The Impact of AI-Powered Platforms and Tools on Architectural Education

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Abstract

The integration of artificial intelligence AI into educational processes has been a topic of increasing interest across various disciplines. In the field of architecture, where creativity, design thinking, and technical proficiency are paramount, the use of AI-powered platforms and tools has the potential to reshape the education scape. This research aims to investigate the impact of using AI-powered platforms and tools on students' performance. The investigated platforms are Promeai and Midjourney and the case study was held on architectural design course. Through a comprehensive review of the literature, case studies, and surveys, this study seeks to provide insights into the transformative potential of AI in architectural education, shedding light on the opportunities and challenges it presents. This research follows a quantitative approach by gathering students' coursework marks that indicate their performance in the architectural design course. The paper also followed an analytical approach in which it held an analytical study of the student's performance through their marks in the coursework using traditional concept generation methods and the performance change after using AI-powered methods. The analytical method concluded that students' performance in architectural design courses was greatly upgraded after using AI tools. The students' performance upgrade was measured through a comparative study of their performance in the same project using traditional concept generation methods. The performance indicators concerning their marks were also compared against their marks in previous projects of the same size. The study's results emphasize the improvement in students' performance within their architectural design projects. This enhancement is observed both when employing the traditional schematic design method with traditional concept generation approaches and when utilizing AI tools. The research findings provide valuable insights that can guide educators, institutions, and policymakers in effectively leveraging AI to enhance the teaching methodologies of architectural design courses, thereby contributing to the overall advancement of architectural education.

Keywords

Artificial Intelligence (AI), Text-to-image, architecture education

الملخص:

لقد أصبح دمج الذكاء الاصطناعي (AI) في العمليات التعليمية موضوعًا يحظى باهتمام متزايد عبر مختلف التخصصات. في مجال الهندسة المعمارية، حيث يعتبر الإبداع والتفكير التصميمي والكفاءة التقنية أمرًا بالغ الأهمية، فإن استخدام المنصات والأدوات التي تعمل بالذكاء الاصطناعي لديه القدرة على إعادة تشكيل المشهد التعليمي. يهدف هذا البحث إلى دراسة تأثير استخدام المنصات والأدوات التي تعمل بالذكاء الاصطناعي على أداء الطلاب. المنصات التي تم فحصها هي Promeai و Midjourneyوقد تم إجراء دراسة الحالة على عملية التصميم بمقرر التصميم المعماري. من خلال مراجعة شاملة للأبحاث

السابقة ودراسات الحالة والاستطلاعات، تسعى هذه الدراسة إلى تقديم رؤى حول الإمكانات التحويلية للذكاء الاصطناعي في التعليم المعماري، وتسليط الضوء على الفرص والتحديات التي يطرحها. تسلط نتائج هذه الدراسة الضوء على الارتقاء في أداء الطلاب في مشاريع مقرر التصميم المعماري الخاصة بهم بعد استخدام أدوات ومنصات الذكاء الاصطناعي بمرحلة التصميم المبدئي وتم مقارنتها باستخدام الأساليب التقليدية. يمكن لنتائج هذا البحث أن تفيد الأساتذة والمؤسسات التعليمية وصانعي السياسات التعليمية في تسخير قوة الذكاء الاصطناعي لتعزيز التعليم المعماري.

أثبتت نتائج هذا البحث أن استخدام المنصات والأدوات المدعومة بالذكاء الاصطناعي في التعليم المعماري وخاصة في مقرر التصميم المعماري له تأثير مباشر على أداء الطلاب وفقًا لنتائج هذه الدراسة. تعتمد مرحلة التصميم المبدئي للمشاريع المعمارية بشكل أساسي على الإبداع والابتكار الذي يتم تعزيزه بشكل كبير باستخدام الذكاء الاصطناعي. إن استخدام أدوات الذكاء الاصطناعي لتحويل النص إلى صورة لديه القدرة على تغيير مستقبل التعليم المعماري من خلال تعزيز المزيد من الأفكار والمفاهيم الإبداعية في المراحل المبكرة من المشروع. يمكن أن يغير بشكل كبير تعليم التصميم من خلال تقديم وجهات نظر جديدة.

