecture students. To validate the impact of Midjourney, a mixed-methods approach was used. Students' design outputs were evaluated both qualitatively, through feedback and reflections, and quantitatively, using predefined design criteria such as creativity, technical execution, and efficiency. A comparative analysis was performed to measure the improvements made by students before and after using the software. This dual approach ensured a comprehensive understanding of the tool's effectiveness. The research aims to thoroughly explore the impact of intelligent drawing technology on the students' design abilities, creative thinking, and learning experiences from multiple dimensions.

Research Subjects:

- The subjects of this study are ten second-year architecture students from a university in a certain city, all of whom voluntarily participated in this research. All participants

signed an informed consent form before the start of the study, which explained the purpose of the research, the procedures involved, and their rights and responsibilities.

Design Arrangement:

- A plan to reconstruct a kindergarten for 6 classes (20–25 children each) within the site of Hailun Road Kindergarten in Qingdao, with a controlled building area of 1500–2000 m², was proposed to address the kindergarten admission issue in the vicinity. The design should at least meet the following requirements:
 1. Integrate closely with the terrain, geomorphology, urban environment, and climatic conditions for the overall design to achieve distinct zoning and rational layout. While meeting functional requirements, incorporate children's physiological, psychological, and behavioral aspects into the architectural design. The design should start from the needs of multiple stakeholders, making the layout lively and variable, creating a plan with interest, and providing children with a safe, comfortable, and rational physical and spiritual environment.
 2. Focus on the activity unit as the core to arrange other rooms, ensuring the optimal position, orientation, sunlight spacing, natural lighting, ventilation, and open views of the activity unit.
 3. Broaden horizons and explore innovative architectural designs, drawing on beneficial creative techniques to create a friendly, lively, and variable entertainment and educational space environment.
 4. Emphasize analyzing the spatial needs of teaching and learning to create a rich and friendly environment for teaching and living. Ensure that children can enjoy their kindergarten life happily and develop good habits and attitudes in social life.
 5. Address the combination of large and small spatial scales to form a continuous whole between play and learning, indoor and outdoor spaces.
 6. The building should not exceed 3 floors.
 7. Reference for various architectural control indicators: (all areas are measured along the axis)
- Classroom activity room (unit): 990 m²
- Multi-purpose activity room: 200–240 m²
- Service rooms: 160–200 m²
- Logistics rooms: 100–150 m²
- 8. Public activity area: 280 m² (includes at least 6 lanes of 30m track, playground equipment area, sandpit, paddling pool, flag-raising platform, etc.) (Students may adjust the functions and areas appropriately based on actual research conditions)

Assistive Software:

Intelligent Drawing Software Midjourney: This software utilizes advanced deep learning technologies to generate images based on textual descriptions, supporting the visual expression of design thinking. The text-to-image generation model is a type of machine learning model that typically takes natural language descriptions as input and produces images that correspond to those descriptions. The development of this model began in the mid-2010s and has been progressively refined with the advancement of deep neural network technologies.

Midjourney Version: Students were provided with access to the paid version of Midjourney to ensure they could take full advantage of its extended functionalities, such as higher resolution image outputs and faster generation times. This decision was made to avoid limitations imposed by the free version, which could have impacted the quality and variety of the designs produced.

4.2. Method

Research Design

This study employs a case study approach, meticulously documenting students' design processes to analyze the practical effectiveness of the Midjourney software and its impact on learning outcomes.

Throughout the experimental process, students were required to produce a minimum of three images at different stages of their design process: an initial concept image, a mid-stage iteration, and a final design. This structured approach allowed the study to assess how the software was used to refine and enhance students' design concepts at each stage. Additional images were permitted if students felt it was necessary to explore further variations or adjustments.

Experimental Steps

1. Distribution of Assignment and Preliminary Discussion

Activity: The instructor explains the project requirements and objectives in detail to the students and distributes a brief containing specific design requirements.

Purpose: To ensure that students have a clear understanding of the project's requirements and objectives, providing them with direction for their subsequent design thinking.

2. Individual Reflection and Submission of Preliminary Concepts

Activity: Students conduct research related to the site, perform preliminary surveys, think independently, and submit a document outlining their design philosophy, target users, expected functions, and preliminary spatial layout.

Purpose: To preliminarily express and solidify their design ideas through a written document, preparing them for using the Midjourney software.

3. Using Midjourney to Generate Initial Images (Image one)

Activity: Students input their design concept texts into Midjourney, optimize keywords and descriptions based on guidance from instructors, and generate initial images.

Operational details: Midjourney can output four images at a time; students need to learn how to adjust descriptions to better control the details and style of the image output.

Purpose: To use AI-generated images to provide students with a visual reference that helps them identify potential design issues and opportunities during the visualization process, bringing them closer to their envisioned design.

