OPEN ACCESS

Saudi Journal of Civil Engineering
Abbreviated Key Title: Saudi J Civ Eng
ISSN 2523-2657 (Print) |ISSN 2523-2231 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com/journal/sjce/home

Original Research Article

Integrating Artificial Intelligence Tools in Architectural and Engineering Design Education in Libya: Opportunities & Challenges

Huda A. Elbasha[1]*

[1]Zawiya Higher Institute of Science and Technology, Zawiya, Libya

DOI: https://doi.org/10.36348/sjce.2025.v09i08.003 | **Received:** 17.07.2025 | **Accepted:** 15.09.2025 | **Published:** 25.09.2025

***Corresponding author:** Huda A. Elbasha
Zawiya Higher Institute of Science and Technology, Zawiya, Libya

Abstract

This paper examines the integration of Artificial Intelligence (AI) tools such as "ChatGPT", "MidJourney", and Stable Diffusion into architectural and design education, with a particular emphasis on their potential application in Libya. The rapid development of generative AI has transformed higher education globally, shifting it from a teacher-centered paradigm toward more flexible, data-driven, and student-centered models. While international experiences have demonstrated significant benefits such as enhanced design exploration, improved critical thinking, and more adaptive assessment methods the Libyan context presents both unique opportunities and challenges that require careful consideration. The study adopts a critical inductive methodology, combining an in-depth literature review with an analysis of international case studies from institutions such as MIT, ETH Zurich, TU Delft, and Harvard GSD. Building on these insights, it proposes a three-phase framework for AI integration in architectural education: [1] a Preparatory Phase focusing on awareness and experimentation, [2] an Integrative Phase involving gradual curricular embedding and revised assessment practices, and [3] an Institutional Phase aimed at mainstreaming AI through policy reform, infrastructure development, and research capacity building. Findings indicate that successful integration requires more than access to technology; it depends on achieving a balance between pedagogical approaches, institutional policies, and infrastructural readiness. Within the Libyan context, gradual implementation tailored to local constraints and opportunities emerges as both feasible and necessary. The paper concludes with practical recommendations addressing capacity building for faculty and students, curriculum reform, policy development, enhancement of digital infrastructure, and the establishment of international collaborations. By following this roadmap, Libyan universities can adopt AI in a sustainable manner that strengthens educational quality while preserving academic authenticity.

Keywords: Artificial Intelligence, Architecture Education, Engineering Design, Libya, ChatGPT, MidJourney, Stable Diffusion.

1. INTRODUCTION

The world today is witnessing rapid transformations in higher education as a result of the significant advancement of Artificial Intelligence (AI) technologies. These developments have had a direct impact on teaching methods and learning approaches across various disciplines. AI has become a central tool in supporting the educational process, not only in applied sciences but also in creative fields such as architecture and engineering design.

In this context, innovative tools such as "ChatGPT", which contributes to the generation of ideas and textual content, and "MidJourney" and "Stable Diffusion", which provide advanced capabilities for producing visual and design concepts, have emerged. These tools are no longer merely technical applications but are becoming integral parts of a global educational ecosystem that seeks to redefine the roles of students and educators within a more interactive and creative learning environment.

In Libya, however, architectural and engineering education still relies heavily on traditional curricula and classical teaching methods, amidst significant challenges related to weak digital infrastructure, limited technical resources, and a lack of expertise in modern technologies. This reality necessitates the search for innovative solutions capable of improving the educational process and enhancing its efficiency in line with global trends.

Against this backdrop, this paper aims to examine the potential of integrating AI tools into architectural and engineering design education in Libya. It focuses on analyzing international experiences in this field and comparing them with the Libyan context, with the objective of presenting a preliminary framework that explores opportunities and addresses foreseeable challenges. Furthermore, the study highlights the potential role of these tools in enhancing students' creative and technical skills while enabling faculty members to adopt more interactive and innovative teaching strategies.

