

# Artificial Intelligence Applications in Green Architecture

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## Abstract

Green architecture is the process of designing buildings with ideas that preserve the surrounding environment, while artificial intelligence provides unlimited design ideas and various alternatives for applying the principles of green architecture. Artificial intelligence also helps measure energy use in buildings for energy conservation, heating, cooling, lighting, sensor systems, data mining, emissions reduction, and waste management. Thus, it can help achieve the principles of green architecture. Some buildings were designed using a combination of BIM and AI. The research aimed at identifying the role of artificial intelligence and benefiting from it to apply the principles of green architecture by examining the concept of artificial intelligence, its role in architecture, and the most important applications that can be used to apply those principles, such as architecture applications (ARKDESIGN.AI). In addition, the research aimed at measuring the architects' opinions regarding the role of artificial intelligence in achieving the principles of green architecture by using a questionnaire. The research results indicated that artificial intelligence currently has the potential to revolutionise the field of sustainable design, but it requires human assistance. Furthermore, it was concluded that it is important to understand the benefits of artificial intelligence and employ it to apply the principles of green architecture.

## Keywords

Artificial Intelligence Programs, Green Architecture

## 1. Introduction

Artificial intelligence can perform many tasks during the architectural design process, so it is necessary to understand this technology and its advantages and disadvantages, especially for those concerned with environmental and sustainable aspects. AI-generated designs focus on providing individuals with comfort. They also highlight conserving the environment. Moreover, they help mitigate the negative impact of climate change by making use of data inputs, for example, weather, temperature, humidity, etc.

AI-generated designs, by proposing multiple and different solutions resulting from their ability to receive a large amount of data continuously, generating dynamic, accurate, and appropriate simulations, modifying strategies and proposals, enabling decision-making, and transferring them into design principles, The research suggests that it can harness the power of artificial intelligence and change traditional workflows, especially in the early stages of a project, to provide quick and attractive alternatives as a benefit to architects. The research problem is how to benefit and

activate the role of artificial intelligence and benefit from it to apply the principles of green architecture.

The research aims at studying the concept of artificial intelligence in architecture, in general, and green architecture, in particular, to analyze and extract the most important environmental trends using artificial intelligence to provide thermal comfort for users and provide energy to adopt the principles of green architecture, and measure architects' views on artificial intelligence.

To achieve the research aims, a methodology was followed, (Figure 1) which divides the research into three parts as follows: the first part follows the inductive approach in its theoretical framework with a comprehensive study of the available literature.

The second part follows the deductive analytical approach to the role of artificial intelligence in green architecture and the vision of architects towards artificial intelligence in green architecture (questionnaire). The third part includes the most important results and recommendations. Most results were identified in relation to how artificial intelligence will affect green building and its guiding principles. Perhaps most objections, reluctance, and ambiguity, either its positive or negative outcomes, are attributable to the fact that it is a contemporary trend that has not been applied widely yet or that it is applied in a small number of buildings.

## 2. Artificial Intelligence Definition:

- Artificial intelligence is defined as designing and building intelligent algorithms and elements that consider the surrounding environment data. AI has changed from just a tool for functional improvement to a resource for design inspiration<sup>1</sup>. Artificial intelligence is designed to simulate human intelligence and human thinking; for example, in designing standard rooms, dealing with repetitive work, analysing design, finding inconsistencies, discovering errors, correcting them before causing damage, and proposing alternative solutions that save time.<sup>23</sup>
- Artificial intelligence (AI) refers to a certain set of computing methods that enable systems to do a variety of tasks that were previously assumed to require human intelligence.<sup>4</sup>

- The Egyptian strategy vision for artificial intelligence is concerned with using artificial intelligence technologies to support the achievement of sustainable development goals in Egypt for the benefit of all Egyptians.<sup>5</sup>
- Previous studies did not neglect the relationship between modern architectural trends and artificial intelligence. In a study focused on the role of artificial intelligence in mitigating climate change and the role of AI in managing the biomimetic database and weather data, it concluded the importance of artificial intelligence (AI) programmers in taking advantage of variables and inputs, creating algorithms, automatically updating databases, providing scenarios, making decisions, and reducing time consumption. Thus, the designer is interested in overriding results that do not start from scratch. In addition to combining random biomimetic data and models that evolve over time, interdisciplinary and climatic changes are needed to develop more efficient solutions.<sup>6</sup>
- Another study was carried out to focus on the evolution of the role of artificial intelligence in architectural design. It concluded that artificial intelligence could inspire and enhance architectural design, but it must be used ethically and responsibly to avoid negative effects on human creativity and design ethics.<sup>7</sup>
- In a study, based on the role of artificial intelligence techniques for conceptual design problems in architecture, it is clear that research on artificial intelligence has increased since 2015 as it helps solve architectural design problems and produce more complex shapes by a percentage of 85%.<sup>8</sup>
- Since 2003, genetic algorithms (GAs) have been used to create a building form with çades from an interface that enables designers to create initial CAD solutions and display modified GA solutions, leading to environmental solutions.