4. Design Iteration and Assessment of Concept Maturity and Detailed Design Sketches

Activity: Based on AI-generated images and feedback from teachers and peers during mid-term reviews, students undergo multiple rounds of design iteration, including hand-drawn sketches and computer modeling, which include first and second rounds of refinement.

Evaluation mechanism: Regular design review meetings are held to collect feedback, facilitate critical discussions, and make suggestions. This step deepens the design details to ensure every part of the concept is fully developed and designed, ready for the final project presentation.

Purpose: Through practical operation and repeated iterations, to finely adjust and optimize the design, enhancing its functionality, aesthetics, and innovation.

5. Final Design Evaluation and Reapplication of Midjourney (Image two)

Activity: Students input their final design concepts back into Midjourney to generate images, which are then compared and analyzed against earlier generated images and hand-drawn sketches.

Purpose: To ultimately assess the usability of Midjourney by comparing and analyzing how AI assistance throughout the design process contributes to innovation and solving design challenges.

6. Comparative Analysis: Image one, Image two, and Final Outcome

Activity: Students will conduct a comprehensive comparative analysis of two key AI-generated images (Image one and Image two) and the final outcome image. Image one, generated in the early stages of the design process using Midjourney, reflects the preliminary design concepts; Image two, produced after mid-process iterations, shows further development and refinement of the design concepts; the final outcome image represents the detailed and precise expression of the completed design.

Operational details: Students need to meticulously record the conditions and input parameters for generating each stage's images to ensure the accuracy of the comparison. Additionally, they will use specific design evaluation criteria to analyze the differences in consistency, innovation, and functionality between the images at different stages and the final design.

Purpose: The comparative analysis aims to assess the support provided by Midjourney at different stages of the design process and its contribution to the final design results. This step not only helps students evaluate their design progress from visual and technical perspectives but also promotes a deeper understanding of the design process and self-reflection. Moreover, the comparative analysis is a key component in verifying the effectiveness of intelligent drawing technology in practical design applications, showcasing its potential to enhance creativity and solve complex design challenges in the field.

Data Collection and Analysis:

Qualitative data: Includes design concept documents, feedback from mid-term and final reviews, generated images, and hand-drawn sketches.

Quantitative data: Scores collected through design review meetings that assess functionality, aesthetics, and innovation of the designs.

Analysis Methods:

Qualitative analysis: Use content analysis to study changes in language descriptions and visual expression throughout the student design process.

Quantitative analysis: Use statistical methods to analyze changes in design scores to assess the specific impact of the Midjourney software on design quality.

This study will provide educators with deep insights into how to utilize intelligent drawing technologies like Midjourney to enhance architectural design education, particularly in fostering students' innovative thinking and visual expression capabilities. The results will help improve teaching methodologies, aligning them more closely with contemporary technological developments.

5. Results

Image one: Image one is generated in the first phase, where students receive the assignment brief and, after initial conceptualization, input their conceptual text into Midjourney to produce the image.

Image two: Image two is generated in the third phase, where students have completed the refinement of the floor plan, their ideas have maturely developed, and they believe these are reflected in the design. They input the conceptual text into Midjourney to produce the image.

Final outcome: The final output is the completed drawings produced by the students after refining the floor plans and elevations, and integrating the images generated by Midjourney.

5.1. Student One

Image one by Midjourney.

Initial conceptualization: According to the educational philosophy of Friedrich Froebel, education should follow the natural development of children, emphasizing the importance of setting up the environment, and advocating that kindergartens must have gardens and other green spaces for activities. The preliminary concept involves erecting two non-parallel

walls to divide the building, creating a secluded “oasis” where children can engage in planting activities. Two vertical gardens face each other, with a connecting corridor linking them together (Figure 1).



Figure 1. This is an image generated by Midjourney based on the keywords “non-parallel oasis”.

Image two by Midjourney.

The most distinctive feature of the kindergarten is the erection of two non-parallel walls that cut through the building to create a secluded “oasis” for children’s planting activities. The two vertical gardens face each other, with a connecting corridor linking them. These two non-parallel walls, each 10 m high, form the central corridor of the building, which serves as both a separation zone between the children’s activity units and other functional areas, and as a circulation area connecting them. On one side, three south-facing blocks are distributed, with two floors used for six classrooms for children, where the blocks are interspersed with the walls, creating small “oases”. On the other side, relying on the walls, parallel walls are established to enclose the functional areas. The building further intersperses these walls to serve as outdoor areas for children to play (Figures 2 and 3).

5.2. Student Two

Image one by Midjourney.

The architecture as a whole is formed by the evolution of geometric shapes, featuring diverse materials and colors. The building has a varied profile that creates a rich play of light and shadow, offering open and flexible spaces that create diverse spatial experiences. The design facilitates connectivity between indoor and outdoor areas, allowing for outdoor planting activities (Figure 4).