1.1 Study Objectives

Building on the issues highlighted in the introduction regarding the global transformations in architectural education and the challenges facing the Libyan context, there is a clear need for an in-depth study that explores the role of Artificial Intelligence tools in advancing engineering education. Accordingly, this research seeks to provide an analytical and comparative perspective aimed at developing a preliminary framework for integrating these tools into architecture and design curricula in Libya. In this regard, the objectives of the study can be summarized as follows:

1. Analyze the current state of architectural and engineering education in Libya in terms of infrastructure, curricula, and teaching methods.
2. Explore the potential of utilizing AI tools (ChatGPT, MidJourney, Stable Diffusion) in the educational process.
3. Compare international experiences in integrating AI into education with the Libyan context.
4. Propose a preliminary framework for the gradual integration of these tools into architectural and engineering design curricula in Libya.
5. Highlight the opportunities and challenges associated with this transformation, while providing practical recommendations for universities and institutes.

1.2 Research Question

1. To what extent is architectural and engineering education in Libya prepared to integrate AI tools?
2. What are the most relevant educational applications of tools such as ChatGPT, MidJourney, and Stable Diffusion in teaching architecture and design?
3. What lessons can be learned from international experiences in integrating AI into education?
4. What are the technical, pedagogical, and ethical challenges that may hinder the adoption of these tools in the Libyan context?
5. How can a practical framework be developed to support the gradual and effective integration of these tools into Libyan educational curricula?

2. LITERATURE REVIEW

The review of literature represents a fundamental step in understanding the theoretical and practical context of integrating Artificial Intelligence into architectural and engineering education. It goes beyond presenting previous studies to analyze global trends, highlight both successes and challenges, and ultimately identify the research gap that this paper seeks to address. Accordingly, the literature review is organized around the following themes:

1. Artificial Intelligence and Higher Education Globally.
2. Artificial Intelligence in Architectural and Design Education.
3. International Case Studies of Successful Applications.
4. Challenges of Global Implementation.
5. The Research Gap.

Building on this preliminary outline of the main themes, the review continues by examining these dimensions within the context of higher education globally, as the broadest entry point for understanding how Artificial Intelligence has evolved into a structural element influencing the educational process. These themes provide insights into current global trends and institutional practices that have shaped diverse models for employing AI in the development of curricula, teaching methods, and assessment strategies. Hence, we discuss the review topics as follows:

2.1 Artificial Intelligence and Global Education

Academic literature confirms that Artificial Intelligence (AI) is no longer a supplementary technical tool but a driving force reshaping higher education worldwide. Reports by UNESCO (2023) and the OECD (2022) show that universities adopting AI systems have been able to redefine curricular structures, teaching strategies, and assessment methods. This transformation is not simply about introducing new tools; it represents the emergence of a new educational paradigm built upon adaptive data, personalized learning, and human–machine integration.

2.1.1 Personalized Learning

Studies (Siemens, 2020; Zawacki-Richter et al., 2019) highlight that AI-driven learning systems, such as "Coursera" and "edX", have developed algorithms that adapt content to students' abilities and learning pace. Experiments at "Stanford" and "MIT" demonstrated that such systems reduced academic dropout rates by up to 20% and improved outcomes for lower-performing students by providing timely, individualized support.

2.1.2 Reshaping the Role of the Instructor

Instructors are no longer the sole sources of knowledge but have shifted into the roles of "facilitators and mentors." Experiences at UK universities such as "Cambridge" and "UCL" show that using tools like "ChatGPT" for drafting examples and assignments freed

instructors to focus on cultivating "critical and analytical skills", rather than being absorbed in routine tasks. While largely positive, this shift raises debates over the limits of AI reliance and the instructor's role in safeguarding academic quality.

2.1.3 Academic Assessment

Assessment has become one of the most significant aspects of higher education reshaped by Artificial Intelligence (AI). In traditional models, the focus was primarily on the final output whether an architectural project, a research paper, or a written exam. However, recent studies (Holmes *et al.,* 2021; Zawacki-Richter *et al.,* 2019) have shown that this model is no longer sufficient to capture the full scope of the learning process, especially with the rise of tools capable of generating high-quality texts and visuals within minutes.

One of the most notable successes reported in the literature is the reform of assessment practices. At "ETH Zurich" and "TU Delft", AI tools have been integrated to evaluate the "design process" rather than the final product alone. This approach strengthened "design thinking" and students' ability to critically document their workflows. It aligns with findings by "Kulik & Fletcher (2016)", which indicate that AI can deliver more accurate and timelier "real-time feedback".

