Teaching Architectural Project Design in the Age of Digital Technologies and Artificial Intelligence

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Abstract: Teaching architecture is a continual process of re-evaluation, shaped by evolving methodologies and technological advancements. This research examines the didactic tools employed in first-year architectural design education at the National School of Architecture and Urban Planning of Tunis, focusing on the influence of digital technologies and generative artificial intelligence. Through a critical analysis of teaching practices, we explore how the integration of innovative digital tools enhances knowledge consolidation and improves architectural project creation. By experimenting with various approaches within the project workshop, we seek to answer a fundamental question: How does the digital transition in architecture reshape the teaching of architectural design?

Keywords: *Architectural Design Education; Didactic Tools; Project Workshop; Digital Technologies; Generative Ai.*

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I. INTRODUCTION

Architectural training at the National School of Architecture and Urban Planning of Tunis spans six years, structured into two distinct cycles: an initial two-year cycle followed by a four-year cycle, culminating in the development of an architectural thesis in the fifth year and a professional internship in the sixth. The first year of the initial training cycle serves as a gateway for new students into the previously unfamiliar world of architecture, fostering curiosity, imagination, and creativity while building a foundational interdisciplinary understanding of the field.

The first year of the initial training cycle serves as a gateway into the discipline, introducing students to the unfamiliar world of architecture while stimulating curiosity, imagination, and creativity. Through an interdisciplinary approach, students begin to develop a nuanced understanding of architectural concepts and methodologies.

A cornerstone of this foundational year is the project workshop, which equips students with essential tools for architectural representation and expression. By honing their perception and analytical skills, they construct a technical and ideological reference framework critical to architectural learning. These objectives collectively lay the groundwork for their initiation into architectural design.

Despite the widespread integration of computer graphics into architectural education for over half a century, the role of digital tools in early-stage training remains a subject of ongoing pedagogical debate, particularly within the framework of education reform at the National School of Architecture and Urban Planning. As it stands, Tunisia's official architectural curriculum introduces comprehensive digital training—including image processing software, computer-aided design (CAD), 3D modeling, and intelligent digital modeling—only in the first year of the second cycle.

This delayed integration raises a fundamental pedagogical dilemma: pencil or mouse? In response, we have continuously refined study frameworks, analytical methodologies, and adaptive educational approaches, enabling students to navigate the intersection of traditional and digital design tools. By fostering critical engagement with emerging technological advancements, we seek to empower learners in their exploration of architectural project conception and innovation.

II. CONTEXTUALIZATION

The integration of digital design processes in architecture has been a subject of inquiry in architectural education since the 1980s. In 1987, the Bulletin of the French Institute of Architecture (IFA) addressed computer-aided design, highlighting that "building is a sector where

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computing is still very little developed" [1]. This opened discussions on the relationship between computing and the actual production of buildings. The following year, *Cahiers de la Recherche Architecturale* published a comprehensive issue on digital tools, presenting diverse perspectives—ranging from methodology and project organization to assisted drawing, computer-generated imagery, site management, environmental simulations, and engineering applications [2].

The early 1990s saw a notable shift in digital architecture, led by pioneering figures such as William Mitchell, author of *The Logic of Architecture*, and Marcos Novak, who introduced the concept of "trans-architecture" in 1991. Novak envisioned digital 3D environments as immersive spatial experiences, asserting that "we design algorithmically (morphogenesis), we model digitally (rapid prototyping), we build robotically (new tectonics), we inhabit interactively (intelligent space), we communicate instantly (pantopicon), we are informed immersively (liquid architectures), we socialize non-locally (non-local public domain), we transform virtuality (transarchitectures)" [3]. By 1994, Bernard Tschumi had launched the *Paperless Studio* at Columbia University, marking a key milestone in the integration of digital technology into architectural design. His vision extended beyond existing architectural software, seeking new technological possibilities.

Today, digital technologies—particularly generative artificial intelligence—have emerged as powerful drivers of innovation, inspiring both optimism and critical inquiry regarding their implications for architectural conceptualization. The computerization of architecture is now a tangible reality, with digital tools transforming collaboration, modeling, analysis, and representation throughout a project's lifecycle, from initial sketches to renovations and connected objects.

Among the many technological advancements, generative AI stands apart due to its profound societal, economic, and educational impact. Its ability to emulate human cognitive processes directly influences decision-making and creative potential [4]. In contemporary architectural education, AI is increasingly integrated into conceptual design processes, utilizing adaptive algorithms that respond to their environment. As a system that generates diverse forms of content—including text, imagery, voice, music, video, and presentations—it expands the scope of architectural exploration.