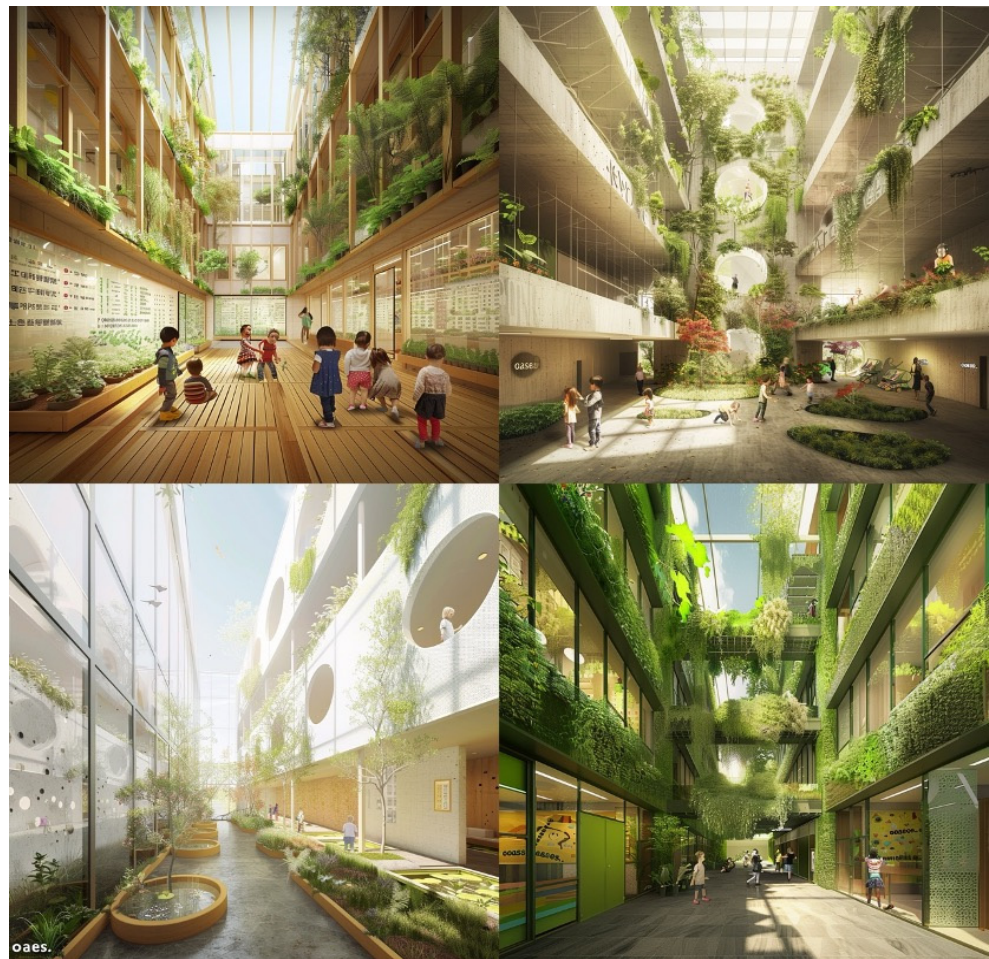


Figure 2. This is an image generated by Midjourney based on more keywords.

Image two by Midjourney.

The basic shape of the architecture is derived from simple geometric bodies, which are dynamically combined and cut to present a rich variety of geometric forms on different facades and levels, creating unique visual focal points and depth, thus forming distinctive architectural forms. Different colors and tones are applied to various parts and facades of the building to enhance its visual impact.



Figure 3. *Cont.*



Figure 3. Final outcome by student named “Green Corridor”.

The facade design of the building breaks the monotony with its convex and concave variations, creating a rich visual experience and depth, and producing intricate light and shadow effects that add layers and a dynamic quality to the architectural space. The interior adopts an open spatial layout, allowing different functional areas to interconnect and permeate each other, forming flexible and variable spatial relationships. Flexible spatial divisions and movable partitions enable the building to adapt to different usage demands. Transitional spaces are set up to create a natural transition and connection between indoor and outdoor spaces. On the building’s facade, planters or hanging plants are installed to green the facade, further enriching its visual effect (Figures 5 and 6).



Figure 4. This is a figure from Midjourney based on the keywords “geometric shapes”.



Figure 5. This is an image from Midjourney featuring more diverse geometric façades.



Figure 6. The façades in the student's final project are shaped as smooth small squares.

5.3. Student Three

Image one by Midjourney.