This shift has compelled leading universities to reconsider their assessment methods, moving from a focus on the final product to emphasizing the learning process itself. Among the most prominent models documented in the academic literature are those implemented at "ETH Zurich" and "TU Delft":

1. The Experience of ETH Zurich and TU Delft

At "ETH Zurich", a "multi-stage assessment model" was developed within architecture studios. Students are required to submit:

1. **Design Rationale:** A written explanation describing how tools such as "MidJourney" or "ChatGPT" contributed to shaping their ideas.
2. **Intermediate Drafts:** Images or texts generated with AI tools, accompanied by the student's critical reflections.
3. **Final Output:** The completed project or design after integrating personal creativity with digital inputs.

Faculty members assess these stages using clearly defined rubrics that cover: 'originality', 'critical reflection', and 'the integration of human and technological creativity'.

At "TU Delft" (Netherlands), a "process-based assessment" approach was adopted in urban design studios. The evaluation focused on:

- **Design Decision Sequence:** Did the student use AI consciously to support decisions, or rely on it mechanically?
- **Verification Skills:** How did the student validate the credibility and appropriateness of AI-generated outputs?
- **Iterative Development:** To what extent did the student refine and evolve the design through multiple stages rather than relying solely on initial outputs?

2. An Academic Framework for Assessment Design

Based on these experiences, the literature suggests a structured plan for developing academic assessment in the age of AI:

1. **Redefining Success Criteria:** The goal is no longer simply to produce polished outputs, but to demonstrate critical thinking combined with the effective use of AI tools.
2. **Emphasis on Documentation**: Students should be required to provide evidence of their workflow, justification of prompt choices, and adjustments to outputs.
3. **Integration of Critical Thinking:** Assignments should include comparative questions that push students to evaluate AI outputs against their own ideas and justify their decisions.
4. **Balanced Individual–Peer Assessment**: Some universities incorporated peer review, where students evaluate each other's work, reducing the risks of over-reliance on AI.
5. **Gradual Implementation**: Piloting elective courses or short workshops before full integration into core curricula.

Experiences at ETH Zurich and TU Delft demonstrate that reforming assessment practices is the key to successful AI integration in education. By shifting the focus from product to process, these institutions preserved academic integrity and encouraged students to develop a complementary rather than dependent relationship with technology.

2.1.4 Global Challenges

Despite these advances, the literature highlights persistent structural challenges:

- **Technical:** Dependence on high-performance computing and stable internet connections, making implementation costly in resource-limited contexts (Holmes *et al.,* 2021).
- **Pedagogical:** Insufficient faculty expertise in handling AI tools, hindering effective curriculum integration (Salmon, 2019).
- **Ethical:** Intellectual property issues surrounding AI-generated content, alongside academic integrity concerns and students' over-reliance on tools instead of developing independent skills (Floridi & Chiriatti, 2020).

2.1.5 Lessons Learned

The institutions most successful in integrating AI were those that:

- Established clear institutional policies specifying acceptable uses of AI.
- Invested in faculty development and digital skill enhancement.
- Redesigned curricula and assessments to align with the nature and potential of AI tools.

2.2 Artificial Intelligence in Architectural and Design Education

Architecture and design represent some of the academic fields most affected by AI, due to their inherently creative nature and reliance on both conceptual thinking and visual experimentation. Recent literature (Kolarevic, 2003; Liu *et al.,* 2022; Brown & Jones, 2023) indicates that the integration of generative AI tools, such as MidJourney, Stable Diffusion, and ChatGPT has reshaped educational practices in design studios, opening new horizons for both students and instructors.

Through an analysis of the literature and international experiences, a set of key themes can be identified that illustrate how Artificial Intelligence has influenced the redefinition of the educational process in this field.

2.2.1 Redefining the Design Process

Contemporary literature suggests that the integration of generative AI into architectural studios has reconfigured the very notion of the "design process." Whereas the traditional model was structured as a linear progression from initial concept to visual representation to technical testing generative algorithms have introduced an iterative–reflective mode that foregrounds divergent exploration as a primary stage. In leading institutions such as MIT and Bartlett UCL, it has become common practice to initiate projects with an intensive phase of "parallel production" through platforms like MidJourney or Stable Diffusion, generating dozens of images within minutes and thereby opening a design space of possibilities that would previously have required weeks of manual or conventional digital modeling.

