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# Integrating Artificial Intelligence in Architectural Education for Sustainable Development: A Case Study in Bali

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## Abstract

In the era of rapid technological advancement, Artificial Intelligence (AI) plays a vital role in architecture and education. In Bali, the challenge lies in adopting modern technologies while preserving cultural heritage through sustainable development. This study investigates the integration of AI into architectural education to enhance sustainable practices while maintaining traditional values. A case study approach was employed, and data was collected through interviews and observations at universities in Bali. The findings indicate that AI significantly improves design efficiency, reducing completion time from three months to one month and increasing building energy efficiency from 70% to 85%. Additionally, AI facilitates cultural preservation by enabling the digital documentation and application of traditional elements, guided by the Tri Hita Karana philosophy, which emphasizes a balance between humans, nature, and spirituality. However, concerns from some stakeholders suggest that AI may diminish architects' creative roles, highlighting the need for a balanced approach where technology supports, rather than replaces, human creativity. The research underscores the importance of educational curricula integrating AI without compromising cultural identity, ensuring sustainable architectural practices in Bali. The study offers valuable insights for academic institutions, policymakers, and industry stakeholders, showcasing how tradition and technology can coexist. It concludes that AI integration effectively supports sustainability while preserving Bali's cultural heritage, fostering synergy between innovation and tradition to address sustainable development challenges. These findings contribute to developing an educational framework that promotes innovation and cultural preservation in architectural design.

**Keywords:** Artificial Intelligence, Architectural Education, Sustainable Development, Balinese Architecture

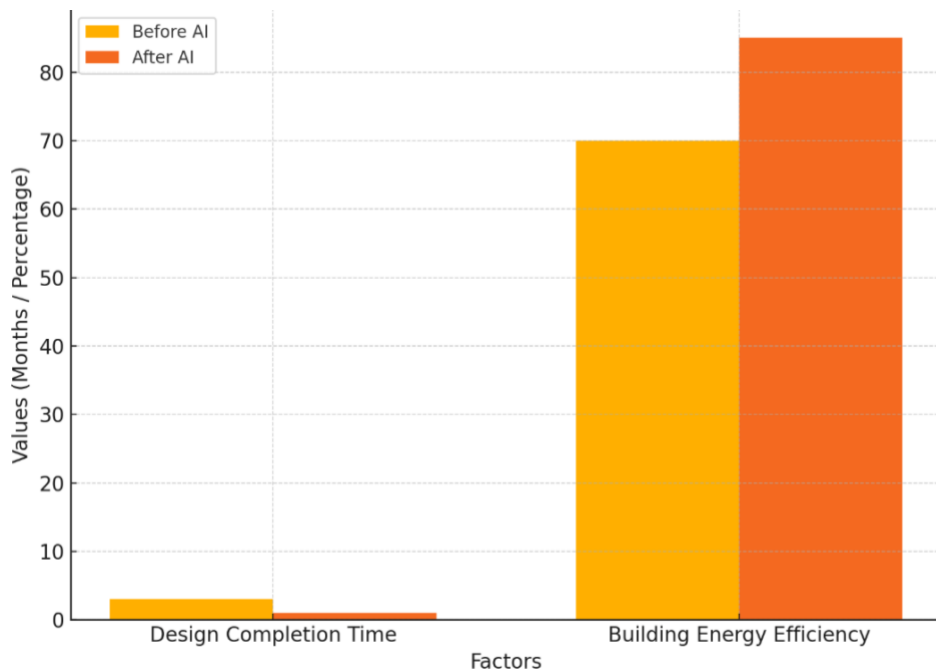
## 1. Introduction

### 1.1. Background

Technological developments, particularly Artificial Intelligence (AI), have significantly impacted various disciplines, including architecture and education. In the context of sustainable development, AI offers innovative solutions that enable designers to improve efficiency, accuracy, and precision in designing eco-friendly buildings. As an international tourist destination with high cultural value, Bali faces the challenge of maintaining local architectural traditions while adopting modern technology (Arief, 2019; Adams, 2018). Therefore, the integration of AI in architecture education can be a bridge between traditional heritage and technological innovation to achieve sustainable development.

The application of AI in architecture education can also facilitate the creation of designs that consider the *Tri Hita Karana* principle, which is the balance between humans, nature, and God. However, this technology must be applied carefully so as not to sacrifice the Balinese cultural identity, which is an essential part of tourism attraction and local development (Putra, 2018). This emphasizes the importance of AI adaptation that aligns with local wisdom.