1. Introduction

Artificial intelligence (AI) has sparked substantial changes in many disciplines due to its computational skills, which improve on established procedures and encourage novel ideas. From the conceptual phase to the execution of projects, architecture stands out as one of the industries making use of AI's disruptive potential [1]. AI is becoming acknowledged in the field of architecture as a revolutionary instructional tool in addition to its function in design generation. With its ability to see unbuilt ideas and comprehend design principles, AI delivers a learning experience that goes beyond typical design studio techniques [2]. The use of artificial intelligence (AI) in architectural design has increasingly become essential, pushing the bounds of what is feasible and redefining traditional design approaches to become cutting-edge, forward-looking ones [3]. The process of building design requires creative and intellectual skills to generate the optimum shape, mass, and all elements. Integrating artificial intelligence tools to enhance the design process, especially in the conceptual phase is a leap towards enhancing the quality of the architectural product [4].

1.1 Artificial Intelligence in Architectural Education

Artificial intelligence (AI) has a great impact revolutionizing several industries, and its use in education has drawn a lot of interest. The function of AI in education is examined in this literature review, focusing on its implications for the study of architecture. We may better comprehend the revolutionary potential of this technology by looking at the current state of AI in educational settings and its prospective impact on architectural students and educators. According to Gopal, Singh, and Aggrawal, The appearance and consistency of online platforms have a great influence on the students and their academic success [5].

According to Siemens & Baker- 2012, One of the key advantages of AI in education is its ability to personalize learning experiences. Adaptive learning platforms use AI algorithms to analyze students' strengths and weaknesses, tailoring content and assessments to individual needs Such personalization can lead to improved student engagement and learning outcomes [6]. As Balfour & Pepper- 2016 mentioned, Chatbots and virtual assistants that are driven by AI provide instant support to students and educators in answering common questions, providing explanations and guiding learners. This can aid students in navigating complex design software and better interpreting architectural concepts [7]. The use of AI in architecture has been studied by several academic institutions, including The Massachusetts Institute of Technology (MIT), which did so through courses like "How to Make (Almost) Anything." They have combined

manufacturing and AI-driven tools to enable students to design cutting-edge architectural prototypes [8]. The Royal Institute of British Architects (RIBA) also used AI to create a design studio toolset that helps students during the initial stages of design. Students can create design variations and comprehend the effects of various parameters thanks to this toolbox [9]. The potential of using AI in the field of architecture has shown great performance that sometimes exceeds the quality of human performance in terms of creating attractive designs [10]. As Lopes, et al stated in their research, Generative design as a branch of AI, enables architects to specify limits and goals they aim to get while algorithms produce several design alternatives that allow students to quickly explore a variety of design options which enhances creativity and innovation [11]. Moreover, Designers are provided with new perspectives and design concepts when they use AI tools as it provides easier data processing, generates innovative solutions to issues, and enhances creativity[12]. Chen & Liu have identified that Visualization and simulation play a big role in architectural education when it comes to explaining design ideas. With the help of AI-powered rendering and simulation tools, students may better comprehend their designs by creating photorealistic pictures and simulating real-world settings. These technologies also make it easier to investigate environmental and sustainability issues in architecture [13].

While incorporating AI into architectural education has many benefits, there are drawbacks as well. In some educational institutions, access to AI technologies and expertise may be restricted, which might lead to significant discrepancies among students. The quick rate of technological development also calls for ongoing curriculum changes and teacher development. It is imperative to address these issues in AI-driven architecture education [14].

1.2 AI-Powered Tools and Platforms

There is a wide range of AI application categories, such as Text-to-Text, Text-to-Image, Image-to-Image, Image-to-Text. Applications for Text-to-Text AI create text from input text or translate text between languages. These programs make use of natural language processing (NLP) methods to comprehend and produce text that resembles that of a person. One well-known example is GPT-3, which can produce text that resembles human speech in response to a cue. It is employed in many different applications, including code production, language translation, chatbots, and content creation [15]. Generating visuals from text has been made possible due to the recent advances in AI algorithms. This method has enabled the creation a wide variety of images and visuals that are so realistic and creative. The text-to-image technique is a very widely used AI technique nowadays due to the variety, creativity, and reality of the visuals it produces [16]. Creating visuals using AI isn't only about 2D but also extended to 3D generation for immersive experiences that allow users to examine the whole design and get immersed into such an experience. Thise visuals create visually appealing designs that can be used in the conceptual designs to examine a variety of creative options and concepts that are beyond the creativity abilities of one person while providing novel solutions [17]. According to Ringvold et al., AI text-to-image generation starts with idea, articulation, prompt, and then the result which will be further refined and adapted to get more suitable results. It is an iterative process that consists of different stages as shown in Figure 1 [18].