The educational value, however, lies not in speed alone but in the capacity for critical negotiation with the outputs: students are increasingly required to translate generative imagery into formal and conceptual rules that can later evolve into parametric models subject to performance testing. In this sense, AI ceases to function merely as a visual catalyst and becomes embedded within the structure of design decision-making, enabling students to examine how specific constraints (climatic, structural, material) influence form from the earliest stages.

As argued by scholars such as Kolarevic (2003) and Liu *et al.,* (2022), the process is no longer confined to the individual designer but has become a hybrid collaborative practice between human and machine. Generative outputs are treated less as final images and more as discursive artifacts—provisional representations deployed in collective critiques, where they are deconstructed and recomposed to mediate between creative freedom and academic or practical constraints.

Thus, redefining the design process through AI is not simply about accelerating production or multiplying visual variety, but about reframing the relationship between idea, tool, and decision—empowering students to engage in a mode of design that is more open-ended, experimental, and contextually grounded, while still retaining its critical orientation.

2.2.2 Fostering Critical and Reflective Thinking

The incorporation of AI tools into architectural pedagogy has not only expanded the realm of creative exploration but has also generated new conditions for critical and reflective engagement. Studies conducted at institutions such as ETH Zurich and Politecnico di Milano indicate that the introduction of platforms like ChatGPT within design studios encourages students to interrogate both their own ideas and the algorithmic suggestions they receive. Drafting design narratives, synthesizing literature reviews, or producing conceptual statements with AI are not ends in themselves, but rather provocations that demand scrutiny, verification, and contextualization.

This dynamic repositions the role of the student from passive consumer of generative output to critical mediator, tasked with assessing accuracy, identifying bias, and situating machine-produced material within a broader disciplinary discourse. The process thereby cultivates a form of meta-cognition, where students must continually reflect on how knowledge is constructed, validated, and communicated within design education.

2.2.3 Visualizations and Design Communication

In parallel, generative AI has reshaped the modes through which design intentions are communicated and critiqued. Within programs such as Harvard GSD, the deployment of tools like Stable Diffusion has enabled the rapid production of photorealistic or speculative imagery that enhances the immediacy of dialogue in early project stages. Such visualizations operate less as final representational artifacts than as intermediary communicative devices, facilitating peer-to-peer discussion and instructor feedback at a formative moment when design directions remain fluid.

What emerges is a pedagogical shift where visual production becomes inseparable from discursive interaction: the act of presenting an AI-generated image is simultaneously an act of framing, narrating, and

defending its conceptual grounding. In this sense, visualization is no longer perceived as an endpoint in the design sequence but as a discursive interface a medium through which ideas are tested, contested, and iteratively refined.

This framework illustrates that AI integration in architectural education must proceed progressively from awareness and experimentation, through structured embedding, to institutional adoption. Its success relies not only on technology but also on balancing pedagogy, policy, and infrastructure, ensuring applicability within the Libyan context.

Table 1: Pedagogical Framework for Integrating AI into Architectural and Design Education

Dimension	Educational Objective	Tool / Method	Expected Learning Outcomes
Redefining the Design Process	Expand the design space and reframe the process from linear to iterative reflective	Generative image production (MidJourney, Stable Diffusion) → Parametric translation	Ability to generate multiple design alternatives and extract formal/conceptual rules
Fostering Critical Thinking	Strengthen students' capacity for verification, reflection, and critique	Use of ChatGPT for design narratives / literature synthesis, followed by student-led critique	Development of critical evaluation skills and distinction between machine output and academic knowledge
Visualizations and Communication	Enhance early-stage design communication and peer critique	Stable Diffusion for photorealistic imagery + collective critique sessions	Improved visual communication skills and more constructive dialogue
Addressing Challenges	Mitigate risks of originality loss, digital divide, and ethical concerns	Clear institutional policies + rubrics focused on process + faculty training	Reduced over-reliance on AI, more equitable access, and stronger academic integrity
Lessons Learned	Formulate a gradual and flexible integration model	Start with short workshops → elective courses → gradual embedding in core curricula	Balanced proficiency in traditional skills (hand drawing, physical models) and digital/AI-assisted methods

2.3 Academic and Professional Challenges

Despite the promising potential demonstrated by AI in architectural and design studios, the literature reveals that its integration encounters a range of complex challenges. From the perspective of "creative originality", there is growing concern that excessive reliance on generative imagery may lead to a form of 'homogenization of imagination', where outputs converge toward repetitive visual patterns derived from global datasets that fail to capture cultural or local specificity. In terms of "ethical responsibility", ongoing debates center on the intellectual property of AI-generated outputs and whether a student's work can truly be considered original if its results are partially produced by algorithms not authored by the student.