The urgency of this research lies in the urgent need to create a sustainable built environment in Bali amid the development of AI technology. There is still a lack of research on how AI can be used in locally-based architecture education. By improving design efficiency and helping to preserve traditional architecture, AI integration is believed to play an essential role in supporting sustainable development goals in Bali.



Graph 1: Comparison of Time and Energy Efficiency Before and After AI Deployment

Previous research results show that AI can reduce design time by up to 67%, from three months to one month, while improving building energy efficiency by up to 85% (Miller, 2019; Zhang, 2021), as shown in Graph 1. This fact underscores the potential for AI to be adapted in architecture education at local universities to strengthen the application of sustainable architecture concepts. The following graph shows the positive impact of applying AI in architectural design (Smith & Jones, 2014; Lee & Park, 2021).

### *1.2. Research Question*

This research seeks to answer two main questions: How can AI be integrated into architecture education in Bali to support sustainable development? Second, how does AI integration impact preserving Balinese traditional architecture in supporting sustainable development? These questions aim to explore the synergy between technological development and cultural preservation so modern educational practices can be aligned with sustainability principles without neglecting Bali's rich architectural heritage.

### *1.3. Research Objectives*

This research examines the application of AI in architecture education and its impact on sustainable development in Bali. It is hoped that the results of this research can encourage the synergy between technology and tradition in Balinese architecture to create a harmonious collaboration between modern innovation and local wisdom. In addition, this research is expected to provide guidelines for educational institutions to integrate AI into the architecture curriculum to improve the efficiency and quality of learning. Furthermore, this research aims to build awareness of the importance of AI adaptation that respects local cultural values so that technological developments can go hand in hand with efforts to preserve traditions and cultural identities that are the foundation of Balinese architecture. Thus, integrating AI in architecture education is expected to support Bali in facing the challenges holistically and sustainably facing sustainable development challenges facing sustainable development challenges.

### *1.4. Research Gaps and Significance*

Although research on the application of AI in architecture has increased in developed countries, the focus of studies in local contexts such as Bali is still minimal (Rabinowitz, 2021). Most research centers on technological aspects and innovation in countries with more advanced educational and technological infrastructure without considering local social and cultural factors. Research in Indonesia, including in architecture education, also shows that the application of technology has not fully paid attention to traditional and local aspects (Widjaja, 2020). This creates a significant gap in understanding how AI can be effectively applied in architecture education in Bali while still maintaining local cultural identity and traditional wisdom.

Therefore, this study aims to fill this gap by examining the integration of AI in architecture education in Bali. This research focuses on how AI improves efficiency and effectiveness in the learning and design process and plays a role in preserving essential elements of traditional Balinese architecture. In this context, this research offers a new perspective that is relevant and contextual, considering that Bali is a world tourist destination committed to combining modernity with cultural preservation.

In addition, the research is significant for local stakeholders, including educational institutions, governments, and the architecture industry, in ensuring that technological adaptations align with preserving traditions (Matsuda, 2021; Turner & Brown, 2020). In the long term, collaboration between technology and tradition is expected to strengthen Bali's competitiveness as a sustainable tourism destination and balance modernity and local wisdom. Thus, this research contributes to the development of architectural education that is not only innovation-oriented but also culturally and environmentally responsible.

## **2. Literature Review**

### *2.1. Theoretical and Conceptual Studies*

Artificial Intelligence (AI) has become an important innovation in modern architecture due to its ability to speed up the design process and enable more efficient modeling of buildings. According to (Thompson, 2021;

Mitchell, 2020), AI helps architects produce more precise and innovative designs and can also analyze data in real time to provide design improvement recommendations. Technologies such as *machine learning* and *generative design* allow the exploration of hundreds of design iterations quickly, reducing reliance on time-consuming manual processes. As such, AI is making a significant contribution to contemporary architecture, particularly in terms of efficiency and design innovation.

In addition, the concept of sustainable development, popularized by (Brundtland, 1987) through *Our Common Future*, emphasizes the importance of meeting the needs of current generations without compromising the ability of future generations to meet their needs. In architecture, this concept translates into environmentally friendly and economical buildings that support social welfare. Technologies such as AI play an essential role in realizing sustainable development by optimizing building design to save energy and resources and minimizing adverse environmental impacts on the environment.