Kindergarten design concept: “Cardboard Box”—This design concept uses “cardboard boxes” of various sizes, interspersed throughout, to allow children to explore different spatial scales and satisfy their curiosity. Inside, square spaces are cleverly utilized to form stairs and pathways, as well as to create children’s activity rooms. These square activity rooms are positioned on the south side to receive ample sunlight, meeting the lighting requirements. Other logistical supports are placed on the north side to avoid interference. Different sizes of “cardboard boxes” are used according to their function, with larger squares for the children’s activity rooms and elongated, smaller boxes for circulation spaces. Outdoors, there is a large, free activity space arranged in a circular layout (Figure 7).



Figure 7. This is a figure from Midjourney keyword “Cardboard Box”.

Image two by Midjourney

Architectural concept: “Cardboard Box Concept”—Children aged 3–6 are in a phase sensitive to spatial dimensions and enjoy exploring the scales of space. The “cardboard box” concept, by interspersing boxes of different sizes, allows the children to explore various spatial scales, fulfilling their urge to explore. Through the manipulation of faces, lines, and volumes via movement, stacking, interlacing, and encircling, unique forms and functions are created. Inside, square spaces are diagonally arranged to form stairs and paths, as well as square spaces designed as children’s activity rooms. These square activity rooms are placed on the south side to receive ample sunlight, meeting the lighting requirements. Other logistical spaces are located on the north side to avoid causing disturbance. Different sizes of “cardboard boxes” are used according to the functions, with larger squares for children’s activity rooms and elongated smaller boxes for circulation spaces woven throughout. Additionally, partial walls divide the circulation of students and staff, preventing children from wandering around, and can be integrated into the building, creating a unified interior and exterior feel. The site design includes variously elevated, cave-like spaces with seating, available for parents to wait, or for children to rest (Figures 8 and 9).

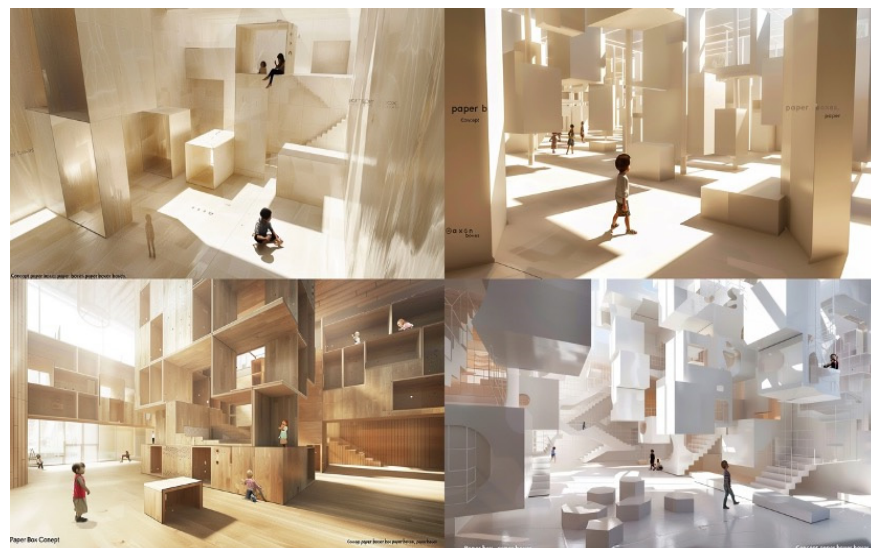


Figure 8. This is an interior rendering of the Midjourney keyword “Cardboard Box Concept”.



Figure 9. Final outcome by student keyword “Cardboard Box Concept”.

6. Discussion

This study, using detailed images, demonstrates the changes in students’ design works before and after using the Midjourney intelligent drawing software. After using Midjourney, students’ designs showed improvements in various aspects including enhanced visual effects, increased design elements, and more complex spatial processing capabilities. Specifically, students were able to quickly validate their design concepts through images generated by the software, identifying potential issues and making adjustments early in the design process, though there were some issues.

Transformation and Enhancement of Initial Design Concepts

Before using Midjourney, students’ initial designs were often limited to abstract concepts and sporadic ideas, which were difficult to fully understand and evaluate without concrete visual expression. With the help of Midjourney, students were able to transform these preliminary ideas into concrete visual images. In terms of architectural space-making, the AI-generated images provided a preliminary framework for spatial exploration. The generated visuals allowed students to quickly assess how their initial ideas translated into

three-dimensional forms, facilitating better spatial composition and proportion analysis. This was particularly evident in how students adapted their designs to address volumetric and spatial challenges, such as optimizing circulation paths and integrating natural light. The images generated by the software allowed students to recognize the strengths and weaknesses in their designs, such as the rationality of space layout, the effectiveness of material use, and the handling of lighting. This rapid feedback loop helped students quickly adjust and improve their designs, thereby enhancing the overall quality of the designs.