Recognizing AI's transformative potential, UNESCO has emphasized a human-centered approach to its implementation in education. The organization advocates that AI should support, rather than replace, human intellectual development [5]. This principle is reflected in international guidelines, including the *UNESCO Guidelines for Generative Artificial Intelligence in Education and Research* (2024), the *Recommendation on the Ethics of Artificial Intelligence* (2021), and the *Beijing Consensus on Artificial Intelligence and Education* (2019) [6].

Universities worldwide have since initiated discussions on generative AI's role in learning, aiming to equip students with the necessary knowledge and skills to strengthen their intellectual and creative capabilities. Academic institutions affirm that "the responsible use of AGI by teaching staff must be complementary to the development of professional skills and digital competence, (...), these dimensions address aspects such as technological proficiency, digital collaboration, problem-solving, and critical thinking" [7]. Consequently, efforts are being made to cultivate AI literacy among educators and students across diverse educational and professional contexts.

These initiatives encourage the integration of AI-driven methodologies into architectural pedagogy, exploring new approaches to digital learning. In this evolving global landscape, our research situates itself within this reflective process. Through experimentation in the project workshop at the National School of Architecture and Urban Planning of Tunis, we explore alternative teaching methods that harness AI innovations, expanding the dimensions of architectural project-based learning.

III. METHODOLOGY OF APPROACH AND EXPERIMENTATION

A. Conceptual approach in the design of the architectural object

Architectural design is a dynamic process that engages a spectrum of cognitive activities and diverse skills, utilizing "all the resources of the mind, brain, and human hand" [8]. The multidimensional nature of architectural space requires consideration of an array of factors—physical, psychological, sociological, historical, cultural, economic, and ecological. This complexity demands a form of thinking that integrates technical precision, functional use, aesthetics, economics, urban dynamics, symbolism, geometry, and perception.

To navigate this intricate process, "the architect is led to make incessant back-and-forths between certainty and uncertainty, between the elementary and the global, between the separable and the inseparable." Architectural design is no longer a strictly linear process of input, processing, and output. Instead, it operates as an interconnected network where various elements co-evolve, interact, and enrich one another. In this context, an architect must prioritize understanding the inputs and the design process rather than fixating on predetermined outcomes, which often emerge as predictable constructs within their own mind [9].

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Fig 1 Examples of Conceptual Research Exploring ideas and Reflections on Spatial Experience.

If architectural design is inherently complex, then one of the fundamental roles of architectural education is to equip learners with the tools to navigate this complexity. As highlighted in the assertion that "the architecture we are talking about is to be considered as the object of the link between people. It is the Link, as multiple and diverse as one can imagine, containing all the possible types of relationships with its environment, with people" [10], architecture is shaped by the intricate interplay between spatial experience and human interaction.

To address this, we have established a pedagogical framework within the project workshop that continuously defines key moments in the architectural design process. This approach centers on understanding how individuals perceive and engage with space, aiming to construct a meaningful spatial experience. Learners are guided to analyze the functionality of a project in relation to its specific use value, determining spatial needs based on factors such as ergonomics, human scale, furniture, and defined living practices.

Beyond functionality, students reflect on spatial qualities and interior atmospheres by examining movement, events, and spatial arrangement. They explore the direct and indirect relationships between functional entities, employing sequencing and division to analyze various scenarios of horizontal and vertical circulation. This process involves defining passable and non-passable areas, as well as visual boundaries that shape perception and interaction. Ultimately, this method fosters a dynamic understanding of space—one that integrates a diversity of phenomena and allows them to converge within a precise moment.

Fig 2 Study of Human Scale and Ergonomics in Furniture Models

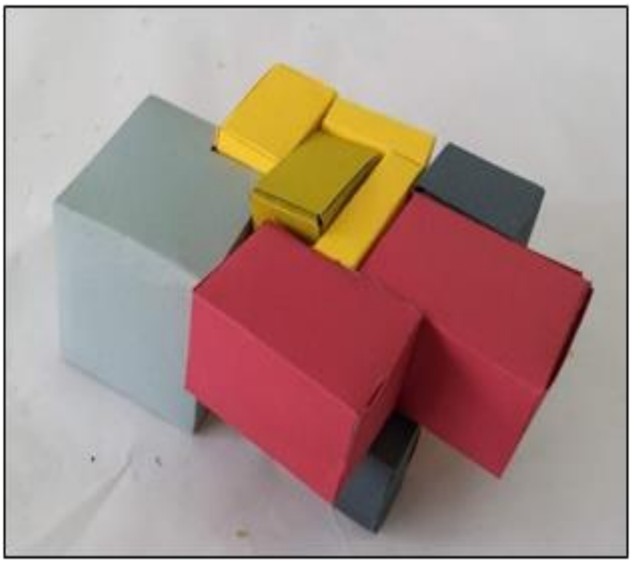

Fig 3 Example of a Model of the Arrangement of the Different Functional Components