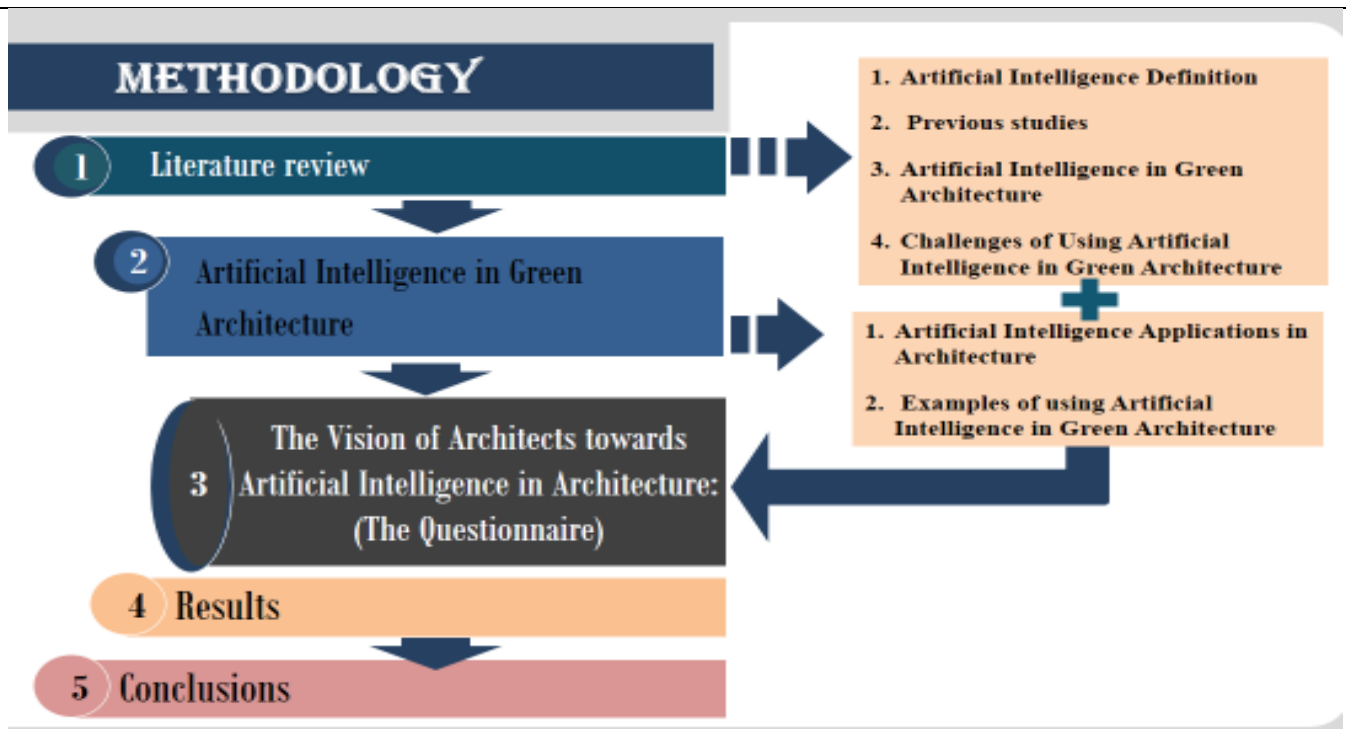


Figure 1 The Research Methodology (Source: Researchers)

### 3. Artificial Intelligence in Green Architecture

Artificial intelligence in architecture is possible to improve efficiency in the use of materials, time, and costs. In addition, it helps improve the quality of designs and develop them in an advanced way. It improves sustainability and safety in construction as well. Generating images with artificial intelligence to revisit traditional architectural styles by merging them with newer styles or using design elements from traditional styles in more futuristic and streamlined forms.<sup>910</sup>

In a study based on understanding the architect's role in the artificial intelligence era: "AIA Approach in Egypt", a questionnaire was administered to some architects, and analysis were carried out to understand the possibilities of applying artificial intelligence in architecture, especially in Egypt. Only 24% of the participants used AI techniques in the design process. Most participants (62%) believed that AI can be used effectively in exhibition and museum projects as it is. Administrative buildings and healthcare are in second place (55%), followed by airports (52%). AI can help design residential and educational buildings (47%). About 76% of them believed that the design process was the most important aspect that AI could be involved in. While 25% of the participants believed that energy use was an essential aspect, the construction stage and material selection are in the last place, according to the professionals' point of view.<sup>11</sup> The study can summarize the effect of artificial intelligence on green architecture as:

#### 3.1. Reduces waste and pollution

Artificial intelligence can be used to develop self-construction technologies, which help reduce costs and increase efficiency in construction operations.

- Artificial intelligence can be used to design buildings

in a way that improves the use of available resources and reduces waste and pollution, which helps achieve the sustainable goals of the urban project.<sup>12</sup>

### 3.2. Quality

Artificial intelligence can be used to analysis data and improve the quality of designs and materials used in construction, which helps to improve the quality, durability, and general appearance of buildings.<sup>1314</sup>

- Automation Architectural Design: Artificial intelligence can be used to design buildings and their surroundings in a responsive way, which means creating buildings that adapt to the weather and natural conditions.<sup>151617</sup>
- Virtualization: Artificial intelligence can be used to create virtual models<sup>18</sup> of buildings and their surroundings and analysis these models to improve design and construction.<sup>1920</sup>
- Smart Maintenance: Artificial intelligence can be used to analysis data related to building maintenance and provide smart solutions for maintenance and fault repair.<sup>21</sup>
- Intelligent Sensing: Intelligent sensing and machine learning can be used to collect data related to weather conditions, thermal conditioning, lighting, and security, and analysis this data to improve the efficiency of resource use in buildings.

### 3.3. Safety

Artificial intelligence can be used to analysis weather and ground conditions and predict natural disasters and other accidents, which helps improve safety in buildings and reduce risks.

### 3.4. Energy Efficiency

Artificial intelligence can be used to design engineering systems for buildings, analysis energy and heat use, and improve heating, cooling, and lighting efficiency.<sup>22</sup>

- Data Analysis: Artificial intelligence can be used to analysis data related to buildings and their surrounding areas and provide accurate information that helps make the right decisions regarding the design and construction of buildings.<sup>23</sup>

### 3.5. Indoor environmental quality

Artificial intelligence can be used to analysis the individual needs of customers and design interior spaces that meet their needs and provide them with comfort and benefit.<sup>2425</sup>

## 4. ARTIFICIAL INTELLIGENCE TYPES USED IN GREEN ARCHITECTURE:

There are many types of artificial intelligence used in architecture, such as:

- Computer-Assisted Engineering Design: Artificial intelligence is used to design buildings and engineering structures more accurately and quickly using advanced computer programs that rely on artificial intelligence techniques to analysis data and identify variables affecting building design.
- Automation in Construction: Artificial intelligence is used to improve the construction process and reduce errors and costs associated with it by depending on robots and advanced equipment that operate independently and using artificial intelligence techniques to analysis data and make appropriate decisions.
- Security and Safety in Buildings: Artificial intelligence can be used to improve security and safety in buildings by analysing data related to the built environment, predicting potential risks and taking appropriate preventive measures.