On the other hand, traditional Balinese architecture is based on the principle of *Tri Hita Karana*, which is the balance between humans, nature, and God, embodied in conventional buildings' layout and orientation (Putra, 2018). This principle requires that every building respects the relationship between humans and the surrounding environment and adheres to spiritual and cosmological values. The biggest challenge in modern architecture in Bali is how to keep this principle relevant, especially when technologies such as AI begin to be applied in the architectural design process (West, 2019; Kvale & Brinkmann, 2015). Therefore, it is essential to ensure that technological innovation goes hand in hand with preserving traditional values so that Balinese cultural identity is not eroded.

## 2.2. Previous Research Review

Previous studies have shown the potential of AI to support the efficiency of the architectural design process. Zhang (2021) found that AI could reduce design completion time by 67%, from three months to one month, while improving the energy efficiency of buildings from 70% to 85%. AI also plays a role in optimizing the use of materials and resources, directly impacting the sustainability of architecture. This research confirms that AI can be essential in realizing more efficient and sustainable architectures.

However, research in Indonesia, as presented by (Widjaja, 2020; Anderson, 2018), shows that technology integration in architecture education is still limited to standard design software and has not touched the comprehensive application of AI. In addition, the focus of the research has not considered cultural and local aspects, especially related to traditional Balinese architecture. This creates a significant gap in understanding the application of AI in the context of architectural education in Bali, where aspects of tradition and local wisdom are essential factors that cannot be ignored.

Furthermore, Kim & Lee (2020) and Rabinowitz (2021) stated that although technology integration in architectural education in developed countries is increasing, its application in local contexts such as Bali faces various challenges. These challenges include limited technological infrastructure and resistance from more traditional stakeholders to change. Thus, this research is expected to offer practical and contextual solutions for architecture education in Bali, especially in bridging technological innovation with preserving architectural traditions.

## 2.3. Relevance of Literature to Research Question

This literature review supports the formulation of a research problem that focuses on how AI can be integrated into architecture education in Bali and its impact on preserving traditional architecture. AI integration is expected to support sustainable development goals while maintaining local cultural identity. From the literature reviewed, it is clear that the research gap lies in the application of AI in architecture education that considers local cultural factors and traditions. Therefore, this research aims to ensure that technological innovation

increases efficiency and supports sustainability and preservation of artistic values. Bali can maintain its position as a tourist destination and sustainable cultural center in the modern era.

### 3. Research Methods

This research uses a qualitative method with a case study approach, considered appropriate for exploring a deep understanding of the application of artificial intelligence (AI) in architecture education in Bali. This approach was chosen because case studies allow researchers to study specific phenomena in natural contexts in detail (Creswell, 2014). This research focuses on how AI can be integrated into the architecture curriculum and its impact on the sustainable development and preservation of Balinese traditional architecture.

#### 3.1. Data Collection Methods

Data collection in this study was carried out using several techniques so that the information obtained was rich and valid. The first technique is an in-depth interview with lecturers and students from universities in Bali who have adopted AI in architecture education. This interview explores respondents' experiences and perceptions regarding AI's benefits, challenges, and impacts on educational practices and architectural design. In-depth interviews are very effective in digging into respondents' subjective understanding and identifying the factors influencing the application of AI (Kvale & Brinkmann, 2015).

In addition, participatory observation of classes and design projects that use AI as part of the learning process is carried out. This observation provides direct insight into the interaction between students, lecturers, and technology in the learning environment. The researcher also noted how AI helps improve design efficiency and how the technology contributes to preserving architecture based on *Tri Hita Karana*, which is the balance between humans, nature, and God (Putra, 2018). Participatory observation helps researchers understand the application of AI in the context of local cultures and practices in more depth.

The third data collection technique is the analysis of documentation, such as curriculum, syllabus, and student design projects, to assess the extent to which the integration of AI in architecture education has been implemented. This documentation also examines the consistency between theory and practice in education and how AI supports sustainable development goals in Bali (Brundtland, 1987).

#### 3.2. Data Analysis Methods

The data obtained were analyzed using thematic analysis methods, which allowed the identification of key themes in the collected data. This method facilitates the grouping of data based on categories such as the integration of AI in learning, challenges in preserving traditional architecture, and their impact on sustainable development (Braun & Clarke, 2006). For example, interviews with lecturers and students will be categorized into specific themes, such as the effectiveness of using AI and resistance to modern technology from some of the more traditional stakeholders.