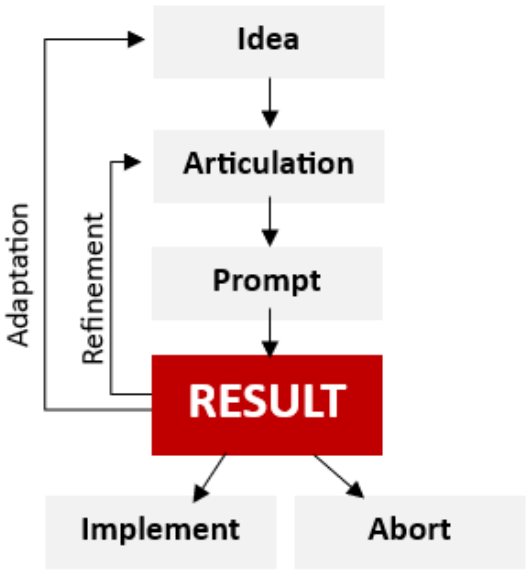

Fig.1: AI text-to-image generation flowchart

Image-to-Image AI applications manipulate or generate images from existing visual data. CycleGAN is an example of this category. It can transform images from one domain to another. For instance, it can convert photos of horses into zebras or daytime scenes into nighttime scenes. Applications include style transfer, image enhancement, and domain adaptation in computer vision tasks [9].

2. Methods

2.1 Research Design and Setting

The study focuses on investigating the impact of AI-powered platforms and tools, specifically PromeAI and Midjourney on student' performance in architectural design course. The research case study was conducted at the department of architecture, The Higher Institute of Engineering in Shorouk City.

2.2 Participants

Fifty second-year architecture students participated in the case study, focusing on a residential-detached villa project.

2.3 Data Collection

The case study employed a quantitative study methodology to quantify the impact of using AI tools in the pre-design phase of architectural design projects on students' performance. The data collection spanned over two weeks. In week 1, students used conventional methods such as sketching and study model building, and the work was evaluated based on architectural design studio evaluation criteria. In week 2, students were introduced to AI-generated platforms and tools using the text-to-image method and then their ideas were evaluated on the same evaluation criteria.

2.4 Statistical analysis

Students' average performance was calculated for each criterion and then a comparative analysis was conducted to assess the impact of using AI on students' performance.

3. Case study

The case study methodology employed in this study follows a quantitative approach allowing for the quantification of the gathered data to give indicators about the impact on students' performance represented on their evaluation according to the architectural design studio evaluation criteria.

3.1 Case Study Sample

The case study was a class of an architectural design studio of 50 students in their second year of architecture department. The project is a residential-detached villa.

3.2 Data collection

The quantitative study methodology involved a two-week data collection period. In the first week, students utilized conventional methods for the pre-design phase, such as sketching and study model building. Their work was evaluated based on architectural design studio criteria. In the second week, students were introduced to [AI-generated platforms, specifically PromeAI and Midjourney], using the Text-to-Image method. The ideas generated were then evaluated using the same criteria.