At this stage of learning, the arrangement of the different functional components is done through an abstract volumetric model, where each sub-space will be defined by a volume with a personalized coloring in order to visualize the relationship between form, function and use. Finally, a formal approach will complement this functional approach, to define the architectural expression of the volumetry in relation to a social, cultural and environmental context by seeking an architectural language highlighting the formal and plastic qualities of the project while integrating into the site.

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Fig 4 Example of a Volumetric Model Explaining the Architectural Expression of the Architectural project

B. Experimenting with digital technologies in reading architectural objects

Based on experimentation in order to build a reservoir of ideas and experiences, we questioned the use, relevance and impact of digital technologies at different stages of the design process. We then wanted to understand the use of digital technology as a tool for interaction, information, integration, simulation and projection in order to put into perspective the ideas and concepts developed during the design of the project. We would like to point out that all the design work and spatial, functional and formal reflection was developed through various manual research in sketches, drafts and volumetric cardboard models.

This didactic approach was dictated, on the one hand, by the official teaching program of the architect training for the first cycle of training in Tunisia, on the other hand, by the conviction that manual drawing is the best tool that adapts to the speed of the sudden advent of an idea and that it is the best way to translate the ideas of the architect's black box. Indeed, we believe that hand drawing would be the very extension of thought, it is a conceptual act that allows the imaginary of the project to be transposed into the process of the birth of concepts. The use of digital technologies will thus come upstream to the work of design and spatial reflection.

Recognizing that first-year learners often struggle with accurately interpreting three-dimensional space from two-dimensional representations—such as plans, sections, and elevations—they typically rely on physical models or hand-drawn sketches to visualize spatial experiences. However, the integration of digital tools in this experimentation has enabled immersive engagement with architectural projects, allowing students to explore multiple design possibilities and manipulate various parameters.

Through digital modeling, learners gain the ability to experience space dynamically, engaging with a "fourth dimension" as they navigate and perceive architectural environments. This spatial walk within the digital model enhances their understanding of spatial experience by visualizing the interplay of shadow and light, the impact of openings, the relationships between volumes, and the nuances of interior design. Furthermore, it enables a detailed exploration of textures, materials, and surface treatments, offering a deeper and more holistic comprehension of architectural composition.

Through this pedagogical approach, we sought to prevent a common misconception among second-cycle learners—that architectural conceptualization can emerge solely through sketching in computer-aided design software. Rather than relying on digital tools for initial ideation, this framework emphasizes their role as perceptual instruments, enabling learners to validate their intentions and refine their architectural vision. By integrating digital technology as a means of verification rather than initiation, students gain the ability to concretize their ideas and enhance the imaginative depth of their projects.

Fig 5 Experimentation of the Space walk through the Digital Model

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C. Experimentation of the IAG in the Visualization of the Architectural object

Explaining the image of the project and an interior view showing the different spatial qualities. In an era where generative AI tools are rapidly evolving and becoming increasingly accessible, we sought to explore their practical application in architectural project creation. Guided by UNESCO's human-centered approach, our objective was to highlight the new competencies that learners must develop—encouraging them to recognize and assert their agency in leveraging generative AI to enhance creative design.

As part of an educational exercise focused on designing a loft for a couple, learners first examined the functional, formal, and spatial attributes shaping the project. They were then tasked with translating key architectural concepts through hand-drawn exterior perspectives that conveyed the project's image and interior views illustrating spatial qualities.

These conceptual sketches, along with the cardboard model, served as an experimental support to test the generative AI tools in the project's production and to observe when it was necessary to integrate new practices generated by the use of digital objects.

- *The Cardboard model as an Experimental Support*

In this experiment, the learner used different Generative AI, presenting the abstract volumetric cardboard model with the glazed and opaque areas that were designed in response to the different uses while providing an exterior-interior relationship between the functional components and the intervention context. The goal was to visualize the architectural expression of the volume according to the desired architectural style as well as the desired materials. This approach made it possible to generate a realistic rendering in a very short period of time, which allowed the learner to save much more time in thinking than in developing computer-generated images. The various architectural visualizations generated by the generative AI are relatively faithful to the proposed volume while offering a better visualization of the architectural image of the project.