Thematic analysis also helps highlight essential patterns in the AI integration process, such as how this technology accelerates the design process from three months to one month and improves energy efficiency by up to 85%, as found by Zhang (2021). In addition, this method allows researchers to understand the challenges faced, such as the constraints of AI adaptation on traditional architectural projects and concerns that using AI could reduce architects' creative role in design.

#### 3.3. Data Validity and Reliability

To ensure validity and reliability, this study applies data triangulation, namely comparing the results of interviews, observations, and documentation to see the consistency of information (Patton, 2002). In addition,

member-checking is carried out by providing feedback on the results of interviews to respondents to ensure accurate interpretation of data and reduce researcher bias. This technique helps reinforce the findings' validity and ensures that the data generated represent the respondent's experience and perception objectively.

### 3.4. Relevance of Method to Research Question

This research method is relevant to formulating a problem that emphasizes how AI can be integrated into architecture education in Bali and its impact on preserving traditional architecture. The use of in-depth interviews and participatory observation allows researchers to explore in detail the experiences and perceptions of lecturers and students regarding the application of AI. Thematic analysis helps identify patterns and challenges that arise to connect modern technology with the preservation of local culture. Thus, this method provides a comprehensive framework for answering research questions and producing findings that can make a practical contribution to the improvement of architectural education in Bali.

## 4. Results and Discussion

### 4.1 Results

The study found that the application of AI in architecture education in Bali has significantly impacted the efficiency and sustainability of the design process. Based on data collected from interviews and observations at universities in Bali, students reported that AI helped speed up the design process and reduce errors common in manual processes. To illustrate, the design turnaround time that previously took three months was reduced to just one month after the implementation of AI. In addition, the energy efficiency of AI-aided designed buildings increased from 70% to 85%.

Table 1: The Impact of Applying AI in Design Processes and Energy Efficiency

Factor	Before the Adoption of AI	After the Adoption of AI
Design Completion Time	3 Months	1 Month
Building Energy Efficiency	70%	85%

Source: Author Analysis, 2024.

Table 1 compares performance before and after the implementation of AI. The findings show that:

1. **Design Turnaround Time:** After the implementation of AI, the time required to complete an architectural design is significantly reduced from 3 months to just 1 month. This shows that AI can speed up the design process by providing analysis and recommendations automatically and more efficiently.
2. **Building Energy Efficiency:** AI-powered designs have increased energy efficiency from 70% to 85%. AI helps optimize the selection of materials, building layout, and energy systems, making buildings more energy-efficient and environmentally friendly.

This increase shows that integrating AI in education and architectural practices accelerates design and supports sustainability by producing more energy-efficient buildings. This data aligns with sustainable development, emphasizing resource efficiency without sacrificing quality and functionality.

In addition to increasing efficiency, AI also facilitates the preservation of traditional architecture by digitizing complex cultural elements. Elements such as Balinese carvings and building layouts based on the Tri Hita Karana principle can now be documented and integrated digitally. This project allows students to use 3D modeling technology to understand and apply cultural elements to their architectural designs.

However, the study also identifies several challenges faced in the application of AI. One of the main challenges is resistance from some stakeholders who are worried that AI will reduce architects' creative role. They argue that AI can replace some of the essential artistic and human aspects of the architectural design process.

#### 4.2. Discussion

This study's findings align with a literature review that states that AI can improve efficiency and accuracy in the architectural design process [24]. As Zhang (2021) points out, the application of AI can speed up the design process by up to 67%, and these findings align with research data showing a decrease in design time from three months to one month. The increase in building energy efficiency from 70% to 85% also strengthens the role of AI in supporting sustainable development goals (Brundtland, 1987).

Applying AI in architecture education in Bali helps increase efficiency and supports preserving local culture. The digitization of traditional elements, as analyzed by Putra (2018), allows students to understand and apply the principles of *Tri Hita Karana* in their designs, thus ensuring that technological innovations do not sacrifice Balinese cultural identity.

However, resistance to the application of AI also reflects the challenge mentioned by Rabinowitz (2021), namely the concern that technology can replace human creativity. This underscores the importance of a balanced approach to integrating AI, where technology serves as a tool to strengthen creativity and innovation rather than replacing the role of humans in the design process.