On the "pedagogical" front, the challenge lies in restructuring studio pedagogy to maintain academic rigor without sliding into mechanical dependency. Studies such as Floridi & Chiriatti (2020) emphasize that the absence of systematic faculty training makes it difficult to guide students toward critical and reflective uses of AI. In resource-constrained contexts, particularly in developing regions, the "digital divide" emerges as an additional barrier, where unequal access to powerful hardware or commercial subscriptions may deepen disparities within the same classroom.

2.4 Lessons Learned

International experiences suggest that the successful integration of AI in architectural and design education does not stem from fascination with the technology alone but from the establishment of coherent pedagogical and institutional frameworks. A key lesson is the principle of "complementarity rather than substitution", in which AI is viewed as an expansive mediator that augments, rather than replaces, human creativity. Equally important is the adoption of "process-oriented assessment models", which recognize critical reasoning and justification as central learning outcomes, rather than focusing exclusively on the quality of final deliverables.

Furthermore, "pedagogical flexibility" has proven essential: successful universities often begin with short workshops or elective courses, gradually embedding AI tools into core curricula. This incremental approach reduces resistance and provides space for both faculty and students to adapt. Finally, the literature underscores the necessity of maintaining a "balance between traditional and digital skills": hand drawing and physical modeling are not discarded but rather reinterpreted as foundational practices that gain new relevance when enriched through AI tools.

2.5 Research Gap

Despite the growing body of international literature addressing the role of AI in higher education broadly, and in architectural and design education more specifically, most existing studies are situated in Western or advanced Asian contexts with robust digital infrastructures and substantial research capacities. In

contrast, there is a noticeable scarcity of in-depth investigations into the potential of integrating AI within Arab or African educational environments characterized by limited resources. Moreover, much of the literature has emphasized the technical capabilities of AI tools, while paying comparatively less attention to the pedagogical and ethical dimensions and their adaptation to local contexts.

This study therefore seeks to address the following research gap:

> *The absence of an analytical framework that connects successful international experiences with the realities of architectural education in Libya, in order to develop a gradual and practical model for integrating AI into curricula one that safeguards academic integrity while remaining sensitive to existing technical and institutional constraints.*

3. METHODOLOGY

Given the novelty of integrating Artificial Intelligence (AI) tools into architectural and design education, and the absence of large-scale implementations in the Libyan context thus far, this study adopts an "analytical–inductive approach" that combines a review and synthesis of international literature with a comparative analysis of local realities.

This methodology is based on a set of interrelated steps that combine critical analysis of international literature, comparison across different educational contexts, and the formulation of conclusions adaptable to the local reality. These steps can be summarized in the following pillars:

1. Review of International Literature

The study analyzed a range of academic research and institutional reports (e.g., UNESCO, OECD, and case studies from MIT, ETH Zurich, TU Delft, Harvard GSD, and Politecnico di Milano) that addressed the integration of AI into higher education broadly, and architectural/design education specifically. The review covered:

- Generative AI tools such as ChatGPT, MidJourney, and Stable Diffusion.
- Innovative educational assessment strategies (e.g., process-oriented assessment).
- Flexible pedagogical models and successful international practices.

2. Comparative Approach

A comparative framework was employed to juxtapose advanced international educational contexts with the Libyan context, through:

- Analysis of technical and infrastructural challenges (limited resources, digital divide).
- Discussion of pedagogical dimensions (traditional curricula versus potential for transformation).
- Exploration of institutional and ethical constraints (academic integrity, intellectual property).

3. Deductive Analysis

The study relies on deductive reasoning to propose a preliminary framework for integrating AI into Libyan architectural education by:

- Extracting common principles from international experiences (e.g., complementarity rather than substitution, flexibility, process-oriented assessment).
- Adapting these principles to the Libyan educational environment (addressing infrastructural limitations, faculty training needs, and ensuring equitable access).