As shown in figure 2, Architectural design courses serve as practical laboratories for students, offering a platform where theoretical and practical aspects of the architectural curriculum are integrated and synthesized. Rooted in core disciplines like "Building Science," "Construction Science," and "Historical Conservation and Architectural History Styles," architectural education is structured around these foundational courses and their sub-branches. The synthesis of these theory-based disciplines is actively practiced in Architectural Design Courses, which serve as prerequisites. Throughout each semester, students engage in building projects aligned with their academic levels,. These projects, evaluated through the lens of "Form," "Function," and "Construction," are essential universal criteria shaping the assessment of any architectural design [^{2}]. ^{0}

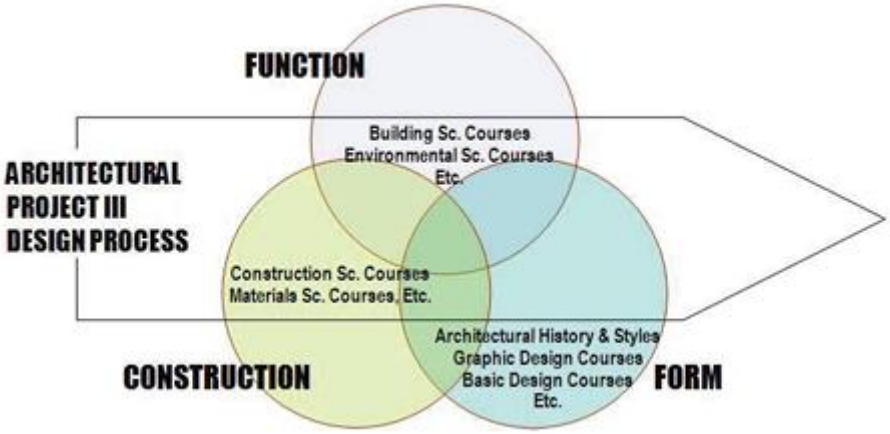

Fig. (2): Architectural project Education Curriculum

Students in the architectural design studio are involved in the Pre-design and research phase, schematic design phase, and design development phase. In the Pre-design and research phase, they work on program analysis where they understand and analyze the requirements of the projects, site analysis where they evaluate the characteristics and constraints of the project site and examine and analyze existing similar projects and designs that are relevant to the project.

In the schematic design phase, students work on conceptualization where they develop the initial design idea and concepts, space planning where they arrange spaces and functions within the design and sketching and diagramming their ideas through drawings and diagrams. In the design development phase, students work on the refinement where they iterate and refine the chosen design concepts, materials, and systems selection where they explore materials and construction systems, and develop a more detailed version of the project considering scale and proportions. The case study is concerned with the ideas and designs generated at the pre-design phase as shown in Figure 3.

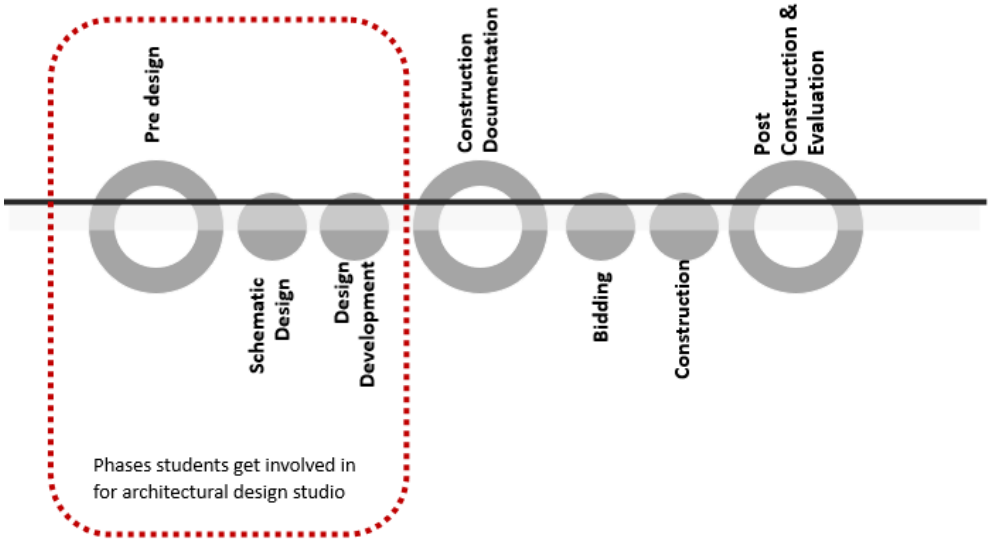

Fig.3: Architectural projects timeline for undergraduate design studios

3.3 Evaluation Criteria

According to Özer H., (1989), students architectural design projects are evaluated on three main conceptual criteria which are form, function and construction [2]. The details of these criteria are shown in figure 3. Arcan E. F.; Uzunoglu K stated in their research that the evaluation of students' performance in architectural design projects must include the following concept evaluation list; research, building mass, program adaptability, studio sketches, details and finishes, concept presentation and technical drawings [2]. The evaluation criteria is shown in figure 4.