## 5. Challenges of Using Artificial Intelligence in Green Architecture

There are some challenges of using artificial intelligence in the architecture field as it follows:

- The ability to analysis large and diverse data and ensure the security and privacy of data related to design and construction. In addition, the use of artificial intelligence requires specialized training for engineers and designers to analysis data and understand how to use the available tools and technologies. There is also a need to train designers and engineers to use the various available technologies,

- Ensuring the security and privacy of data related to design and construction: Appropriate goals for the use of artificial intelligence in urban project must be set, and variables affecting design and construction must be identified.
- Data Quality: Renewable energy suffers from a lack of accurate and sufficient data at times, which poses a challenge to the use of artificial intelligence techniques.
- Investments: Artificial intelligence technologies require large investments in infrastructure, training, and development. This represents a challenge for companies and small and medium enterprises operating in the renewable energy sector.
- Legal and Legislative Challenges: There are some legal and legislative challenges in the use of artificial intelligence technologies in the renewable energy sector, especially with regard to data protection, privacy, and intellectual property rights.
- Predictability: The renewable energy sector needs the ability to predict production, consumption, and storage. This causes a challenge to artificial intelligence techniques that rely on previous data to predict the future.
- Compatibility with Current Technologies: Artificial intelligence technologies must be compatible with current technologies in the renewable energy sector. This requires the development of integrated technologies that are compatible with current systems.
- Investments: Artificial intelligence technologies require large investments in infrastructure, training, and development. This represents a challenge for companies and small and medium enterprises operating in the renewable energy sector.
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- Predictability: The renewable energy sector needs the ability to predict production, consumption, and storage. This is considered a challenge to artificial intelligence techniques that rely on previous data to predict the future.

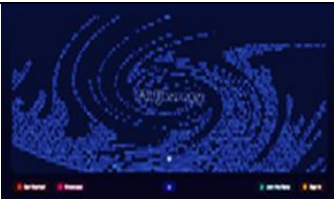


- Compatibility with Current Technologies: Artificial intelligence technologies must be compatible with current technologies in the renewable energy sector, and this requires the development of integrated technologies that are compatible with current systems.<sup>26</sup>

## 6. Artificial Intelligence Applications in Architecture

Programs, based on BIM System (Building Information Modelling), are considered among the first applications of artificial intelligence systems in architecture, such as Navisworks and Revit. These programs, in relation to the art of architecture, deal with designs and process their data, as it has become necessary to deal with them as a single building with interconnected elements and not just lines that are entered into the computer. The entered design turns into elements with engineering and architectural implications whose quantities can be counted, their costs calculated, and dealt with.

One of the applications of artificial intelligence in architecture is the Midjourney Dall-E-Mini site. As these sites are based on entering an accurate description of everything that engineers or designers imagine for obtaining accurate designs, they provide many suggestions for one description. There are many artificial intelligence programs and today it is impossible to identify their number. Every day there are new applications, such as: ARCHITEChTURES , ArkDesign.ai ,Sidewalk Labs , Kaedim Sloyd.AI , Midjourney , Adobe Firefly , Maket.ai , Autodesk Forma , and, BricsCAD BIM. The following are some of the most famous programs (Table 1):

Table 1. Artificial Intelligence Applications ( Source: Researchers)

Application Name	Description	Type	Principles of Green Architecture
<b>The Best AI Tools for Concept Design</b>			
 Midjourney27	The program converts text into images and various designs. Midjourney is an independent research laboratory that explores new avenues of thought and expands the imaginative powers of the human species; focusing on human design and infrastructure.	Online Program:	It does not perform environmental simulations, but it produces various innovative forms of shading system and other environmental treatments.
 Adobe Firefly (beta)28	Through using the program, the text is converted into an image. The program produces various and innovative graphics; both static and dynamic. It is a component of the Adobe Suite.	Online Program:	It does not perform environmental simulations, but it produces various innovative forms of shading system and other environmental treatments.
<b>The Best AI Tool for Generating Design Alternatives</b>			
 Maket.ai29	Maket.ai: A launchpad that can offer different design options. Maket.ai saves time for architects by taking over the time-consuming work of creating design options, allowing them to focus more on client interaction and creativity. It also helps implement zoning studies, and make sure that projects abide by the rules. It answers questions on zoning in a timely manner and ascertains that projects adhere to zoning laws and regulations, simplifying interactions with legal documents.	Online Program:	<b>Building codes can be uploaded and committed in the design, which helps in designing the lighting and ventilation rates.</b>
<b>The Best AI Tool for Renovation Projects</b>			
Luma.ai30	Luma. AI: It is an innovator in 3D scanning and modelling that is driven by artificial intelligence. This platform creates highly detailed 3D models that are reimaged. It enables architects to fully understand structures, furnishings, or complex architectural designs.  Luma.AI is used in reconstruction and restoration projects because it can create virtual twins of existing structures and capture them with amazing accuracy. It connects the physical and digital worlds, enabling the architects to visualize the renovated building even before the start.	Platform:	It does not perform environmental simulations, but it produces various innovative forms of shading system and other environmental treatments.
promelai.31	an AI-powered design assistant that help bring creative ideas and Create stunning designs with extensive controllable AIGC (C-AIGC) model style library. Image to Sketch: create a line drawing effect from an image. Erase and Replace: any area that need adjustment Image Variation: Produce visuals with	Online Program:	It does not perform environmental simulations, but it produces various innovative forms of shading system and other environmental treatments.

comparable perspectives, styles, layouts, and sensory details.

Relight: Relighting improves the brightness of the image.

AI Image Generation: Create beautiful art, illustrations, drawings, paintings, and images by transforming words into an amazing AI-generated image.

The Best AI Tool for Sustainable Design



Autodesk Forma32

Autodesk Forma: It is a comprehensive AI-powered planning tool that gives architects and urban planners the power to design sustainable communities. Autodesk Forma collaborates with AutoCAD and Revit and runs on a cloud-based platform, making it easy to use from anywhere. In order to avoid expensive corrections in the future, Autodesk Forma is equipped to help spot any design flaws before implementation. stimulates the production of sustainable designs, as well as time and money efficiency. Autodesk Forma, formerly known as Spacemaker, helps planning and design teams deliver projects digitally from day one.

Cloud-Based Platform

To improve the sustainability and vitality of projects; such as energy consumption, traffic flow, and air quality.

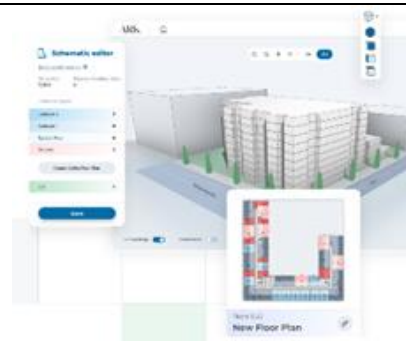


Architecture33

The Program: Architecture software has revolutionised residential planning. Site planning increases efficiency and simplifies the engineer's decision-making process. Architecture examines site conditions, climate dynamics, financial constraints, and client expectations. Building design that includes room sizes, window placements, and the selection of sustainable materials Architecture enables precision and easy adjustment. It reveals a wide range of design possibilities while beautifully balancing form and function to achieve architectural ideals through automation.