Characteristics and Limitations of Midjourney Images

Although Midjourney offers a fast way to visualize concepts, the images it generates often focus on visual presentation, potentially overlooking the functionality and sustainability of the designs. For example, the images might show an aesthetically pleasing building but fail to display the building's energy efficiency or how natural resources are utilized. Additionally, these images might lack consideration of the social and cultural adaptability of the designs, such as integration with regional characteristics or responsiveness to user needs. Moreover, Midjourney does not inherently evaluate critical functional and environmental aspects such as energy efficiency, material sustainability, or long-term environmental impact. For instance, a visually appealing building generated by the software may neglect passive design strategies, insulation, or the efficient use of materials. Therefore, students are encouraged to complement the software-generated visuals with further sustainability analysis using tools such as building information modeling (BIM) to assess energy performance and life cycle impacts. This approach ensures that their designs are not only visually striking but also functionally robust and environmentally sustainable. Although Midjourney excels in generating visually compelling images, it lacks the interactive and immersive qualities that VR and AR technologies offer. VR allows users to walk through their designs in a three-dimensional space, providing a better understanding of the scale, proportions, and functionality of architectural elements. AR, on the other hand, can overlay digital elements onto real-world environments, offering an additional layer of context, such as how a building fits into its surroundings. While Midjourney is efficient for quick visualization, VR and AR provide a more comprehensive tool for assessing usability, functionality, and overall design coherence in real-world settings. This limitation requires students and teachers to maintain a focus on the comprehensiveness of the designs when using these tools, ensuring that the final products are not only visually striking but also functionally sound and environmentally friendly.

While tools like Midjourney provide significant support for the design process, they do not replace the need for creative design thinking skills. Creative thinking goes beyond merely visualizing concepts; it involves critical problem-solving, conceptual innovation, and the ability to balance aesthetic vision with functional and cultural relevance. Midjourney aids in speeding up visualization and enhancing experimentation but cannot substitute the architect's capacity to think holistically about a project. Therefore, it is essential to teach students how to use these tools as supplements to their creative processes, rather than as replacements.

Comprehensive Evaluation of Student Designs and Midjourney Outputs

A detailed comparison of student designs before and after using Midjourney reveals significant progress (Appendix A). After using Midjourney, students showed marked improvements in handling design details, innovation, and technical execution. For example, some students were able to better showcase the facade details of buildings, including the texture of materials and color coordination, as well as more complex structural forms, after using the software. While Midjourney facilitates rapid visualization and enhances the students' ability to experiment with design concepts, it is essential to recognize its limitations. The software tends to emphasize visual aesthetics over functional and sustainable aspects of the design. For example, it might generate an attractive building image but fail to address critical architectural issues such as energy efficiency, material sustainability, or social and cultural integration. Additionally, the software can oversimplify spatial relationships,

making it challenging for students to grasp the nuanced dynamics of three-dimensionality, especially when dealing with intricate interior spaces or complex site conditions. Midjourney can significantly foster creativity by allowing students to experiment freely with form, structure, and space. However, it is crucial to ensure that students do not become overly reliant on AI-generated visuals, potentially stifling their critical thinking and creative problem-solving abilities. While the software encourages innovative thinking by providing visual stimuli, it should be integrated into a broader pedagogical framework that promotes a balance between creative exploration and technical rigor.

This study highlights the potential and limitations of intelligent drawing tools in architectural design education. Although these tools can significantly accelerate the design process and provide strong visual support, they still fall short in fully integrating sustainable design principles and addressing complex ecological issues. Therefore, when introducing these technologies, educators should emphasize their role as auxiliary tools, ensuring that their application does not replace fundamental design education methods, particularly those aimed at developing the students' critical thinking and innovative capabilities.

Detailed Student Feedback and Technology Preferences

In this study, students provided diverse feedback on their experience with the Midjourney software, which can be categorized into several areas: design efficiency, creativity enhancement, functionality limitations, and technology preferences.

Many students highlighted the ease of generating visual concepts rapidly. One student commented, "Midjourney significantly shortened the time I spent on the initial design phase. Instead of manually sketching, I could instantly visualize my ideas, which accelerated my design process". Another student noted, "It saved me hours by generating multiple design variations that I could refine based on what worked visually". Several students felt that the software allowed them to explore more creative ideas. One student mentioned, "Midjourney helped me step outside my usual design boundaries. I was able to experiment with more abstract forms and unconventional design approaches without worrying about technical feasibility at the concept stage". Another added, "It's a powerful tool to push my creativity because it allowed me to see visual outcomes of ideas I might not have considered if I were working manually".

Despite its benefits, some students raised concerns about the limitations in reflecting functionality and structural aspects. As one student explained, "While Midjourney produced impressive visuals, it didn't address how the building would function structurally or the practicality of the design. I had to use CAD tools to check whether my design would actually work in terms of scale and materiality". Another echoed this concern, saying, "The software's focus on aesthetics often left me with designs that looked great but weren't feasible when I considered the building's actual purpose and the need for sustainable solutions".