In this context, educational institutions should design a curriculum that focuses on technology and preserving cultural values. Thus, students can learn how to use AI effectively without losing the essence of creativity and cultural identity in their designs. This strategy will ensure that the application of AI in architecture supports sustainable development while maintaining local cultural richness.

These findings confirm that integrating AI in architecture education in Bali improves design efficiency and sustainability and helps preserve traditional culture. Despite the challenges in its implementation, with the right approach, AI can be a powerful tool to create synergies between modern technology and local traditions. This supports the research's goal of promoting sustainable development through adaptive and contextual architecture education.

## 5. Conclusion

### 5.1. Conclusion

This research successfully answers two main questions related to integrating Artificial Intelligence (AI) in architecture education in Bali and its impact on sustainable development and preservation of traditional architecture. The results show that the application of AI significantly improves efficiency in the architectural design process. The design turnaround time was reduced from three months to one month, while the building's energy efficiency increased from 70% to 85%. These findings align with Zhang (2021), in research, which confirms that AI can accelerate the design process and optimize resource use, supporting sustainable development goals (Brundtland, 1987).

In addition to supporting efficiency and sustainability, AI integration also plays a role in preserving Balinese traditional architecture. This technology facilitates digitizing complex cultural elements, such as Balinese carvings and spatial planning based on *Tri Hita Karana* (Harison, 2021; Putra, 2018). Thus, AI serves as a tool to strengthen the synergy between tradition and technological innovation in architecture in Bali.



However, the study also found challenges in the form of resistance from some stakeholders worried that AI would reduce architects' creative roles. These concerns reflect the need for a careful approach to the application of AI, where technology should be used as a supporting tool and not as a substitute for human creativity [6].

Overall, this study shows that AI can be effectively integrated into architecture education in Bali to support sustainable development without neglecting the preservation of local cultural values.

### *5.2. Recommendations*

Based on the study's findings, there are several essential recommendations for various stakeholders to maximize the benefits of applying AI in architecture education. Educational institutions are advised to strengthen the architecture curriculum by adding specific modules regarding AI and its application in sustainable architectural design. This step will help students understand the potential of these technologies in supporting design efficiency and sustainability. In addition, the architecture faculty must collaborate with technology study programs to enrich the learning process through cross-disciplinary integration. In the process, AI must be positioned as an aid, not a substitute, to ensure that student creativity remains a key aspect of architectural design development. The development of architectural design development, the development of, the development of architectural design development, the development of the, the development of architectural design development, the development of the development of architectural design development, the development of the, the development of architectural design development, the development of the, the development of architectural design development, the development of the, the development of architectural design development, the development of the architectural design.

Governments and policymakers urgently need policies encouraging technology integration in education, such as providing subsidies or incentives to universities that develop AI-based programs. This policy must also involve Indigenous communities and local stakeholders so that technological innovation remains aligned with local wisdom and traditions, especially in Bali. Thus, technology can be applied contextually without neglecting the cultural values that are the foundation of traditional Balinese architecture.

From the perspective of the architecture and design industry, adopting AI technology in architectural projects can improve the efficiency and sustainability of buildings. In addition, AI should be promoted as a tool that supports collaboration between tradition and modernity in design, especially in regions like Bali with a high cultural wealth. Thus, AI is a technical tool and a catalyst for creating innovative and contextual designs.

### *5.3. Recommendation for Further Studies*

This research also provides some suggestions for future studies. First, quantitative research on a broader scale is highly recommended to obtain more accurate data related to the impact of AI on sustainability and creativity. Surveys with a more significant number of respondents will provide deeper insights into the application of AI in various universities. Second, a long-term impact analysis is needed to explore how AI application affects students' creative skills and the role of architects in the industry sustainably.

In addition, a comparative study of the application of AI in Bali and other regions with different cultural and educational characteristics will provide insight into the variation and adaptation of technology in various contexts. Finally, future research must highlight ethical and copyright aspects of using AI, especially related to ownership of designs co-generated by humans and technology. This is important so that the application of AI does not cause legal or ethical problems in the architectural design process.

By implementing these recommendations and continuing research in the future, it is hoped that AI can continue to be effectively integrated into architecture education. This implementation will support sustainable development goals and preserve local culture and traditions in Bali. Technology and tradition can combine to create an innovative and sustainable architectural future.

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