Online program

It simulates site conditions, climatic dynamics, window locations, and sustainable materials.



ArkDesign.ai34

ArkDesign.ai is the solution for schematic design packages. The rapid optimisation of building designs through the intelligent platform allows you to work quickly and decisively. ArkDesign.ai examines and teaches architectural plan metadata, generates variations taking into account US local laws and regulations, and advocates for effectiveness, efficiency, and cost-effectiveness.

intelligent platform

There are no studies yet on the program's role in achieving the sustainable development principles, except for a study about cost-effectiveness as it can be used in LCA.

## 7.Examples of using Artificial Intelligence in Green Architecture

Artificial intelligence technology enables the processing of various data related to building codes for each area, zoning, interior designs of residential and commercial buildings, space analysis, relations between rooms, privacy, wind direction, light, temperature, and other aspects.

### 7.1. Museum of the Future in Dubai by Killa Design

- Location: Dubai, Arab Emirates
- The stage of using artificial intelligence: In design and the stage of implementing the building.
- Description: The Company generated design choices using AI that combined elements of conventional Islamic architecture with cutting-edge digital fabrication methods.

Killa Design created design ideas for the exterior and interior designs of the museum using an AI system for the same purpose. The algorithm was trained on using information about traditional Islamic patterns and architecture, as well as information about advanced digital manufacturing methods and sustainable design principles. The algorithm produced many design ideas that included these components and made the most use of available space and materials.



Figure 2 :Museum of the Future in United Arab Emirates  
Source : <https://www.killadesign.com/portfolio/museum-of-the-future/>

The 17,000 m<sup>2</sup> stainless steel-covered torus-shaped building designed by AI for the Museum of the Future designs (n.d.). It had striking and cutting-edge elements, including a dynamic facade that adapts to its surroundings and several interactive installations showcasing the most recent developments in digital technology. The designs, which were refined for both energy and material use, have come to represent Dubai's dedication to both innovation and sustainability.<sup>35</sup> (Figure 2)

The museum not only sets new inventive standards, but also serves as a lighthouse for the arts, especially the visual arts. The building, a 17,000m<sup>2</sup> torus-shaped structure covered in stainless steel, was created using BIM holistically at every design step to symbolise the future through cutting-edge design concepts.

- Principles of Green Architecture: passive solar architecture, low-energy and low-water engineering solutions, recovery systems for both energy and water, and building integrated renewables. The design is a low-carbon civic building.<sup>36</sup> (Figure 2).

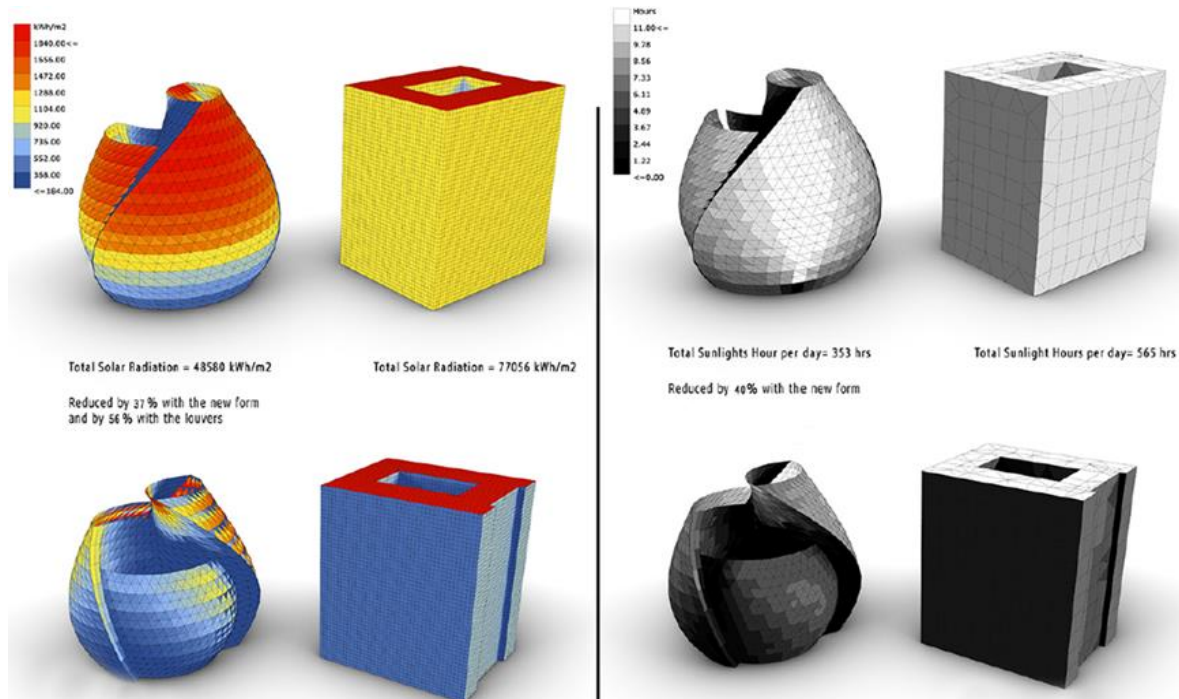
### 7.2. A Commercial Building by CONIX.AI Designer

- Location: No information.
- The Stage of Using Artificial Intelligence: Through Design.



- **Description:** During the design phase, the company asked the developer to provide his vision and design needs and then entered this information into the design engine. This resulted in the production of several designs compatible with the required standards, which allowed for the selection of the most appropriate design based on the preferences of the real estate developer. This design was made in a quarter of an hour at CONIX.AI. The CONIX.AI engine was able to produce a design that included the highest possible selling space. The building consists of 113 shops with an area of more than 2,000 square meters and 118 administrative offices with a total area of 5,700 square meters. A total of 25% increase in additional selling space, compared to a previous traditional design, was implemented in two months. This saves more than 80% of the time used to produce prototype designs. <sup>37</sup> (Figure 3)
- **Principles of Green Architecture:** Some environmental studies were conducted using CONIX.AI to compare the energy savings of the new design. This resulted in an 11-storey glass building that allows an abundant diffusion of natural light without direct solar heat. In addition, maximum daylight is provided throughout the day, with an increase of 65% and a reduction of direct sunlight by more than 56% compared to a previous traditional design implemented two months ago.