Preferences for technology varied among students. One group of students appreciated the straightforward and intuitive interface of Midjourney. As one student stated, "The simplicity of the interface made it easy to use, especially when I just wanted quick visual feedback on my ideas".

Some students observed that while Midjourney allowed for rapid aesthetic experimentation, it sometimes detracted from the focus on practicality. "I loved how quickly I could create beautiful images", one student explained, "but I realized halfway through that I was getting too caught up in making the design look good without considering if it was functional or sustainable". Another noted, "I had to constantly remind myself that while Midjourney gives me a good visual start, I needed to switch back to technical software to ensure my design worked in real-world conditions."

A few students mentioned that the tool often focused more on the aesthetic elements rather than integrating sustainable or socially relevant factors into the design. "Midjourney made it easy to experiment with forms and styles", one student shared, "but I had to take extra steps outside the software to ensure my design was environmentally friendly and culturally appropriate for the location". In summary, students generally found Midjourney to

be a useful tool for boosting creativity and design efficiency. However, they also highlighted challenges, particularly in addressing the functionality and sustainability of their designs. Moving forward, future research should explore how Midjourney can be integrated with other tools to create a more comprehensive design process that balances visual appeal with practical application. The study involved a sample size of ten sophomore architecture students, all of whom were from the same academic institution. This limited sample size may restrict the generalizability of the findings to other educational contexts. Future research should involve a broader and more diverse participant pool to ensure that the results are representative of a wider range of students with varying backgrounds. While the findings of this study demonstrate that technologies like Midjourney can significantly enhance design education, further studies are needed to explore how these tools can be integrated across different educational levels and disciplines. The results from this small-scale study suggest a strong potential for broader applications, but additional research should confirm these findings across diverse educational environments.

7. Conclusions

7.1. Research Conclusions

This study conducted an empirical analysis to explore the specific effects of Midjourney intelligent drawing software on architectural design education, examining its impact on students' design abilities and innovative thinking. The results demonstrate that the software significantly benefits several key areas.

Enhancement of Design Efficiency and Expressive Capability

Midjourney significantly enhances students' design efficiency by providing instant high-quality images. Students can explore more design options and modifications in a shorter time frame. This rapid iteration process is crucial for unlocking students' design potential and elevating the creativity of their work. The software allows complex design concepts and forms to be visualized quickly, thus boosting students' confidence and capabilities in both technical and artistic expression.

Promotion of Innovative Thinking and Mastery of Technology

Using Midjourney, students have shown considerable improvement in design thinking and technical proficiency. The software not only sparks their interest in unconventional design approaches but also provides a platform for them to test and realize their innovative ideas without restrictions. This technological support enables students to break through traditional design limitations and explore cutting-edge architectural languages and strategies.

Improvement of Teaching Methods and Student Feedback

Midjourney has transformed traditional architectural design teaching methods, offering a new platform for interaction between teachers and students. Instructors can provide specific technical and stylistic guidance based directly on images generated by the software. This direct feedback mechanism is vital for students to understand and apply design principles. Moreover, the tool enhances the interactivity and engagement of the classroom, making the learning process more dynamic and appealing.

Support for Sustainable Design

Midjourney has also been explored for its potential to support sustainable design education. By generating design proposals that consider environmental factors, the software aids students in understanding and integrating sustainability principles such as natural light usage, energy efficiency, and sustainable material choices. However, the visual outputs from Midjourney should not be solely relied upon for determining the environmental performance of a design. It is essential that students use additional tools and methods, such as energy modeling or environmental impact assessments, to validate the sustainability of their designs. This ensures that the final outcomes meet both aesthetic and functional criteria, aligning with sustainability goals. This integration offers students a practical tool to innovatively address environmental challenges and enhances their ability to apply green technologies and strategies in their designs.

In conclusion, while Midjourney provides a powerful tool for rapid visual-concept generation, its use should be complemented with VR or AR technologies to offer a more interactive, immersive, and functionally detailed design experience. The integration of these technologies can significantly enhance the learning process, giving students a fuller understanding of their design's spatial and functional dynamics. Future educational models may benefit from combining Midjourney's visualization capabilities with the interactive qualities of VR and AR to provide a more comprehensive architectural design education.

7.2. Research Limitations and Future Directions

Although this study has revealed various positive applications for Midjourney in architectural design education, there are several non-negligible limitations that indicate some important directions for future research.

Expanding Research Samples and Environments

The current study is primarily based on a limited sample within a single educational institution. Future research should include a broader geographical and cultural background to ensure the universality and reliability of the results. By expanding the research sample, it is possible to gain a deeper understanding of Midjourney's effect in different educational settings and assess its potential for global educational impact.

