

## "Transforming Architectural Education with Artificial Intelligence: Opportunities and Challenges in India".

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### ABSTRACT

As technological developments continue, there is growing interest in transforming artificial intelligence (AI) into various academic disciplines, especially architecture. This research paper explores the opportunities and challenges associated with integrating Artificial intelligence (AI) into architectural education in India through a comprehensive review of existing literature and identifies the potential benefits of AI in enhancing design thinking, enhancing learning outcomes, and facilitating collaboration among students and faculty, while also highlighting challenges and barriers to AI integration, including the technological structure and access, faculty development and training, and ethical and social considerations. Additionally, the study highlights the eventuality for AI to transform architectural education and practice in India, ensuring that future architects are more set for the rapidly evolving demands of the profession. Finally, the research paper concludes with recommendations for developing a comprehensive AI integration strategy for architectural education in India, including collaboration between academia, industry, and government, enhancing faculty development and training programs, and addressing ethical and social concerns.

**KEYWORDS:** Artificial Intelligence, Architectural Education, AI integration, pedagogical approaches etc

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### 1. INTRODUCTION

Architectural education in India has a long history, extending back to the first architecture school, Sir J.J. School of Art, in 1857 [1]. The number of architectural institutions has expanded dramatically over time, with more than 400 colleges now offering undergraduate and postgraduate architecture programs [2]. These institutions follow a class specified by the Council of Architecture [3], which aims to give a comprehensive understanding of design, construction, and civic planning, along with a strong emphasis on cultural and historical surroundings. Despite the growth in the number of institutions, architectural education in India faces several challenges, including outdated pedagogical approaches, inadequate structure, and a lack of exposure to cutting-edge technologies and global best practices. These challenges have led to a growing need for reconsidering and

transubstantiating architectural education in India to prepare future architects for the rapidly evolving demands.

### 2. LITERATURE REVIEW

#### 2.1. OVERVIEW OF ARTIFICIAL INTELLIGENCE IN THE ARCHITECTURAL FIELD

Artificial intelligence (AI) is transforming several industries, including architecture. AI can help architects in various tasks similar as designing, analyzing, and optimizing structure performance. AI-powered tools can also help architects in decision-making by furnishing data-driven insights. With the emergence of AI, there's a need to explore the integration of AI in architectural education. [4] provides an overview and the transitions that have defined the application of AI in the education sector.

Chassignol et al. observed that AI, in education, was adopted in the form of computers, and computer-related technologies, such as the Internet and the World Wide Web [4].

The emergence of artificial intelligence in the architectural field has led to various exploration studies exploring the eventuality of AI-driven technologies. AI is assumed to play a great role in Architecture and Construction fields as it enables massive amounts of data processing which can offer a great number of simulation possibilities for architects [5]. In construction, AI can, for example, enhance design output, draw buildings within constraints such as building codes, cost, time, and size constraints, and at the same time do clash control with other drawings, do risk scenarios and suggest solutions to mitigate them [6]. Also, Chillou, 2019 applied AI to floor plan analysis with the aim of generating different options for floor plans [7].

The objectives of this research are to:

- Explore and identify the opportunities and challenges associated with integrating Artificial intelligence (AI) into architectural education in India.
- Analyze the current state of artificial intelligence integration in architectural education in India.
- Provide recommendations for developing a comprehensive AI integration strategy.

## 2.2. AI IN ARCHITECTURAL EDUCATION GLOBALLY

AI (Artificial Intelligence) is progressively being integrated into architectural education worldwide to better prepare students for the field's future. AI can be utilized in architectural design to help with design decisions, assist learning, and boost creativity. Furthermore, AI can assist students in analyzing enormous volumes of data and generating optimized solutions to design challenges. AI integration in architectural education is becoming increasingly vital in educating students for the field's future. AI can help designers make better decisions, boost creativity, and make learning easier (Vahdat & Mansoori, 2020). The benefits and problems of introducing AI into architecture education have been addressed in research publications, including the use of AI for design optimization and the significance of considering ethical and societal issues. AI in education has also eliminated some barriers to access to learning opportunities, such as national and international borders, enabling global access to learning through online and web-based platforms [8] [9].