After studying artificial intelligence programs, it became clear that both programs: Midjourney, promo ai, evolve ai, and Adobe Firefly (beta) are concerned with generating design ideas that can help produce architectural solutions to achieve green architecture principles. The architectures (ArkDesign.ai and [Autodesk Forma](#)) make simulates to improve sustainability. (Table 2)



**Figure. 3 - CONIX.AI in Comparing the Energy Savings of the New Design.**  
 Source: <https://www.linkedin.com/pulse/hani-farrag/?originalSubdomain=ae>

**Table 2.** Application of Artificial Intelligence in Green Architecture (Source: Researchers)

Principles of Green Architecture	Applications of Artificial Intelligence						
	Midjourney	Adobe Firefly (beta)	Architecture	Ark-Design.ai	Luma.ai	Conix .Ai Designer	Maket.ai
Energy Efficiency			√	√		√	
Water Efficiency							
Sustainable Site			√			√	
Material Efficiency							
Thermal Comfort			√	√			
Visual Comfort						√	
Noise Measurement							
Lighting Quality						√	
Ventilation Rate							
Climate Data			√			√	
Various Innovative Environmental Treatment Forms.	√	√			√		√

## 8.The Vision of Architects towards Artificial Intelligence in Architecture: (The Questionnaire)





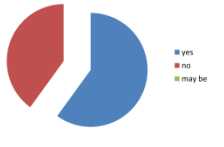

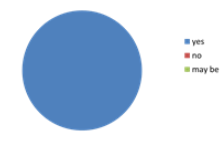

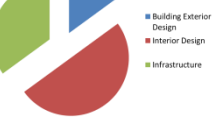
Artificial intelligence in architecture is considered one of the most important and latest applications and technologies that may help facilitate the processes of thinking, design, and construction. Despite this fact, many concerns haunt engineers, and designers. Some consider it a threat to the future of the profession despite the various benefits it offers today; however, it increases competition in the labor market, i.e., artificial intelligence in architecture. Skills can be acquired to use it to provide progress and development for architecture, in addition to building new systems to explore new methods for adapting systems to use software and machine intelligence technology in the service of humans.

The questionnaire was prepared for those involved in

the field of architecture. The questionnaire's title illustrates its aim, which is measuring architects' opinions about the impact of artificial intelligence on the application of green architecture principles. The first section includes general questions about name, age, and profession. The second section includes questions measuring the extent of their knowledge of artificial intelligence and its capabilities in the design process, the expected obstacles facing artificial intelligence in architecture, and the role of artificial intelligence in generating appropriate solutions for the goals of green architecture. The questionnaire targeted a variety of architects (60 architects): 33.5% PhD, 50% work field, 20% academic, 46.5%, external designers, and 33.5% interior designers. (Table 3)

**Table 3.** A Questionnaire Measuring the Opinions of Architects about the Impact of Artificial Intelligence on the Application of the Principles of Green Architecture (Source: Researchers)

Questionnaire Questions	Percentage of Answers			Program Name: using ai
	Yes	No	Maybe	
Have you ever used an artificial intelligence program to design a building? What is its name? (If any)	25%	75%		
In your opinion, have the buildings been designed with artificial intelligence become more interactive and appropriate to the needs of users?	85%	5%	10%	
In your opinion, does the effect was positive about the potential impact of artificial intelligence on the design of green architecture?	Not Specified 70%	Negative 0%	Positive 30%	
In your opinion, is the artificial intelligence, in the design stage, used in an appropriate way to the users' culture and the architectural identity?	0%	40%	60%	
In your opinion, did artificial intelligence techniques give multiple alternatives to environmental treatments?	83.3%	0%	16.7%	
In your opinion, will artificial intelligence programs help the designer make design decisions to achieve the green architecture principles?	80%	20%	0%	
In your opinion, did the use of artificial intelligence programs help site analysis and climatic data?	100%	0 %	0%	
In your opinion, can artificial intelligence programs comply with the green evaluation systems of LEED and BREEAM?	20%	20%	60%	

In your opinion, does artificial intelligence affect energy saving?	Yes 33.3%	No 0%	Maybe 66.6%	
In your opinion, can artificial intelligence help save materials?	Yes 33.3%	No 0%	Maybe 66.6%	
In your opinion, can artificial intelligence help achieve thermal comfort in the building?	Yes 33.3%	No 0%	Maybe 66.6%	
In your opinion , can artificial intelligence help improve water efficiency?	Yes 33.3%	No 0%	Maybe 66.6%	
In your opinion, does artificial intelligence has a positive role in reducing carbon emissions	Yes 33.3%	No 0%	Maybe 66.6%	
In your opinion, can artificial intelligence programs support innovative ideas and preserve intellectual property rights?	Yes 0%	No 60%	Maybe 40%	
In your opinion, does education in the engineering sector need to develop its curricula to suit the era of artificial intelligence?	Yes 100%	No 0%	Maybe 0%	
In your opinion, do architects have the required experience to deal with artificial intelligence programs?	Yes 10%	No 30%	Maybe 60%	
In your opinion, what kind of projects can AI help in the design process?	Building Exterior Design 15%	Interior Design 50%	Infrastructure 35%	

In your opinion, what are the common ways to use artificial intelligence in architecture?	Generate Design 55%	Virtual Reality 20%	Operation and Maintenance of the Building 25%	
In your opinion, what do you think about the experience of using artificial intelligence in architecture?	Not specified 66.7%	Unsuccessful 0%	Successful 33.3%	

The survey results were analysed in relation to theoretical research and discussed in order to get a limited understanding of the potential applications of artificial intelligence to the principles of green buildings, particularly in Egypt. Although, in some stages of the architectural sector, artificial intelligence takes on the role of the architect, there are still some challenges encountered during the use and implementation stages. At this time, human creativity cannot be replaced by artificial intelligence for evaluation or decision-making. Hence, architects must become familiar with emerging artificial intelligence techniques.

## 9. Results

- The research concluded that artificial intelligence could enhance the efficiency of the sustainable environmental design process, but it cannot be relied upon, leading to the disappearance of the architect's role. Therefore, tools that rely on artificial intelligence can be used as auxiliary tools in the process of sustainable environmental design.
- Some believe that architects can be replaced by artificial intelligence, but in fact, the primary role in the design process will be the architect's task. Artificial intelligence will not replace the architect, but it will improve his work as it saves time and effort.
- Integrating digital technology, especially artificial intelligence, into architecture helps architects realise their creative imagination in design.
- Artificial intelligence can be used to generate ideas and make various alternatives, but it cannot be relied upon as an evaluation tool or decision-maker. These aspects remain the task of the human mind. It can extract a large amount of data from projects and offer a variety of solutions. The relationship between artificial intel-

ligence and green architecture, especially regarding the environmental aspect, is not new, and it will not end up with a specific form. The role of artificial intelligence in architecture is not limited to making design proposals; it also helps improve the environmental performance of the design. Artificial intelligence programs help raise energy efficiency, thermal comfort, health, and productivity in the built environment. Through the use of applications and programs of artificial intelligence and machines, the risks that the building may face can be predicted.