Fig 6 Cardboard model (left) and Images Generated on My Architect AI

Fig 7 Cardboard model (left) and images generated on Re Render AI

Fig 8 Cardboard model (left) and images generated on Chat GPT

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➢ *Drawing in External Perspective as a Support for Experimentation*

By drawing a primary, embryonic exterior perspective showing only the hollow and projecting volumes and the location of the different openings, the generative AI was able to read the geometry in space by distinguishing between solid and empty, the spatial limits between interior and exterior, and the layout around the pool.

It thus offered the learner, depending on the chosen intervention context, different materials, textures, and colors each time, and even considered the design of the glass areas by defining the uprights and crosspieces of the different windows in line with the immediate environment. This experimentation thus made it possible to simplify the visual process of the exterior appearance of the project.

Fig 9 Exterior perspective (left) and images generated on ChatGPT

➢ *Interior perspective drawing as a support for experimentation*

Fig 10 Interior perspective (top left) and images generated on different AIs

In order to evaluate the interior ambiances designed in 2D at the plan level, we offered the learner the opportunity to visualize the imagined spatial experience on different generative AIs. In this example (Fig10), the learner presented a staged interior view where only the glass beaches and vegetation are treated in favor of the other spatial components.

The most important element in this spatial sequence is a suspended swimming pool which was designed on the first floor as an extension to the master suite. Given that on the sketch, the proportions and dimensions of the swimming pool were very poorly drawn, the different generative AIs interpreted this element as a circular chandelier with different textures and colors each time, the glass beaches were also

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treated sometimes transparent, others translucent and even opaque, as for the plant element, it was imagined as pots of plants aligned in accordance with the proposed sketch, while in her imaginary project, the learner designed a swimming pool suspended in a void which will be occupied by an interior garden.

Wanting to have a better visualization of this space, the learner mentioned this idea to the generative AI, which in turn generated several variants that are all focused on the swimming pool and the garden, emphasizing the components: vegetation - water but ignoring the impact of this space in the architectural volume and in the visual relationship between the spaces (Fig11).

Fig 11 Images generated on ChatGPT

In this second example, based on the interior sketch drawing, the generative AI proposed different responses in order to better visualize a very poorly drawn staircase that it interpreted each time as a dining table, console or even a bench (Fig12). These two experiments allowed the learners to assert and show the importance of the accuracy of the sketch drawing in order to convey the ideas and concepts imagined.