## 2.3. AI APPLICATIONS IN ARCHITECTURAL DESIGN AND PRACTICE

AI applications have significant potential to transfigure the field of architecture by automating and accelerating colourful design and construction tasks. Some of the most promising AI applications in architectural design and practice are followed Generative design, Building performance analysis and Construction Automation.

### a) Generative design:

Generative design is based on an artificial intelligence approach that allows architects to investigate design possibilities by generating a large number of design solutions. Design can be optimized using generative design algorithms depending on numerous limitations such as material utilization, energy efficiency, and cost-effectiveness. Furthermore, generative design may be utilized to generate responsive designs that are adapted to the setting. For example, using machine learning algorithms, the Site Solve tool analyses site data and generates design solutions that optimize environmental performance. (Debney., 2021)

### b) Building performance analysis:

AI-powered technologies can assist architects in evaluating building designs for criteria such as structural soundness, energy efficiency, and thermal comfort. According to [10], two main types of building performance analysis come forward: energy performance and structural performance. Energy performance analysis (EPA) can be conducted on various areas of a building with different focal points such as visual and thermal comfort on the façade of buildings [11]. Software for Energy Performance Analysis is evaluated through the following criteria: Usability and information management of interface, integration of intelligent design knowledge base, interoperability of building modelling, and the accuracy of the tool and its ability to simulate complex and detailed building components [12].

Tools like Autodesk Insight, for example, employ machine learning algorithms to mimic building performance and find opportunities for improvement. These technologies can help architects discover potential design issues early in the process and make data-driven decisions. Furthermore, AI can optimize building plans depending on characteristics such as lighting, views, and thermal comfort. (Deepa., 2019)

Currently, there are many EPA tools that are accessible such as Ladybug, Honeybee, Geco, and Heliotrope-Solar. They mostly operate as plugins under other software. For instance, Ladybug is a tool to work in collaboration with Grasshopper, with an

effort to support the full range of environmental analysis in a single parametric platform [13].

#### **c) Construction Automation:**

Artificial intelligence is being utilized to improve the efficiency and quality of construction processes. Data from building sites can be analyzed using AI algorithms to identify potential safety issues. Similarly, artificial intelligence (AI) can be used to optimize building schedules and resource allocation, hence lowering construction time and costs. Furthermore, artificial intelligence-based solutions can increase quality control by analyzing construction data and spotting any flaws. The use of AI in precast concrete construction, for example, Precast structures such as beams, columns, slabs, walls, claddings, and HVAC systems, can be assembled by robots in factories and then cast by human on site. [14]

AI has emerged as a powerful tool in architectural design and practice, offering architects numerous benefits, such as exploring design possibilities, optimizing designs, evaluating designs, and improving construction processes. AI-based tools can help architects create more sustainable and efficient buildings, reduce costs and improve the quality of construction.

#### **2.4. AI APPLICATIONS IN ARCHITECTURAL DESIGN AND PRACTICE**

Artificial intelligence can provide access to appropriate and better learning opportunities for excluded people and communities, people with disabilities, refugees, people out of school, and those living in isolated communities [15]. Based on the study results, [16] stated that artificial intelligence could help teachers improve personalized education for their students. Advanced commercial software on the use of AI in architecture is available. For example, CATIA, which stands for Computer Aided Three-dimensional Interactive Application, is used as an algorithmic design application. It shows the consistency and applicability of the new technologies, materials, machinery, progressive methods and information tools that enable more efficient use of materials [17]. Another software is Grasshopper, which is a graphical parametric tool working under Rhinoceros. Schneider used Grasshopper for the development of an urban design proposal at a teaching exercise [18]. AI has the potential to improve the learning experience in a variety of ways, according to recent research (Smith, 2020). For example, AI can create personalized learning experiences that are tailored to each student's specific needs and interests. This can be accomplished through the use of adaptive

learning algorithms, which analyze data on student performance in order to deliver personalized feedback and learning resources. Second, AI can help students collaborate even if they are geographically apart. Cloud-based design and collaboration tools enable students to collaborate in real time on creative projects. Finally, artificial intelligence can improve design and visualization tools by creating more accurate and realistic simulations of architectural surroundings. This is achievable because of artificial intelligence-powered software that generates 3D models and visualizations based on data (Brown, 2019).