- Some AI programs; like Midjourney and Adobe Firefly (beta), do not perform environmental simulations, but they produce various innovative forms of shading systems and other environmental treatments. But some programmes, like Autodesk Forma and Architectures, are concerned with sustainability. The study sample as 60 architecture 31 only using AI programme, this indicates that it did not spread as required.
- While the sample's opinion about whether you used an artificial intelligence program to design a building is 51% Yes and 49% No. The programs that were previously used are Midjourney, Promo ai, revolve lab, Ai Maket, minml, and versa. . Figure 4.
- The answer to the query is (What are the common ways to use artificial intelligence in architecture?) as follows: design and idea generation (55%), as a tool for virtual reality (20%), and as a tool for operation and maintenance of the building (25%)
- The result of the questionnaire was the opinion of the sample: Which type of projects can use artificial intelligence in the design process? As a result, the external design of the building scored 15%, the interior design of the building scored 50%, and the infrastructure scored 35%.
- Most of the results are related to the impact of artificial intelligence on green architecture and its principles. Perhaps most responses, hesitation, and uncertainty about its positive or negative results are due to the fact

that it is a modern trend that has not been used on a large scale and it has not been implemented in a limited number of buildings.

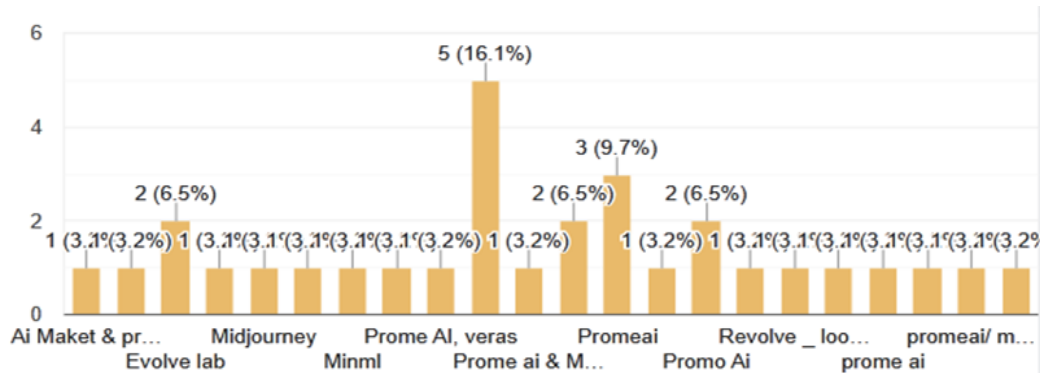


Figure 4. the study sample's opinions about using artificial intelligence. Source: Researchers.

- While 80% of the study sample was still hesitant and believed that they may help the designer make design decisions to achieve the principles of green architecture, 20% answered (No). This indicates that architects are only responsible for making design decisions to achieve the principles of green architecture, to achieve the principles of green architecture.
- In addition, 60% of the sample believed that the artificial intelligence programmes may comply with the green evaluation systems of LEED and BREEAM, while 20% of the sample said yes, and 20% of the sample thinks that the artificial intelligence programmes can comply with the green evaluation systems of LEED and BREEAM.( Figure 5)

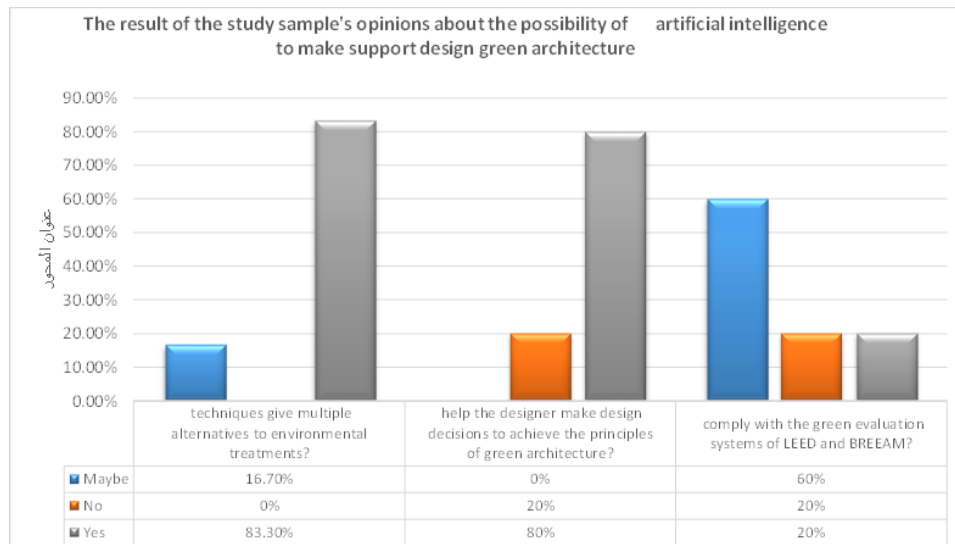


Figure 5. the result of the result of the study sample's opinions about the possibility of artificial intelligence to make support design green architecture. Source: Researchers

- 66.6% believed that artificial intelligence may help in saving materials, saving energy, achieving thermal comfort in the building, improving water efficiency. However, and reduce carbon emissions.
- Consequently, doubt and uncertainty appeared about the possibility of artificial intelligence programs in achieving the principles of green architecture, while 100% of the study sample was sure that it would help in analyzing climate data. Figure 6.

