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How Artificial Intelligence Could Affect the Future of Architectural Design Education

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Abstract

There is currently a high level of uncertainty about the potential impact of artificial intelligence (AI) on architecture as a profession and consequently on architectural education. Some suggest that schools of architecture should prepare themselves for a dramatic reform that clearly integrates AI technologies into their study plans and pedagogical methods, while others argue that AI can't fully replace the traditional methods and conventions in architectural education and that more time is needed to understand its potential impact in this regard. In all cases, AI is coming and will be soon or later an integral part of our work and teaching methods in architecture. This paper discusses this issue considering some AI applications in the different design stages from an educational perspective. This was supported by a sample project conducted by architecture students to show how AI could impact teaching methods in architectural design courses and introduce new approaches in the design process. The study concluded that there is an urgent need to explore and understand how AI could affect our educational systems and provoke changes in the architectural design process we currently follow. Quality assurance organizations should reflect this in their accreditation guidelines to offer the required guidance for the schools of architecture in this regard.

Keywords

Architectural design; Artificial intelligence; Education; Generative Design

1. Introduction

Artificial Intelligence (AI) could be defined as "a computational system demonstrating behavior that would be considered intelligent when performed by humans" (Wingström et al., 2022). More technically, it could be defined as "a field that combines computer science and robust datasets, to enable problem-solving". AI encompasses several sub-fields such as machine learning (ML) and deep learning (DL). These sub-fields are based on AI algorithms that are able to create expert systems that could effectively predict or classify based on input data (IBM, 2023). AI applications nowadays have a significant impact on almost every sector of industry. It is claimed that AI could replace up to 300 million jobs across all industries in the world. This includes the domains of architecture and engineering, where it is predicted that AI could be used to automate 37% of tasks within these domains (Hatzius et al., 2023). This has to be reflected in our educational systems, which should be updated to respond to the new skills and competencies

that are needed in the market. AI could be used in education through the utilization of technologies or applications that facilitate teaching and learning through the simulation of human intelligence to provide guidance and feedback to both students and educators (Hwang et al., 2020).

In fact, AI has already started to change teaching methods in many disciplines. Architecture as a discipline focuses mainly on building design, construction, and operation, which makes it highly affected by AI technologies and tools (Ceylan, 2021). Many issues are questioned here such as design data collection, design ideation, form finding, generation and optimization of design alternatives, extraction and analysis of construction data, evaluation of building performance, and management of building operation to enhance energy efficiency. Despite the promising potential of AI in architectural education, universities are still unsure how to benefit from it and integrate it into their study plans (Schulman, 2023). One main reason here is the fast development of AI technologies, which makes their impact on the quality of education and academic integrity unclear so far. Another reason is the current requirements in the relevant accreditation systems, which still follow the traditional model of academic programs in architecture. AI is still not well-addressed and considered in these accreditation systems where some benchmarking statements and quality assurance indicators are needed. Thus, this paper discusses the potential role of AI in architectural design education and aims to address several concerns that exist in this regard.

2. Materials and Methods

This paper aims to question the impact of AI on the future of architectural design education. This question is challenging considering the accelerating development of AI tools and the associated high level of uncertainty about its impact on architecture. To achieve this aim, the paper carried out a literature review to introduce some essential concepts and sample AI tools that are used at the different stages of the architectural design process. This was followed by an experiment in the form of a design project conducted by architecture students at King Fahd University of Petroleum and Minerals (KFUPM). This aimed to show how AI could impact pedagogy in architecture and introduce new approaches in the design process. The examined approach is based on combining the traditional methods and the emerging AI tools for architectural form finding. The study used a combination of physical models, photography, and Midjourney in this regard. This experiment has been used to introduce thought-provoking questions about the use of AI in architectural education. These questions should be addressed by the concerned stakeholders including architects, universities and academic institutions, and decision-makers in the organizations of education quality assurance.

3. Results and Discussion

What is the role of computers in architectural education? This is a very traditional question that witnessed several stages of development since the end of the 20th century when the use of personal computers became common. For example, you may have witnessed the emergence of computer-aided design tools (CAD) and the argument they brought forward regarding their potential role in architectural design education. This issue has become more critical nowadays considering the recent accelerating developments of AI. AI, and in particular ML, has the potential to offer architectural design alternatives in addition to design analysis and development based on pre-defined functional performance criteria (As et. Al., 2018). It could also be effectively used to categorize several architectural designs into groups based on their architectural style and characteristics (Yoshimura et al., 2019). In general, the following requirements should be implemented when using AI tools to generate architectural designs with limited human interaction: parametric relationships, self-organizing processes, and algorithms (Pena et al., 2021).

The rapid development of AI technologies and their relationship to the field of architectural design is expected to have a substantial impact on architectural education. Architectural design forms the main domain of any architecture academic program. Architectural design courses form the backbone of architectural academic programs, where “design thinking and integrated design solutions are hallmarks of architecture education” (NAAB, 2020). They are delivered using a well-defined design process that shapes the built environment considering multiple factors in different settings and scales. Students are usually required to integrate the outputs of other theoretical courses into their design studio projects such as design philosophy, structural solutions, building materials, constructability, mechanical systems, sustainability requirements, etc. Utilization of AI tools in architectural design studios could take

several forms. It is believed that all design stages including design data collection, preliminary design and conceptualization, and design product generation and refinement could be supported by AI (Ceylan, 2021). Several strategies and tools could be implemented in this regard to help students push the boundaries of their design thinking skills. For example, AI-supported databases could be used to find out relevant information for different design projects. ChatGPT and Bard are common examples in this regard to collect and analyze vast amounts of data quickly and effectively.