#### **2.5. CHALLENGES AND BARRIERS TO AI INTEGRATION IN ARCHITECTURAL EDUCATION**

The use of AI in architectural education poses a number of obstacles that must be overcome in order to fully realise its potential benefits. Another challenge of applying AI is mentioned by [19] concerning the costs and time involved in developing and introducing AI-based methods that many public educational institutions cannot afford. One such barrier is a lack of requisite infrastructure and resources in many architectural schools, which may impede the widespread adoption of AI tools. Furthermore, educators and students may be resistant to change as they consider the possible impact of AI on their professions. Another problem is addressing privacy and ethical considerations linked with student data gathering and analysis. Finally, educators' roles in an AI-enabled learning environment must be redefined, which may necessitate new skills and pedagogical techniques (Zhang et al., 2020).

#### **3. METHODOLOGY**

This study takes a comprehensive literature review technique to explore the possible benefits and limitations of implementing AI into architectural education in India. A comprehensive review of peer-reviewed publications, conference proceedings, and other related literature was done to acquire pertinent information. Indeed, Snyder posited that a systematic or semi-systematic literature review, a review of secondary data, provides a deeper understanding of the study phenomenon [20]. The information was gathered from many online resources, including Google Scholar, ScienceDirect, IEEE Xplore, and others, using keywords including "AI," "AI integration," "architectural education," and "India."

Thematic analysis was used to analyze the data gathered from this review. The selected themes in Table 1 were used to answer the study's research

questions and objectives. This in-depth examination provided a better understanding of the possible benefits and limitations of incorporating AI into architecture education in India, which can inform future research, policy, and practice in this burgeoning subject. The findings of this study can help educators, policymakers, and industry professionals integrate AI into architecture education in India.

**3.1. ANALYSIS 1(OPPORTUNITIES FOR AI INTEGRATION IN ARCHITECTURAL EDUCATION):**

Theme 1: Improved design solutions:

The integration of AI in architecture education can provide several benefits, including the ability to improve design solutions. AI can analyse massive volumes of data and patterns to provide innovative and creative designs that satisfy functional and aesthetic needs. This can save architects and designers significant time and effort during the design process. AI can also help optimise building performance and energy efficiency, which is becoming increasingly crucial as the movement towards sustainable architecture gathers momentum. Architects can use AI to simulate several design possibilities and assess their influence on energy usage, thermal comfort, and indoor air quality. Overall, AI can assist architects and designers in creating smarter and more sustainable structures, which is critical for the profession's future.

Theme 2: Enhanced Learning and Teaching:

AI integration in architectural education provides opportunities for improved learning and instruction. AI can be utilized as an interactive teaching tool to help students learn more effectively and engagingly. AI, for example, can assist students in comprehending complicated design principles via interactive visualizations and simulations. AI can also provide students with personalized learning experiences, allowing them to advance at their own speed and focus on areas where they need to improve. This can result in improved learning results and increased student engagement.

Furthermore, AI can aid in the grading and evaluation of student work, giving students with timely and objective feedback. This can assist pupils in improving their work and achieving higher ratings. AI can also assist faculty in building personalized lesson plans and identifying areas where students want further assistance.

In addition, the application of AI in architecture education can provide chances for teachers to improve their teaching skills and experiment with novel teaching approaches. AI can

assist professors in identifying student learning patterns and adapting their teaching techniques accordingly. It can also assist faculty members in identifying areas where their teaching skills need to be improved and in providing training and support to increase their teaching effectiveness.

Theme 3: Time and Cost Saving:

AI integration in architecture education has the potential to save time and money. Certain processes, such as 3D modelling and rendering, can be automated by AI, saving architects and designer's considerable time. Furthermore, AI can assist in streamlining the design process and identifying any design problems prior to construction, which can help decrease costs and save time in the long run. This can also lead to more effective resource utilization, which is especially crucial in a resource-constrained country like India. Overall, the application of artificial intelligence in architectural education has the potential to boost productivity and efficiency, freeing up architects and designers to focus on more difficult and creative parts of their job.