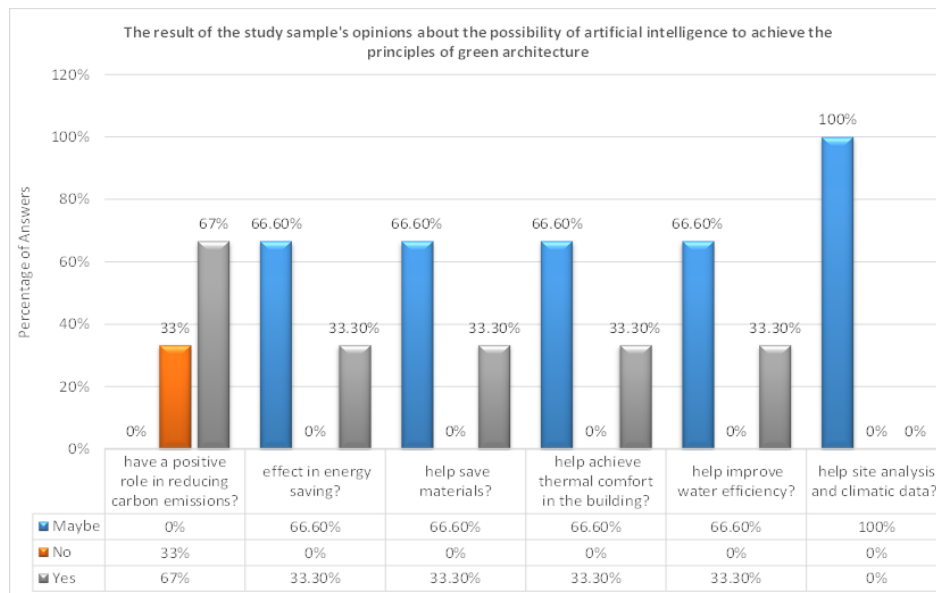


Figure 6 the study samples' opinions about the possibility of artificial intelligence to achieve the principles of green architecture

-Source: Researchers

- The use of artificial intelligence in implementation will help change business strategies in the construction sector, reduce costly errors, reduce workplace accidents, and improve construction operations. One of the disadvantages of artificial intelligence programs at the present time is the focus on generating images and the multiplicity of formations, which sometimes affects their function and adherence to codes and laws. So far, no programs have been found that take green architecture systems into account when designing or producing simulation results, especially LEED and BREEAM environmental assessment systems. Architects must understand technology and develop skills to integrate AI capabilities into their workflow rather than resist it. Attention must be paid to creating data sets compatible with the Egyptian environment. In addition, 60% of the sample believed that the artificial intelligence programmes may comply with the green evaluation systems of LEED and BREEAM,
- Academics should develop architecture courses and use artificial intelligence programs in sustainable environmental design to help produce ideas. They should encourage investment in areas where AI has the greatest potential to meet the specific requirements of their organization.
- The researchers conducted a Questionnaire for architects, architecture students, and academics. Through that survey, it was concluded that architects have an ambition towards learning new design tools for artificial intelligence. A few used artificial intelligence programs in their design.
- The positive impact of artificial intelligence on assisting in designing buildings according to the green architecture principles was indicated, and the results are as follows: 70% of the research sample believed that the effect was not specified when asked about their opinion regarding the potential impact of artificial intelligence on the design of green architecture, while 30% of the sample thought it was positive.
- While 80% of the study sample was still hesitant and believed that they may help the designer make design decisions to achieve the principles of green architecture, 20% answered (No). This indicates that architects are only responsible for making design decisions.
- 85% of respondents believe that artificial intelligence was used in the buildings' design to make them more interactive and easier to use. Moreover, 60% of the research sample believed that it may be possible to use artificial intelligence in the design stage in a way that is appropriate to the culture of the users and the architectural identity, while 40% of the sample said no

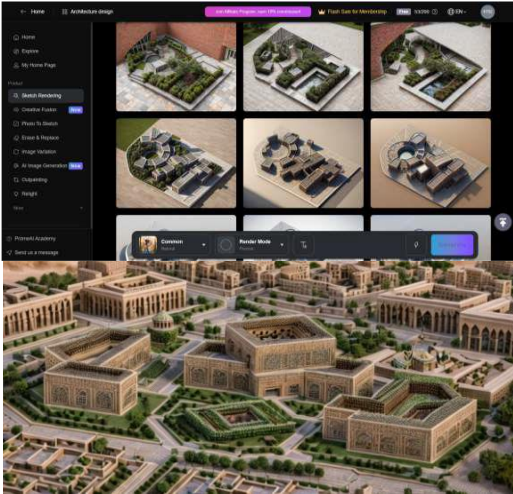
Figure 7

- while the question about the positive impact of AI on assisting in designing buildings according to green architecture principles was indicated, and the results are as follows: 70% of the research sample believed that the effect was not specified when asked about their opinion regarding the potential impact of artificial intelligence on the design of green architecture, while 30% of the sample thought it was positive.
- There is rapid and continuous development in AI programs from day to day, and some programs give incorrect results if the purchase is not completed, and all of them are expensive.
- Artificial intelligence programs help produce different designs with various ideas, and after experimenting with many programs, including 0000, they gave different ideas for designing shading systems and double facades, in addition to different design ideas for designing different environmental treatments in the facades

- The feedback from using the AI program is: The output is in 2D, which can't give you access to modify it. Once you skip a photo, you can't get it back, even when you use the same script, It gives a very good result compared to the input, It's useful as it gives some new ideas, Some programs connect the blocks together, and Shapes different from the mass in the case of a 2D photo
- The following table shows the researchers' experience using AI programs and comments on that experience. It is clear from the use of programs that they all neglected the principles of green architecture and climate and environmental analyses. Therefore, the study recommends developing AI programs to include energy simulation, carbon, and others.

Mid journey is a powerful tool that can help architects generate breakthrough ideas and innovative solutions midway through a project. Also, if it gives us a model or diagram of this plan, it will help us even more .

Table (4) the researchers' experience using AI programs and comments (Source: Researchers)

AI PROGRAME	Outputs	Comments of researcher from using this program	Principle of green archecture			
			Energy Efficiency	Environmental Treatment Forms.	Thermal Comfort	Climate Data
Evolve lab extension		Description must be given. Precise. user can change and experiment with multiple models, and this helps in choosing the right project style You can also draw and specify how far to continue with the drawing's borders Negatives: The number of trial times is limited.	×	√	×	√