Balancing Technology Use and Fundamental Educational Needs

Future studies need to explore how to utilize technological tools like Midjourney without sacrificing the foundation of traditional design education. Research should focus on how technology can complement, rather than replace, fundamental design teaching, ensuring that students can maintain and develop crucial manual skills and creative thinking while mastering high-tech tools.

Exploring Sustainability and Socio-Cultural Factors in Design

Given the increasing importance of socio-cultural and environmental impacts in design, future research should pay more attention to integrating these factors into education. Studies should assess Midjourney's capabilities for supporting sustainable and culturally sensitive design and explore how to improve the software to better meet those needs.

Developing Integrated Educational Models

Future research should develop and test integrated educational models that combine Midjourney with other educational technologies and methods. This includes using mixed reality, virtual reality, and other technologies to enhance the interactivity and practicality of design education, while also studying the specific impacts of these technological combinations on student learning outcomes.

Through these extensive studies, we can more comprehensively assess the role of intelligent drawing technology in architectural design education and provide educators with the knowledge and tools needed to support student development in a rapidly changing technological environment. These studies not only help to advance educational technology but also enable educators and students to meet future challenges in design and architecture more effectively.

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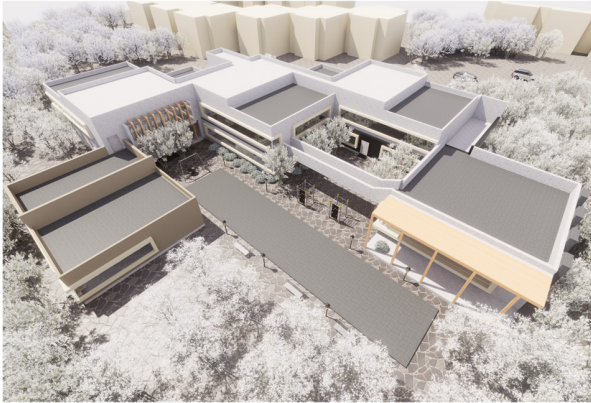
Data Availability Statement: Data are contained within the article and Appendix A.

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Appendix A

Student 1: The kindergarten primarily enrolls children aged 3 to 6, who are at a stage of life characterized by significant creativity and malleability in their thinking. My personal approach adopts the Reggio Emilia educational philosophy—there is no fixed curriculum, with the focus on fostering children’s initiative and creativity, which can better stimulate the limitless possibilities of preschoolers’ thinking. Similar to a tangram, where different shapes and sizes are pieced together to form a variety of unplanned figures, this approach can better nurture children’s creative thinking and hands-on abilities. The design concept utilizes the elements of a tangram—five isosceles right triangles (two small triangles, one medium triangle, and two large triangles), one square, and one parallelogram. These regularly shaped geometric forms create spatial light and shadow effects, and with the addition of different block colors, they better stimulate and guide children’s imagination.		
A figure from Midjourney	A figure from Midjourney	Final outcome by student
		
Student 2: The main structure of the kindergarten is designed in a honeycomb shape, with the northern section being two stories and the southern section being one story, ensuring ample natural light in the classrooms. Each classroom is connected by corridors, allowing food to be delivered to each class indoors. The kitchen is open and transparent, with low glass windows facing outside, so children can observe the meal preparation process. The dining area opens up to the outdoors, allowing children to feel as if they are dining in nature. The nap area is divided according to children’s living habits, offering more options for those who do not enjoy napping. The parent waiting area not only provides a temporary spot for children, parents, and visitors to rest and change shoes, but also serves as a convenient resting place for parents waiting to pick up their children after school. This thoughtful waiting area adds warmth to the space and reflects a nurturing educational philosophy. In addition, flowcharts on the walls can show the children’s daily activities, helping parents understand their child’s day and increasing trust in the kindergarten and its educational standards.		

A figure from Midjourney 	A figure from Midjourney 	Final outcome by student 
Student 3: The kindergarten design adopts cubic elements with the concept of creating a safe haven for children. Through cutting, stretching, and shifting the volumes, a functional architectural space is created. Children can safely explore, play happily with their peers, and grow together in this kindergarten. After entering through the main entrance, children can quickly access the building after passing through a small gathering space. Each part of the building is equipped with an adjacent activity space, and there is also a rooftop activity area on the upper floors. The kitchen is located inside the building, with a dedicated transportation route to avoid conflicts with the children’s movement. A designated drop-off and pick-up area for parents will be reserved near the building’s entrance.		
A figure from Midjourney 	A figure from Midjourney 	Final outcome by student 

Student 4: The kindergarten design introduces the concept of “vines,” incorporating an irregular platform around the exterior of the building that connects with the interior, providing children with an outdoor activity space. The internal spatial connections borrow from the shape of vines, making the interior more fluid and interesting, allowing children to freely move and play. Additionally, greenery planters are set up in areas where the interior and exterior spaces connect, enabling children to engage with nature. A central courtyard is designed to offer an outdoor activity environment, with features such as sand areas, running tracks, sports equipment, and playground facilities for the children to enjoy.		
A figure from Midjourney	A figure from Midjourney	Final outcome by student
		