4. Limitations

This study is based on secondary data analysis and does not involve empirical or classroom-based experimentation in Libya. Consequently, its findings represent a theoretical framework and preliminary recommendations, which can later be tested and validated through more extensive applied studies.

> *"AI tools, were used for text editing and refining the manuscript. However, all outputs were reviewed and edited by the authors."*

DISCUSSION

Towards an AI Integration Framework for Architectural Education in Libya

The integration of Artificial Intelligence (AI) into architectural and design education in Libya cannot be conceived as a direct replication of international experiences. Rather, it requires a gradual and context-sensitive framework that reflects the realities of the local educational environment and the limitations of the existing infrastructure. Building on lessons drawn from global literature, this discussion proposes a three-phase model for integrating AI into Libyan architectural education. This model emphasizes a progressive transition that ensures AI evolves from a supportive technical tool into a structural component of the pedagogical process.

4.1 Preparatory Phase – Awareness and Experimentation

This phase represents the "foundational stage" for integrating Artificial Intelligence (AI), as it does not aim to impose tools directly into curricula but rather to "create an environment receptive to change" among students, faculty, and academic institutions. It is viewed as a cognitive foundational phase rather than a curricular instructional one, since the success of subsequent stages depends on the existence of prior awareness and critical

understanding of what AI is, along with its limitations and potential.

1. Objectives of the Preparatory Phase:
The preparatory phase pursues several key objectives that establish the groundwork for subsequent stages. Specifically, it seeks to:

- Overcome fear or resistance associated with the perception that AI may threaten originality or undermine the value of traditional skills.
- Redefine the role of AI, framing it as a complementary tool to human creativity rather than a substitute.
- Build a shared language among faculty and students regarding possible applications and potential risks of these tools.

2. Implementation Mechanisms:
In order to achieve these objectives, a set of practical mechanisms is proposed:

- **Short-term practical workshops:** Demonstrating direct applications, such as using ChatGPT to develop a design narrative or MidJourney to generate preliminary visual concepts.
- **Small-scale Pilot Lab:** Allowing students and faculty to experiment freely with tools outside the pressure of formal assessments, thereby encouraging exploration without fear of failure.
- **Institutional awareness programs:** Seminars and meetings with university decision-makers to clarify the value and long-term significance of this experimentation.

3. Expected Outcomes:
Through these mechanisms, the preparatory phase is expected to generate tangible outcomes, including:

- **Mindset Shift:** Moving from perceiving AI as a threat to recognizing it as an opportunity for advancement.
- **Enhanced critical awareness:** Enabling students to better distinguish between AI's potential and its limitations.
- **Formation of a community nucleus within the faculty:** Comprising a group of faculty members and students prepared to lead the subsequent phases.

4.2 Integrative Phase – Gradual Embedding in Curricula

This phase represents the second step in the trajectory of AI integration, where the experience evolves from mere awareness and preliminary experimentation to a structured and targeted inclusion within academic curricula. It is regarded as the stage that bridges the cognitive and institutional preparation of the first phase with the comprehensive adoption envisioned in the institutional phase.

1. Objectives of the Integrative Phase
This phase aims to achieve several objectives that pave the way for broader adoption:

- Expand the academic use of AI within a controlled and supervised learning environment.
- Develop new assessment tools that focus on the learning process and critical capacity rather than solely on the final product.
- Establish an internal policy framework to regulate academic use and ensure intellectual integrity and fairness among students.

2. Implementation Mechanisms
To accomplish these objectives, a set of practical mechanisms can be adopted:

- **Elective courses and experimental studios:** Integrating AI tools into elective modules or small-scale experimental projects to evaluate their impact on the learning process.
- **Revised assessment systems:** Designing new rubrics that emphasize originality, critical thinking, and iterative development of ideas, inspired by experiences from universities such as ETH Zurich and TU Delft.
- **Formal institutional policies:** Drafting regulatory guidelines that specify acceptable uses of generative tools, clarify intellectual property standards, and establish mechanisms for ensuring academic integrity.