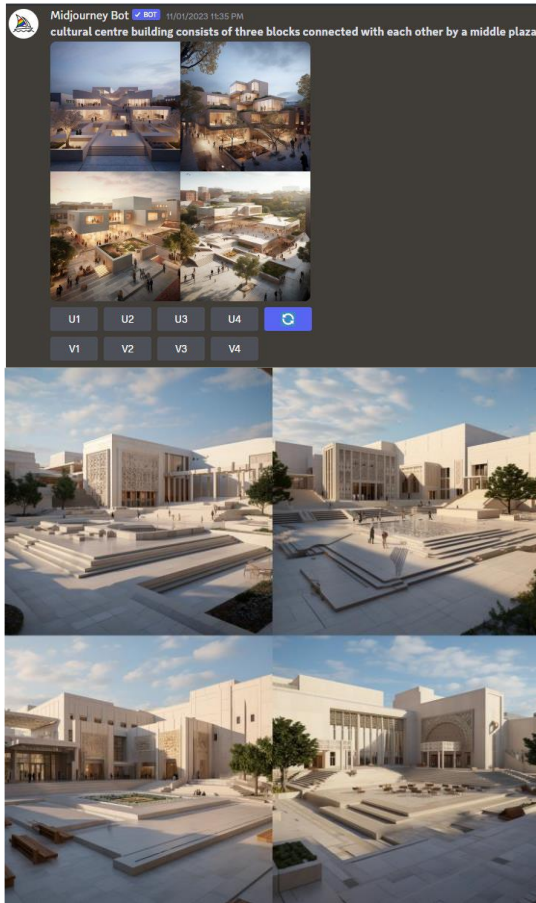
PROME AI



it requires a lot of careful description and experience to get the best results. One of its disadvantages is that the input image must have many and clear details. One of its advantages is that image can be converted into a manual sketch and then entered again to obtain a realistic image with a render

× √ × ×

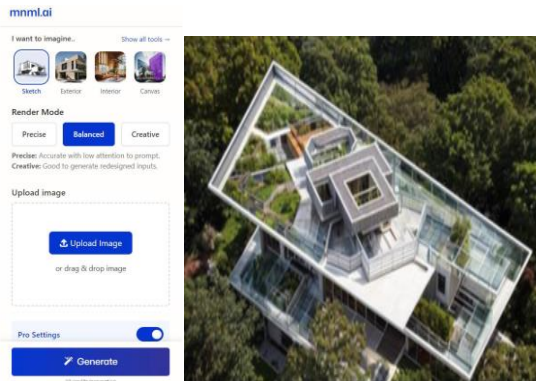
MID journey



This program lacks the ability to enter an image and convert it to the desired description. Also, the output from the program is an image and not a CAD or Revit file. disadvantage of program is The number of trial times is limited.

x      √      x      x

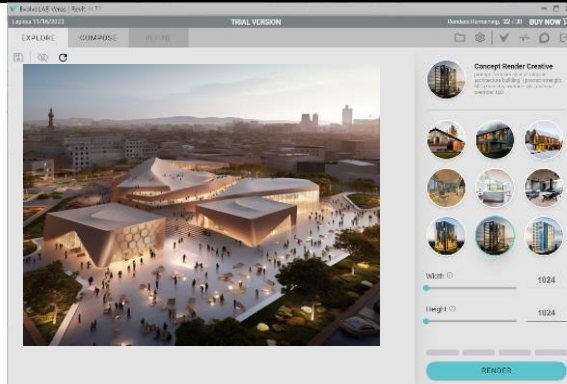
mnm.ai  
(I tried 6 times)



The description Translated in a very literally, the output turns it into an image and not a 3D block.

x      √      x      x

Veras  
(revit  
plugen)



more reliable, help me to link between forms, make difference types of render, easy to use, and many times of trials .

× √ × ×

ArkDesign.ai

When using the program, it was found that it was designed to design residential buildings in New York and follows its building code only, and thus it is not suitable for use outside New York unless it is updated.

× × × ×

## 10.Conclusion

This paper discusses the idea of artificial intelligence and its role in architecture. In addition, it refers to the most important programs that can be used to benefit and activate the role of artificial intelligence and benefit from it to apply the green architecture principles. Artificial intelligence provides several options and proposals to integrate green building concepts into practice. It also offers an endless number of design concepts for energy conservation, heating, cooling, lighting, sensor systems, data mining, emissions reduction, and waste management. A questionnaire was used to measure the architects' opinions regarding the importance of artificial intelligence in achieving green architecture principles. Results indicated the impact of artificial intelligence on green architecture and its principles. Perhaps most of the responses, hesitation, and uncertainty about its positive or negative results are due to the fact that it is a recent trend that has not been used on a large scale and only implemented in a limited number of buildings. None of the respondents felt that artificial intelligence would have a negative impact on the development of green architecture, but some of them are still unsure. This calls for the development of

architectural studies in Egyptian universities. Specialized research in artificial intelligence and its applications in green architecture is needed to add an auxiliary factor in environmental design.

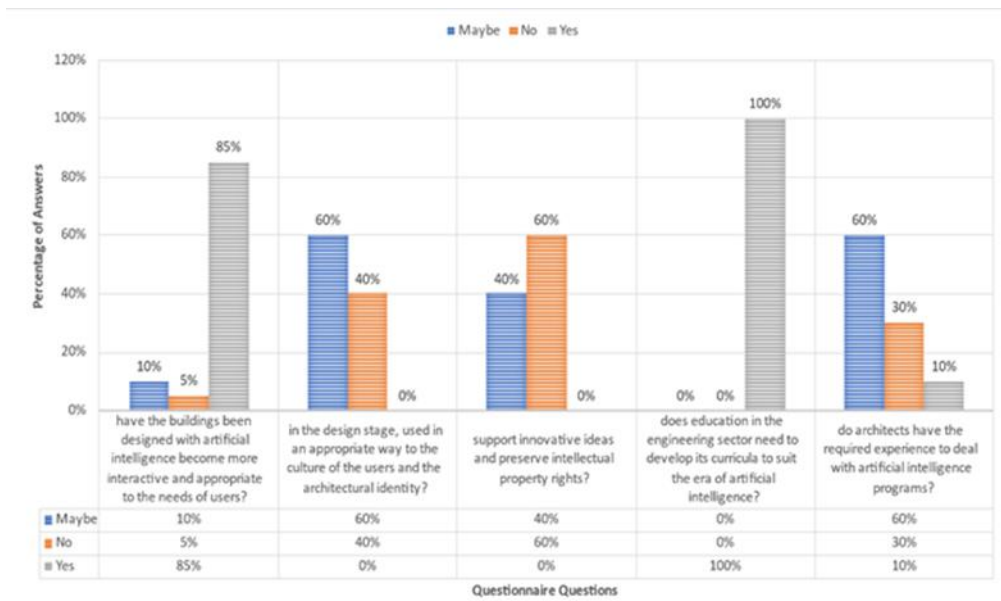


Figure 7. shows the result of the study sample's opinions about the effect of artificial intelligence on identity and ideas of green architecture. Source: Researchers.

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