In the conceptual design stage, generative design algorithms such as Evolutionary Algorithms (EA) and Neural Network Algorithms (NNA) could be used to generate numerous preliminary design alternatives to satisfy specific design criteria including design language, construction materials, and spatial requirements. ML plays a significant role in this regard, which may be defined as "giving computers the capability to learn from data without being specifically programmed" (Motamedian et al., 2023). This enables computers to handle mass amounts of data and learn from them to make decisions without human interference. This data includes past design solutions, which could be effectively used to propose new ones. The use of image-generating software such as Dall-E and Midjourney along with prompt crafting techniques is a common example in this regard. Students can visualize their ideas and concepts and produce high-quality three-dimensional images in a relatively short time (Novoselchuk et al., 2023). This broadens students' design perspectives and inspires them to think creatively using a variety of design languages. It also accelerates the conceptual design stage where the interaction between functional and aesthetical requirements could be thoroughly examined.

Some other tools such as PlanFinder are also available to generate several optimized floor plans based on the required inputs such as building size and layout requirements. Sustainability and environmental performance could also be optimized using AI algorithms, which can analyze and compare several environmental performance indicators such as energy loads (Liang et al., 2023) and greenhouse gas emissions (Zhang et al., 2023). On a larger scale, AI could be used to create smart cities, where buildings are connected with other components of the city, such as transportation systems and services, to ensure better living conditions for people. Although these tools could save architects substantial time and effort, their outputs should be double-checked, synthesized, and further developed by architects. As an example, the Architecture students at KFUPM conducted the following exercise on combining traditional methods and AI tools for architectural form finding. The process begins with constructing a physical model using foam. Photographs are taken from all necessary angles, including the top view, both elevations and sections. These images are then uploaded to Midjourney, accompanied by various prompts to transform the foam pictures into architectural drawings or images as shown in Figure 1. Sometimes, these prompts are combined with a picture of a typical architectural section to aid Midjourney in understanding the desired outcome.

Despite these promising capabilities of AI, some challenges should not be ignored as these tools can also be abused. This includes the potential of plagiarism, the possible bias in data, and the issues of privacy and intellectual property. Another important challenge is how to properly address the relationship between form and function. One main principle of modern architecture is that form follows function. However, the use of AI tools to generate architectural designs may flip the process, which affects design quality in terms of functionality and increases the potential for waste in materials and other resources. This confirms the need for establishing an integrative relationship between architects and AI because architects are needed to define the goals and limits of the design and examine its constructability and adequacy to the context considering the required design criteria. There is also a need for in-depth future research to address several questions and concerns to help architecture schools take the needed actions to upgrade their study plans in response to the challenges brought forward by AI technologies. This includes the following questions:

- What are the new skills needed in the market in the field of architecture, and how to upgrade our academic programs to consider them?
- Is there a need to integrate some digital-enabling courses into the academic programs of architecture such as AI, data science, and coding?
- Do we still need the manual communication courses? Shall they be maintained, reduced, or even eliminated?

- How to benefit from advanced visualization techniques such as immersive visualization to enhance students educational experience and understanding of their design?
- Would design courses continue to be the main component of our academic programs in architecture in terms of duration and academic weight?
- What is the required role and format of the architectural design studios in terms of objectives, setting, and working environment?
- How shall we update the standard design process to integrate AI technologies and foster students' creativity? What is the future role of architects in this AI-enabled design process?

Figure 1: Samples of students' work at KFUPM to generate architectural forms using physical models and Midjourney.

4. Conclusions

The rapid development of AI technologies clearly indicates that we are heading towards an AI-driven future. Universities and academic institutions should encourage interdisciplinary integration of AI applications into their academic programs. This is true in the case of architecture, where AI technologies have significantly affected the architectural design process of buildings. This includes the stages of pre-design data collection, conceptualization and preliminary design preparation, and design product generation and refinement. It is widely believed that the incorporation of AI into architectural design education is an essential strategy to prepare students to face the challenges that exist in the market with more confidence, creativity, and innovation. However, the future relationship between AI and architectural education is still unclear. Although AI can offer significant help to students and save them time, the level of human involvement in this process is still not well-defined. However, it is widely accepted

that this involvement is expected to take place in design evaluation and adaptation rather than initiation and conceptualization, where many questions need to be addressed.

For example, are we going to mix the traditional methods of design thinking and production with AI tools, and at what level this should be done? What is the expected role of the design studio in this regard? Is there a need to shorten our study plans as a result of AI integration into courses? There is a need in this regard to maintain a balance between technological assistance and human involvement in the design process. This is needed to consider the qualitative design requirements that can't be fully addressed by AI such as aesthetical requirements, socio-cultural factors, and the relationship between the design and its environmental and urban context. However, we can't exclude the possibility that AI will keep surprising us and take over more and more tasks that were traditionally fulfilled by architects. This should affect our teaching strategies and accreditation systems which should be regularly reviewed and updated to respond to the new developments in this regard. This requires in-depth future research to address the above-mentioned questions in a way that helps architecture schools take the needed actions to upgrade their study plans and pedagogical methods and respond to the challenges brought forward by AI's accelerating development.

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Ethics approval

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Conflict of interest

The author declares that there is no competing interest.

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