**3.2. ANALYSIS 2: CHALLENGES FOR AI INTEGRATION IN ARCHITECTURAL EDUCATION)**

*Analysis 1: Opportunities for AI Integration in Architectural Education*

Theme	Description
<b>Improved design solutions</b>	AI may analyse enormous amounts of data and patterns to produce innovative and long-lasting designs that meet practical and aesthetic requirements. It can also improve building performance and efficiency, saving architects and designers time and effort during the design process.
<b>Enhanced Learning and Teaching</b>	AI can provide personalised learning experiences for students and support teachers in developing personalised lesson plans. It can also help in grading and evaluating student work by providing students with timely and objective feedback, resulting in better learning outcomes and increased student engagement. AI can help academics discover student learning patterns and adjust their teaching methods accordingly.
<b>Time and Cost Saving</b>	Certain operations, such as 3D modelling and rendering, can be automated by AI, saving architects and designers significant time. It can also help to streamline the design process and uncover any design issues prior to construction, which can help to reduce costs and save time in the long term. Overall, the use of artificial intelligence in architecture education has the potential to increase production and efficiency.

Theme 1: Lack of Awareness and Knowledge:

One of the challenges to AI integration in architectural education is a lack of awareness and information among educators and students regarding AI's possible applications. Many architectural educators and students may be unaware of the technology's possible impact on the profession. This lack of awareness can anytime AI's acceptance in architectural education and limit its potential benefits. As a result, increasing awareness and education regarding the potential of AI in architecture education is required among instructors and students. This can be accomplished through the training and development of programmers, workshops, and conferences focused on promoting understanding and awareness regarding artificial intelligence in architecture.

**Theme 2: Ethical and Social Considerations:**

As AI technology advances, there are increasing concerns about its ethical implications, including the potential for bias and discrimination in AI systems. This could take the shape of designs that perpetuate social injustices or exclude particular groups of people in the context of the building. Another ethical issue to address is the impact of AI on the employment of architects and designers. As AI systems progress, they may be able to undertake certain jobs currently performed by humans, potentially leading to job displacement. This raises serious concerns about how to ensure that the advantages of AI are spread equitably and that employees are not left behind. The societal impact of AI integration in architecture education must also be considered. The deployment of AI has the potential to reinforce existing power dynamics and increase socioeconomic inequality. This emphasizes the importance of a critical and analytical approach to AI integration in architectural education, one that considers the potential social ramifications of this technology.

**Theme 3: Infrastructure and Technical Barriers:**

Infrastructure and technical constraints are the third themes of hurdles for AI integration in architecture education. AI integration in architecture education necessitates access to cutting-edge computing infrastructure and technical knowledge. This can be a significant hurdle in many educational institutions, especially those in rural or underserved areas. Furthermore, the expense of integrating AI technology can be prohibitively expensive for some institutions. Another technical issue is the requirement for faculty growth and training. Many instructors may lack the skills and expertise required to effectively incorporate AI into their teaching practices. This emphasizes the importance of professional development programmes in providing educators with the support and resources they need to successfully integrate AI into their curricula.

Table 1 Source: Author

*Analysis 2: Challenges for AI Integration in Architectural Education*

Theme	Description
<b>Lack of Awareness and Knowledge</b>	AI's potential applications may be unknown to educators and students, limiting its potential benefits. To develop an understanding and awareness of AI in architecture, increased awareness and education through training and workshops are required.
<b>Ethical and Social Considerations</b>	AI has ethical considerations, including potential bias and discrimination, as well as its impact on professional employment. To explore the potential social consequences of AI integration in architectural education, a critical and analytical approach is required.
<b>Infrastructure and Technical Barriers</b>	Access to innovative technology and technical knowledge is required for AI integration in architecture education, which can be a substantial barrier for universities. The cost of incorporating AI technology, as well as the necessity for faculty growth and training, are both concerns that must be addressed. Professional development programmes can give educators the resources and assistance they need to effectively integrate AI into their curricula.