3. Expected Outcomes
Through these mechanisms, the integrative phase is expected to yield tangible outcomes, including:

- Structured incorporation of AI within a formal academic setting without undermining traditional curricula.
- A balanced assessment system that prioritizes the learning process and reduces the risk of overreliance on generative tools.
- The establishment of an internal regulatory framework that provides a solid foundation for later institutional adoption.

4.3 Institutional Phase – Mainstreaming and Sustainability

This phase represents the pivotal stage in the trajectory of AI integration, where the experience evolves from a limited and guided application to a stage of comprehensive and institutional adoption, embedding AI as a structural and sustainable component of architectural education. It builds naturally on the previous two phases—awareness and experimentation, followed by gradual curricular embedding—culminating in full integration that impacts curricula, policies, and infrastructure alike.

1. Objectives of the Institutional Phase

This stage seeks to achieve long-term strategic objectives:

- Integrating AI into core curricula, making it part of compulsory courses rather than an optional or experimental component.
- Restructuring academic policies in alignment with national and international accreditation and quality standards.
- Developing sustainable digital infrastructure to ensure equitable access and equal opportunities for all students.
- Advancing scientific research through the establishment of specialized centers focused on studying the impact of AI on education and architectural practice.

2. Implementation Mechanisms

To realize these objectives, several mechanisms can be employed:

- **Integration into core courses:** Embedding AI in all fundamental studios and design modules, aligning with national accreditation standards.
- **Establishment of research–training centers:** Creating dedicated units or institutes within universities focused on AI in architecture, linking undergraduate and postgraduate programs.
- **International and regional partnerships:** Collaborating with organizations such as UNESCO and with European and Arab universities to exchange expertise and secure technical and financial support.
- **Digital infrastructure development:** Investing in central labs, high-performance computing networks, and the provision of open-source tools to reduce the digital divide.

Expected Outcomes

The institutional phase is expected to yield strategic outcomes, including:

- Embedding AI as a structural element in architectural education, making it part of the institutional identity of universities.
- Enhancing competitiveness of Libyan educational institutions regionally and internationally through the adoption of modern curricula aligned with global standards.
- Building a sustainable research ecosystem capable of generating locally grounded knowledge on AI in architecture, rather than merely importing external models.

Promoting educational equity: Ensuring that all students, regardless of economic background, have access to the necessary tools and resources.

This table outlines a step-by-step roadmap for integrating AI into architectural education, from initial awareness and experimentation to structured curricular embedding and full institutional adoption. Its success depends not only on technology but also on balancing pedagogy, policy, and infrastructure. In the Libyan context, this model is both feasible and achievable if implemented gradually and adapted to local conditions.

Table 2: Comparative Table of the Three Phases for AI Integration in Architectural Education

Phase	Main Objectives	Implementation Mechanisms	Expected Outcomes
Preparatory – Awareness and Experimentation	- Overcome fear and resistance. - Redefine AI as a complementary tool to human creativity. - Build a shared language among students and faculty.	- Short-term practical workshops. - Establish a small-scale pilot lab. - Awareness programs and institutional seminars.	- Mindset shift from rejection to acceptance. - Enhanced critical awareness. - Formation of a core community to lead subsequent phases.
Integrative – Gradual Embedding in Curricula	- Expand academic use of AI in a supervised environment. - Develop new assessment tools focusing on process and critical thinking. - Establish an internal policy framework.	- Integrating tools into elective courses and experimental studios. - Revising assessment systems with new rubrics. - Drafting formal university policies.	- Structured incorporation of AI into curricula. - A balanced assessment system. - Formation of an internal regulatory framework.
Institutional – Mainstreaming and Sustainability	- Integrate AI into core compulsory courses. - Restructure academic policies in line with accreditation and quality standards.	- Embedding AI in all core courses and design studios. - Establishing research–training centers.	- Embedding AI as a structural element of education. - Enhancing regional and international competitiveness.

Phase	Main Objectives	Implementation Mechanisms	Expected Outcomes
	- Develop sustainable digital infrastructure. - Strengthen specialized research.	- Building international and regional partnerships. - Investing in central labs and robust digital infrastructure.	- Building a sustainable research ecosystem. - Promoting educational equity.