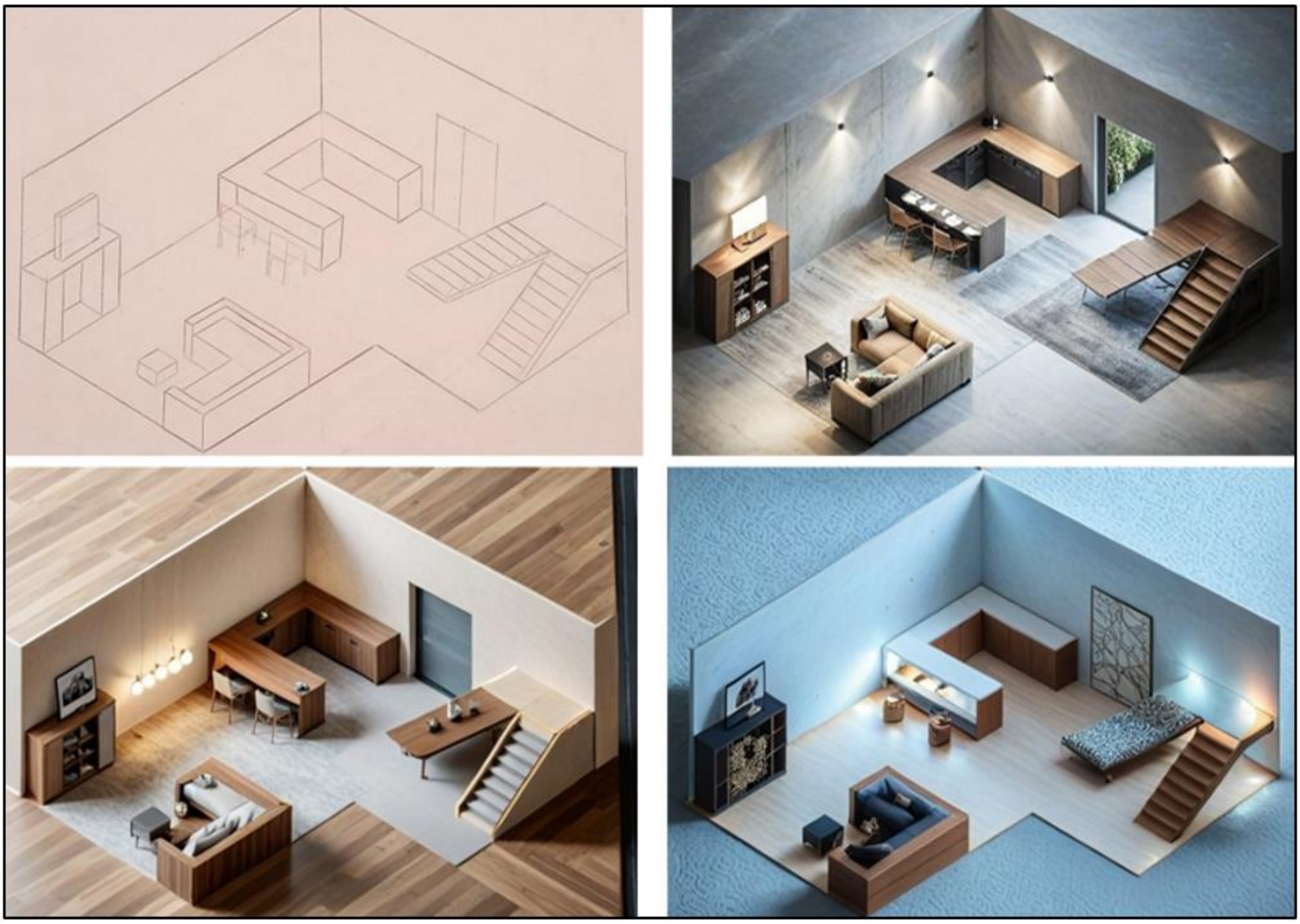

Fig 12 Interior perspective (top left) and images generated on My Architect AI

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➢ *The prompt as a support for experimentation*

In this experiment, based on a given prompt, the generative AI imagined in various ways the external appearance of the project, wanting to render a design that meets the requested instructions in order to convey the learner's ideas.

In this approach, neither the intervention context, nor the interior-exterior relationship, nor the spatial components were taken into consideration. The generated synthetic images are thus detached from the architectural design and the specific needs of the users and become conceptual sketches. (Fig13).

Fig 13 Images generated on ChatGPT

IV. CONCLUSION ET PERSPECTIVE

In an era of rapid technological innovation, our experiments sought to create opportunities for rethinking architectural education in Tunisia, aiming to contribute to the ongoing debate on curriculum reform. Through these explorations, we examined the pedagogical potential of digital tools and generative AI in the training of architects, particularly within the context of the first-year project workshop at the National School of Architecture and Urban Planning in Tunis..

Given that the first year of architectural training functions as an intellectual and sensory awakening, we implemented a pedagogical approach that integrates both traditional and digital processes. This reflexive design methodology enabled learners to first define spatial, functional, formal, and conceptual needs before identifying the points at which digital tools could enhance the creative process. In doing so, we evaluated the current and future challenges posed by generative AI in architectural production.

Our findings indicate that digital technologies and generative AI significantly enhance visual communication, expression, and project presentation, streamlining processes that traditionally required extensive manual effort. This optimization allows educators to dedicate more time to guiding students in critical thinking and design exploration rather than merely focusing on project representation.

Furthermore, we observed that these technologies accommodate diverse cognitive approaches among learners. Some first-year students, who primarily reason in two-dimensional terms, struggle to visualize spatial depth, while others instinctively grasp the third and fourth dimensions of architectural experience. Generative AI facilitates personalized learning by adapting to individual perception abilities, thereby strengthening spatial comprehension.

From these observations, we hypothesize that generative AI, within this specific pedagogical framework, does not replace human intelligence or creativity. Instead, it serves as a decision-support tool, complementing rather than defining architectural design and reflection.

Looking forward, we advocate for the strategic integration of digital technologies based on their educational relevance, fostering adaptive learning tailored to each student's cognitive abilities. This approach could enable the development of differentiated pedagogy, refining the learning process while deepening student engagement in the conceptualization of architectural projects.

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