Table 2 Source: Author

The two tables, Table 1 & Table 2 discuss various issues of AI integration in architecture education.

Analysis 1 focuses on the opportunities provided by AI integration in architecture education. The table is divided into three themes: enhanced learning and teaching, improved design solutions, and time and cost savings. The table emphasizes the benefits of AI to architecture education under each area, such as enhanced energy efficiency, personalized learning experiences, and time savings through automation.

Analysis 2 discusses the problems that AI integration in architecture education encounters. The table is organized into three sections: Lack of Awareness and Knowledge, Ethical and Social Considerations, and Infrastructure and Technical Barriers. Each theme highlights potential barriers to AI integration in architectural education, such as educators' and students' lack of awareness and knowledge about AI's potential applications, ethical concerns about AI's potential impact on the employment of architects and designers, and technical constraints related to the need for cutting-edge computing infrastructure and technical knowledge.

Overall, while Analysis 1 focuses on the possible benefits of AI integration in architecture education, Analysis 2 focuses on the potential challenges that must be overcome in order for AI integration to be successful. The two tables present different perspectives on the question of AI integration in architecture education in India.

**4. RESULTS AND DISCUSSION**

**4.1. OVERVIEW OF AI INTEGRATION IN ARCHITECTURAL EDUCATION IN INDIA**

As mentioned earlier, AI integration in architecture education in India is still in its early phases. AI has the potential to transform the field of architecture by enabling faster, more efficient design processes and improving design accuracy and quality. However, because of a lack of understanding, infrastructure, and resources, the field's adoption of AI technology is limited.

**4.2. PERCEPTION AND UNDERSTANDING OF AI IN ARCHITECTURAL EDUCATION AMONG FACULTY AND STUDENTS IN INDIA**

In India, both professors and students need to be more aware of and understand AI in architecture education. Many architecture instructors and practitioners are unaware of AI's potential to alter the discipline and improve design processes. Students may also lack the skills and knowledge required to apply AI technology effectively in their work.

### 4.3. IDENTIFICATION OF CURRENT AND POTENTIAL APPLICATIONS OF AI IN ARCHITECTURAL EDUCATION IN INDIA

**Design optimisation:** AI can be used to speed up and improve the efficiency of design processes by analysing and finding patterns in massive data sets.

**Virtual reality:** AI and virtual reality technology can be combined to produce immersive design experiences and enhance client-designer cooperation.

**Energy efficiency:** By using AI to optimise building systems and increase energy efficiency, prices and environmental effects can be decreased.

AI may be used to build infrastructure for smart cities and enhance urban planning and design. However, obstacles and problems include a lack of infrastructure and resources, a lack of AI knowledge in the field of design, and ethical and societal issues around these applications preventing their implementation.

### 4.4. OPPORTUNITIES AND CHALLENGES FOR AI INTEGRATION IN ARCHITECTURAL EDUCATION IN INDIA

- The integration of AI in architectural education in India presents several challenges and barriers that need to be addressed to ensure successful implementation. The following are some of the key challenges and barriers:

#### a) Technological infrastructure and access

##### 1. Availability of hardware and software resources:

For AI to be successfully incorporated into architecture education, there must be a sufficient supply of high-quality hardware and software resources. However, some institutions may be unable to get and make use of these resources due to a lack of adequate funds, infrastructure, and resources.

##### 2. Internet connectivity and digital divide:

The digital divide, or the difference between those who have access to technology and those who don't, is another issue. The incorporation of AI in architecture education continues to face substantial obstacles in many regions of India due to inadequate internet connectivity and restricted access to technology.

#### b) Faculty development and training

##### 1. AI literacy and skill development among educators:

The adoption of AI in architectural education necessitates that educators have the requisite training and expertise. However, many educators do not have the expertise and education required to integrate AI-driven tools and technology in their teaching efficiently.

##### 2. Resistance to change and adoption of new technologies:

Another obstacle to the incorporation of AI in architectural education is resistance to change. The potential advantages of integrating AI into education may be constrained since educators who are at ease using conventional teaching techniques may be reluctant to adopt new technologies.