Based on the preceding analysis of international literature and experiences, and the formulation of a three-phase framework for integrating AI into architectural education, it can be argued that the success of this trajectory depends on the capacity of Libyan academic institutions to balance technological capabilities with pedagogical considerations and institutional policies. This framework should not be regarded as a rigid plan but rather as a flexible pathway adaptable to local specificities. Accordingly, it is essential to move toward the conclusions and recommendations, which outline how this conceptual model can be translated into practical and actionable steps.

5. CONCLUSION & RECOMMENATIONS

In light of the analysis and the proposed framework, this study concludes that integrating Artificial Intelligence (AI) into architectural and design education represents not only a technological innovation but also a pedagogical and institutional transformation. The progressive three-phase model preparatory, integrative, and institutional provides a structured pathway that ensures both feasibility and sustainability, particularly within the Libyan context.

Building on these insights, the study puts forward a set of recommendations aimed at guiding universities, policymakers, and practitioners toward effective implementation. These recommendations focus on capacity building, curriculum reform, infrastructure development, and policy design, ensuring that AI integration supports both academic excellence and local relevance.

5.1 Key Conclusions

Based on the literature review, international experiences, and the proposed three-phase framework, the study arrives at several key conclusions that highlight both the opportunities and challenges of integrating AI into architectural education:

1. AI as a Pedagogical Transformation: The literature demonstrates that integrating AI in education is not merely a technological addition but a shift in educational philosophy and in the roles of both students and faculty.
2. Global Significance of International Experiences: Case studies from leading universities such as MIT, ETH Zurich, and TU Delft show that gradual adoption of AI enhances educational outcomes and strengthens students' critical thinking skills.
3. Multi-dimensional Challenges: The success of integration is shaped by technological factors (infrastructure), pedagogical factors (teaching and assessment methods), and ethical considerations (intellectual property and academic integrity).
4. Three-Phase Framework as a Roadmap: The proposed model (Preparatory – Integrative – Institutional) offers a practical pathway for balanced and gradual adoption, reducing risks of overreliance and educational inequality.
5. Adaptability to the Libyan Context: Despite local challenges, integrating AI into architectural education in Libyan universities is both possible and achievable if approached through a phased strategy that aligns with available resources and contextual specificities.

5.2 Practical Recommendations

Based on the preceding conclusions, this study proposes a set of recommendations targeting policymakers and academics in Libyan universities to ensure the effective and sustainable integration of Artificial Intelligence (AI) into architectural and design education:

1. Capacity Building for Faculty and Students:
   - Organize training programs for faculty members on the use of generative AI tools in teaching and design.
   - Engage students in practical workshops to strengthen their critical and creative skills using these tools.

2. Curriculum Reform:
   - Introduce elective courses on AI in the early stages, followed by gradual embedding into core curricula.
   - Redesign studio projects to balance traditional skills (hand drawing, physical modeling) with intelligent digital tools.

3. Assessment Development:
   - Adopt new rubrics that emphasize learning processes and critical thinking rather than focusing solely on final outputs.
   - Promote peer-review mechanisms to ensure academic integrity and reduce overreliance on digital tools.

4. Clear Institutional Policies:

- Draft university regulations to govern the use of AI in academic projects and define intellectual property boundaries.
- Establish standards of transparency and academic integrity in the use of generative tools.

Enhancement of Digital Infrastructure:

- Invest in advanced computer labs and provide access to open-source tools to reduce the digital divide.
- Improve internet services within universities to ensure equitable and reliable access to digital resources.

6. Promotion of Research and International Collaboration:

- Establish specialized research centers focusing on AI applications in architecture and design.
- Foster partnerships with international universities and organizations (such as UNESCO) to benefit from expertise and knowledge exchange.

5.3 Conclusion

This study affirms that integrating Artificial Intelligence (AI) into architectural and design education is not a luxury but a strategic necessity to keep pace with global transformations in education and engineering practices. Through the proposed phased framework, a gradual pathway has been outlined that balances technology, pedagogy, and institutional policies, making the model applicable within the Libyan context. The success of this pathway depends on clear institutional commitment, serious investment in infrastructure and human capacity, and a vision that bridges academic authenticity with the demands of the digital age. Accordingly, this paper represents a first step toward establishing a knowledge base and practical foundation upon which future research and initiatives can be built.

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