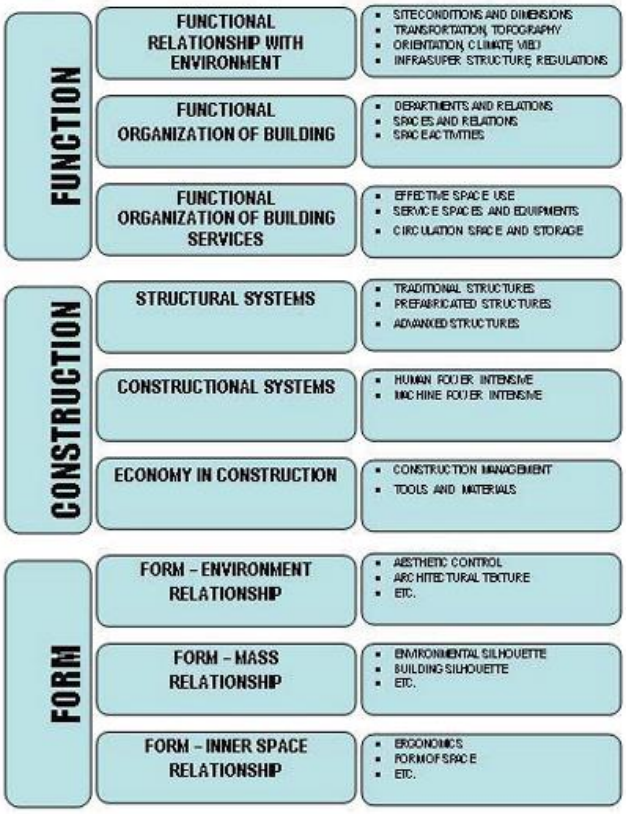

Fig. (4): assessment criteria of form, function

STAGES	CONCEPT EVALUATION LIST	ARCHITECTURAL DESIGN EVALUATION CRITERIA			DESCRIPTION NOTES	NUMERICAL GRADE	AVERAGE GRADE	CHECK LISTS (Technical Drawings)
		FORM	FUNCTION	CONSTRUCT.				
1st STAGE (15%) (environment - mass)	•analytic research					5%		•project research •project analysis •concept •prog. Suitability •site plan •floor plans •ground floor pl. •sections •elevations •system details •silhouettes •mass model •present. Techniq.
	•environment design					5%		
	•building mass					5%		
2nd STAGE (25%) (space organization)	•program adaptability					5%		
	•inner space organiz.					5%		
	•outer space organiz.					5%		
	•studio sketches					10%		
3rd STAGE (20%) (finishes - presentation)	•attendance-interest					10%		
	•details - finishes					5%		
	•technical draving					5%		
4th STAGE (40%) (final evaluation)	•concept-present.					10%		
	•final submis. (compulsory phase)					30%		
SIGNS	Jury Chairman	Jury Member		Jury Member	Jury Member	FINAL GRADE		CONTROL NOTES

Fig.5: architectural project evaluation form

According to previous research, the evaluation criteria of architectural design projects contain four main stages that are presented through three main criteria which are; form, function and construction. Each concept in each stage is represented by a numerical grade assigned to it according to specific weights showing their significance.

The evaluation process is conducted by one jury panel consisting of five architectural design professors. All professors hold a doctorate in architectural engineering and specialize in teaching architectural design courses. The evaluation process is a transparent process where each member of the jury panel can provide their opinions and insights.

As shown in Table 1, building mass evaluation criteria that is graded for 5% is directly affected by using AI tools in the first stage of students' projects' evaluation. Studio sketches design criteria that is graded for 10 % is also affected. Both concept presentation and final submission are greatly affected by the early design stages and they account for 10% and 30 % respectively as evaluation criteria. The affected evaluation criteria represent a weight of 55% of the total numerical weight of all evaluation criteria.