#### c) Ethical and social considerations

##### 1. Data privacy and security concerns:

Large volumes of data must be gathered and processed in order for AI to be used in architectural education, which poses questions regarding data security and privacy. Institutions must take precautions to guarantee that faculty and student information is shielded from misuse or unauthorised access.

##### 2. Potential biases and discrimination in AI-driven systems:

If AI-driven systems are not properly created and built, they may be subject to prejudice and discrimination. Students and professors, particularly those from marginalised groups, may experience severe effects as a result. Institutions must therefore make sure that their AI-driven systems are created in a just and impartial manner.

For educators to successfully integrate AI into architecture education, it will be necessary for educational institutions, industry, and the government to work together to address these obstacles and problems.

I recommend educational institutions in India to start using AI technology into their architecture education programmes in light of the potential and challenges outlined. To identify any gaps that need to be filled, it is crucial to assess the institution's infrastructure, curriculum, and faculty competencies before deploying AI.

Institutions should make the required investments in the hardware and software infrastructure to support AI-powered learning once these gaps have been discovered. To make sure that their faculty has the abilities needed to educate utilising AI technology, they should also think about providing training programmes for them.

Institutions should also set rules to ensure that data privacy and algorithmic bias are handled as well as carefully analyse the ethical implications of AI-powered design. Finally, organisations should keep an eye on how AI technology is being used in architecture education to assess its success and pinpoint areas for development.

By following these recommendations, educational institutions in India can leverage AI technology to

provide students with a more immersive, personalized, and collaborative learning experience while also addressing the shortage of skilled architects in the country.

#### 4.5. STRATEGIES FOR DEVELOPING A COMPREHENSIVE AI INTEGRATION STRATEGY IN ARCHITECTURAL EDUCATION IN INDIA

A multi-pronged plan involving collaboration between academia, industry, and government, improving faculty development and training programmes, and addressing ethical and social concerns is needed to build a complete AI integration strategy for architecture education in India. The following suggestions are provided for each of these areas:

- a) Collaboration between academia, industry, and government.
- b) Faculty development and training programs
- c) Addressing ethical and social concerns.

##### a) Collaboration between academia, industry, and government.

To enhance cooperation on research projects, the development of new AI technologies, and training programmes, architectural schools should a. establish relationships with AI research labs, tech businesses, and governmental organisations.

Establish cooperative research and development initiatives with an emphasis on coming up with AI-based solutions for issues and challenges in architecture.

Establish centres of excellence for AI in architecture that unite professionals from the academic, industrial, and governmental sectors to work on cutting-edge initiatives and foster innovation in the sector.

##### b) Faculty development and training programs

Provide faculty members with training and development opportunities so they can remain updated on the newest AI developments and applications in architecture.

Offer faculty members the chance to participate in workshops, conferences, and seminars on AI and architecture to advance their education and professional development.

Provide faculty members with chances to work on AI projects with researchers and industry specialists in order to get practical experience.

##### c) Addressing ethical and social concerns.

To ensure that the technology is applied responsibly and ethically, it is necessary to develop

ethical norms and guidelines for the use of AI in architecture.

Create tools to keep an eye on how AI is being utilised in architecture to make sure it isn't being abused or exploited against morality.

Use training programmes, seminars, and workshops to increase industry professionals' and students' knowledge of the social and ethical ramifications of AI in architecture.

## 5. CONCLUSION

This study examined both the opportunities and challenges of utilising artificial intelligence (AI) in Indian architectural education. According to the study, there is a lot of potentials for AI to improve architecture education, including personalised instruction, flexible testing, and intelligent tutoring systems. A number of other issues were also noted by the study, including a lack of infrastructure, the requirement for specialised training, and worries about the moral implications of AI in education.

The report suggests creating frameworks and policies to encourage the inclusion of AI in architectural education in India. Infrastructural investments, training courses for teachers and students, and the creation of moral standards for the application of AI in education can all fall under this category. Collaboration between the business world and academic institutions can also assist close the gap between theoretical understanding and real-world application.

The use of AI can, with the correct approach, revolutionise how we learn and teach, and ultimately result in the creation of a built environment that is more creative and sustainable.

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