Student 5: The projection distance from the activity rooms between floors is relatively far, which minimizes the children’s perception of different floor levels. The projection of the main indoor activity area on the second floor onto the first floor serves as the drop-off and pick-up area for parents. The kitchen is located on the first floor for convenient transportation of ingredients, with a cold storage room inside the kitchen and a meal delivery route situated at the back of the building. Each class’s rest area is connected to the activity area and has a separate restroom. To enter the building, one must first pass through the morning inspection area and the cloakroom. The multi-purpose activity area is located on the south side of the site, with the duty room positioned on the west side of the multi-purpose area. There is a semi-open east-west corridor on the second floor facing south. In the outdoor activity area, different colors are used to distinguish different activity zones.		

A figure from Midjourney	A figure from Midjourney	Final outcome by student
		
Student 6: The architectural design is organized by class units, with each class having a partially circular space. These circular spaces are interconnected, and the center of each ring is an outdoor space, mostly consisting of natural environments like grass. The design encourages children to engage with outdoor spaces, and the location is chosen to allow children to be as close as possible to natural elements like blue skies, white clouds, and pools of water. The idea is for children to encounter challenges during their interaction with these spaces, helping to foster problem-solving skills.		
A figure from Midjourney	A figure from Midjourney	Final outcome by student
		

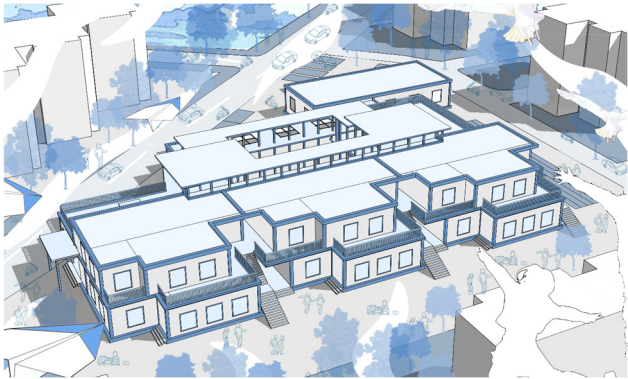
Student 7: The kindergarten has a total of six classes, with 20 to 25 children per class, and covers an area of approximately 1500 square meters. The site is an irregular polygon, with the main road located to the northwest of the site. The east and south sides are lined with trees and residential buildings, along with some small paths. The site enjoys good natural lighting, and the building reaches a maximum of two stories. The kindergarten’s functional areas are divided into class activity rooms, a multi-purpose activity room, service rooms, logistics rooms, outdoor activity spaces, and public activity rooms. Each class has a corresponding outdoor activity space.

The spatial layout of the kindergarten consists of several two-story buildings connected by corridors, forming a courtyard. The courtyard serves as an outdoor public activity area. The buildings are divided into child areas, logistics areas, and service areas, with separate functions but some overlap, such as teachers instructing children and the kitchen preparing meals. While the buildings are not originally strongly connected, the corridors enhance their connectivity, enriching the spatial experience.

The entrance to the school is on the west side, near the main road for easy access. The entrance corridor differs from the others, being taller and more spacious, while other parts are wider and used as activity rooms. Some corridors are narrower and interweave with others, while some recess inward, creating outdoor activity spaces. Thanks to the special design of the walls, these areas benefit from good lighting and shadow effects, making them popular spaces where children love to run around. Trees are planted both inside the courtyard and around the site, with some located close to classrooms and corridors, allowing children to feel the breeze and get closer to nature.

Near the main entrance, there are service buildings like the security office, followed by the kitchen. Next to the kitchen is a secondary entrance on the north side of the site, farther from the main entrance. This entrance is primarily used by kitchen staff and service vehicles, ensuring no interference with the children’s routes. Some parts of the second-floor corridor are open-air, some sections protrude, and some are close to the trees, allowing the children to experience nature. The courtyard is a combination of grass and rubber flooring. The circulation paths are divided into children’s paths, service paths, and kitchen paths, with the children’s paths being the main routes and the others serving as auxiliary routes. A long corridor within the courtyard leads directly to the second floor, with a gentle slope for easy access and views of the garden.

I envision this kindergarten as a natural space where children can fully experience nature and inherit cultural traditions. It is a fresh, fun, and enjoyable environment. The interior design is gentle and natural, with flowers, water features, trees, sand areas, climbing frames, nets, slides, and semi-hidden spaces for children to play in and explore.

A figure from Midjourney	A figure from Midjourney	Final outcome by student
		

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