Table (1): the evaluation criteria that are affected by using AI tools for concept generation

stages	concept evaluation list	Architectural design evaluation criteria			numerical grade	average grade
		Form	Function	Construction		
First stage 15% (environment & mass)	analytic research				5%	
	environmental design				5%	
	building mass				5%	
Second stage 25% (space organization)	program adaptability				5%	
	inner space organizing				5%	
	outer space organizing				5%	
	studio sketches				10%	
Third stage 20% (finishes, presentation)	attendance interest				10%	
	details finishes				5%	
	technical drawing				5%	
Fourth stage 40% (final evaluation)	concept presentation				10%	
	final submission				30%	

As the case study is applied to students from architecture department, Shorouk Academy. The evaluation criteria for architectural design courses is based on how much students have achieved the courses Learning outcomes. These criteria are summarized in the following points:

1- **Creativity and innovation** Evaluate the degree of originality and creative thinking demonstrated in the architectural design project. Consider unique solutions, imaginative concepts, and innovative approaches that showcase the student's creativity.

2- **Presentation** Evaluate the clarity and effectiveness of the design presentation. Consider the quality of drawings, diagrams, and other visual aids used to communicate the design concept to others.
3- **Functionality** Assess how well the architectural design meets its intended purpose and functionality. Evaluate the efficiency of space utilization, the flow of traffic, and the overall usability of the building.
4- **Context and site integration** Evaluate how well the design fits into its surrounding environment. Consider the building's impact on the community, its relation to neighboring structures, and how it utilizes the site's natural features.
5- **Sustainability** Assess the environmental impact of the design, including energy efficiency, use of sustainable materials, and incorporation of eco-friendly technologies to ensure long-term environmental responsibility.
6- **Aesthetics** Consider the visual appeal and creativity of the design. Evaluate the harmony of architectural elements, the use of color, texture, and materials, and how well the design complements its surroundings.

3.4 Students' work samples

Figures 6 and 7 show the samples of students' work for architectural design projects in the pre-design phase. At this stage, students are asked to submit sketches, 3D models, or perspective ideas of their buildings that fit the project program and requirements. They analyze the given conditions and constraints and set a framework for their project that matches the project program.

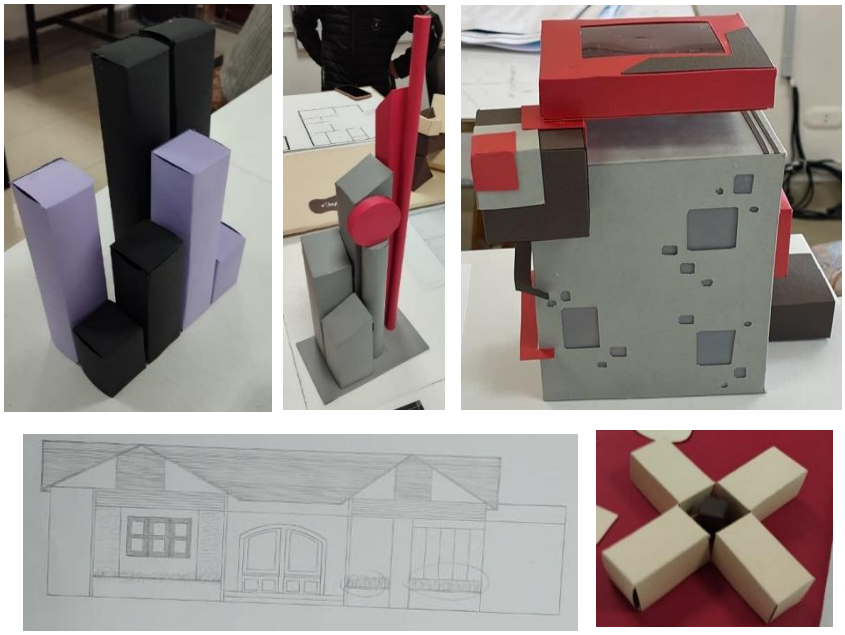

Fig. 6: Samples of Traditionally generated architectural design concepts by students for the villa project

Fig. 7: Samples of AI-generated architectural design ideas by students for villa project

4. Results and Discussion

Effect of using AI-powered platforms and tools on students' performance in Statistics

The case study of this research paper will apply the evaluation criteria from two significant sources. The first evaluation criteria from the literature review which divided the architectural design project into stages, and the second evaluation criteria from Shorouk academy architectural design course evaluation criteria which is based on the course learning outcomes.

Table 2: Students' Average evaluation in traditional method VS AI-powered method (using the first evaluation criteria)

	Building mass	Studio sketches	Concept presentation	Final submission
Traditional	30%	46%	43%	40%
AI-powered	78%	60%	61%	70%

Through the first evaluation criteria, students' performance was enhanced in all the relevant stages. In the building massing, it increased by 43% after using AI tools. Studio sketches were enhanced by 14%, concept presentations by 18% and the final submission by 30%. The overall enhancement in students' performance according to this evaluation criteria is 27%.

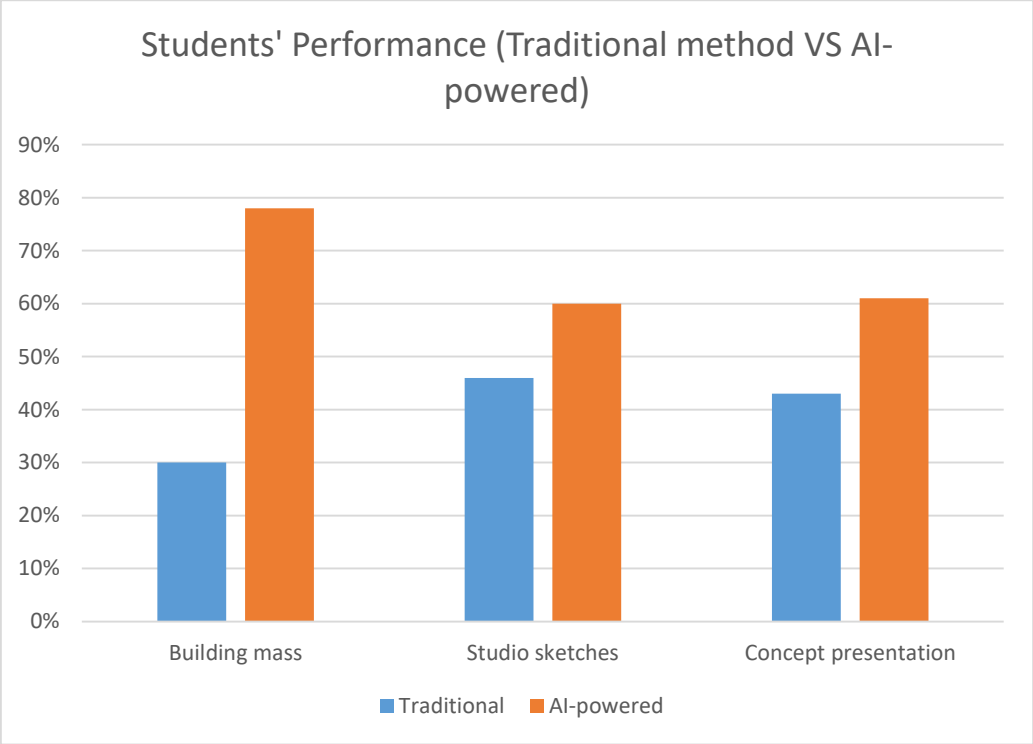

Fig. 8: the difference in students' evaluation criteria showing their performance in the traditional method VS AI-powered method (using first evaluation criteria)

By using the second evaluation criteria and as shown in table 3 and figure 9, students' overall average performance was enhanced by 16% after using AI-powered platforms in the pre-design phase of the architectural design project. According to the evaluation criteria of students, some criteria were greatly affected by the use of AI, and some other criteria were slightly affected. The greatest enhancement was obvious in the creativity and innovation criterion which was improved by 42%, the presentation criterion was enhanced by 17%, Functionality was slightly improved by 2%, Context and site integration was improved by 6%m Sustainability was improved by 3% and Aesthetics criterion, the second greatly affected criterion was improved by 26% as shown in table 3 and figure 9.

Table 3: Students' Average evaluation in traditional method VS AI-powered method (using second evaluation criteria)

	Creativity and innovation	Presentation	Functionality	Context and site integration	Sustainability	Aesthetics
Traditional	34%	44%	67%	71%	56%	42%
AI-powered	76%	61%	69%	77%	59%	68%

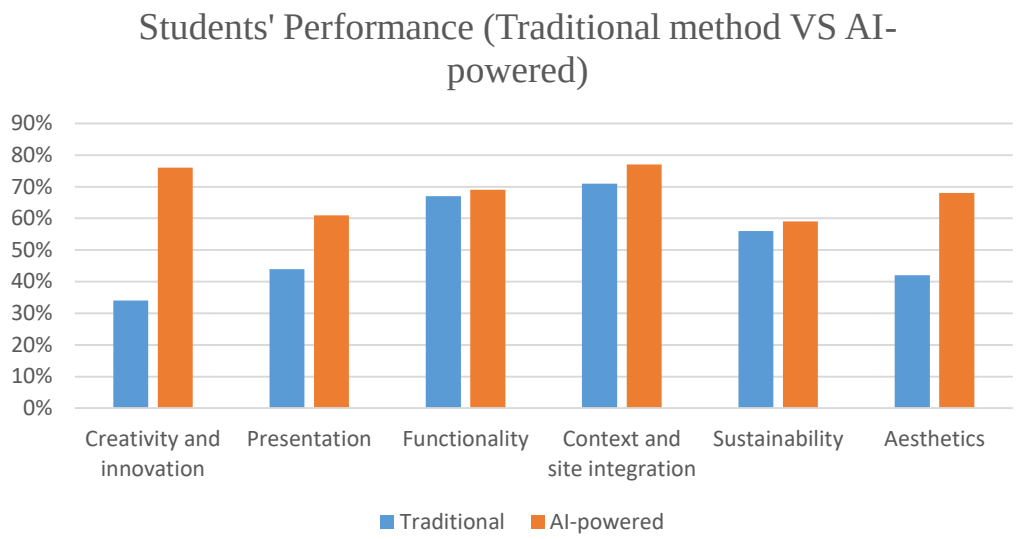

Fig. 9: the difference in students' evaluation criteria showing their performance in the traditional method VS AI-powered method (using second evaluation criteria)

As a final step in assessing the upgrade in students' performance after using AI tools, the average grades of students in all previous architectural design projects were compared against the grades in the case study project after using AI tools. The average grade in the students on whom the case study was conducted was 64%, while the average grade in the case study project after using AI tools was 83 % which indicated an upgrade of 19% in the average overall performance of students from the previous projects where they only used the traditional tools as shown in table 4.

Table 4: Students' Average grades in previous architectural design projects against average grades in case study projects after using AI tools

	average grades
cumulative average grades in architectural design projects	64%
Average grades in case study project using AI tools	83%

5. Conclusions

Utilizing AI-powered platforms and tools in architectural education has a direct impact on students' performance according to the findings of this study. The predesign phase of architectural projects depends mainly on creativity and innovation which is greatly enhanced by using AI. Using text-to-image AI tools has the potential to change the future of architectural education by enhancing more creative ideas and concepts at early project stages. It could significantly alter design education offering new perspectives. Using AI tools and platforms upgraded the overall performance of students in the architectural design course by 19% which is a significant upgrade. This study indicated the great potential of using AI in architectural design courses and recommends widening the scope of its use to cover more phases of the architectural design process and more courses and curricula.

It is recommended that more extensive research should address different AI tools and different methods such as image-to-image and investigate their effect on the student's academic performance in order to help educators in the field of architecture to harness the power of AI to

enhance students' performance and the whole educational process. It is also recommended that more research should shed light on the extent to which using AI tools might limit the creativity of architecture students.

List of Abbreviations:

AI Artificial Intelligence

3D Three dimensional

Declarations:

Availability of data and materials: All relevant data are included within the manuscript

Competing interests: The author declares no conflict of interest.

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