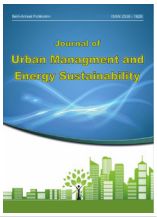
International Journal of Urban Management and Energy Sustainability (IJUMES)

Homepage: http://www.ijumes.com



ORGINAL RESEARCH PAPER

Challenges and Gaps in Parametric Architecture Methodology**

Masoome Moradi[1] , Hamid Reza Sharif [*2]

1 Ph.D. Student, Department of Art and Architecture, Shiraz University, Shiraz, Iran
2 Associate Professor, Department of Art and Architecture, Shiraz University, Shiraz, Iran

ARTICLE INFO

Article History:
Received 2026-02-24
Revised 2026-04-08
Accepted 2026-05-10

Keywords:
Architectural studies, design thinking, design process, digital design, parametric architecture

ABSTRACT

With the rapid expansion of artificial intelligence and digital technologies, their increasing incorporation into architectural practice and particularly into the architectural design process has precipitated the emergence of novel design methodologies shaped by digital paradigms. Accordingly, parametric architecture, as a salient manifestation of digitally mediated design, has been selected as the focal lens through which to investigate the epistemological and procedural impacts of digital technology on architectural design thinking. The present research seeks to develop a comprehensive framework aimed at advancing methodological studies in parametric architecture. It endeavors to identify, categorize, and critically analyze the transformations, shifts, and epistemic gaps that distinguish parametric design research from the established corpus of pre-digital architectural design studies. In doing so, the study aspires to provide a strategic foundation for understanding and further cultivating design practices in the digital era. The research adopts a qualitative methodology grounded in the principles of Grounded Theory. Through a systematic review and comparative analysis of canonical architectural design research conducted prior to the advent of digital technologies, alongside contemporary scholarship on parametric architecture, the study identifies conceptual constructs that signify digitally induced transformations within the parametric design process. These emergent concepts were subsequently coded, classified, and analytically synthesized to construct a structured interpretive framework. The findings indicate that the integration of digital technologies into the architectural design process has fundamentally reconfigured its foundational concepts and facilitated the emergence of new design paradigms. The categorization of these newly identified concepts reveals the breadth and multidimensionality of transformations across various domains of the design process under digital influence. Furthermore, the study delineates areas within parametric architecture that require further scholarly investigation and proposes strategic recommendations for the informed and critical integration of artificial intelligence in intelligent design methodologies.

DOI: 10.22034/ijumes.2026.2085758.1355

Running Title: : Parametric Architecture Methodology

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
63	05	03

*Corresponding Author:
Email: *hsharif@shirazu.ac.ir*
Phone: +989171127132
ORCID: https://orcid.org/0000-0002-9248-3569

**The article is extracted from the thesis titled “Explanation of the strategic plan of the designer’s hidden knowledge in the parametric architecture process” by the first author at the Faculty of Art and Architecture, Shiraz University, and is currently being compiled as a doctoral student.

INTRODUCTION

A substantial body of scholarship has been devoted to the identification and analysis of architectural design methods and the factors influencing them. These investigations have evolved across multiple generations and intellectual paradigms (Špaček et al., 2020). Across these successive phases, architectural design has generally been conceptualized as a cognitive mechanism whereby inputs comprising information, constraints, and programmatic requirements of the design problem are processed within the designer's mind through iterative cycles of analysis, synthesis, evaluation, and refinement, ultimately yielding a design proposal as output. This model has been shaped by the prevailing intellectual climate of the architectural milieu and by pedagogical traditions that emphasized stylistic interpretation and formal articulation as central components of architectural education (Janssen & Stouffs, 2015). Parametric architecture, therefore, should not be misconstrued as merely a representational technique facilitated by software, nor should parametric design be regarded as an incidental or tool-driven process. Rather, it must be understood as grounded in systematic inquiry, theoretical reflection, and codified knowledge. Consequently, its methodology, conceptual content, and theoretical foundations necessitate rigorous formulation and articulation (Oxman, 2006). To fully comprehend the potential of parametric design methodologies across all dimensions of the design process, it is essential to cultivate a comprehensive understanding and pedagogical framework for their application at every stage of design. This entails the development of a new mode of thinking and a reconfigured design mentality (Ponzio et al., 2020) one that integrates a holistic awareness of complexity and the multifaceted requirements inherent in architectural production (Alalouch, 2018). Within parametric architectural education, the promotion of algorithmic thinking beyond mere software proficiency has thus become a central objective (Vazquez, 2024). What must be learned and operationalized emerges precisely from the epistemic divergence between pre-digital and post-digital design thinking in architecture (Fig. 1), a divergence that inevitably engenders a fundamentally distinct design process (Alalouch, 2018).

Figure 1: Studies in design methodology and parametric architecture

Given the rapid integration of digital technologies into architectural practice and the consequent proliferation of parametric and intelligent design methodologies, it appears that the transformations introduced by these technologies have not yet undergone a fully articulated and critically examined evolution across the stages of architectural design from conceptual ideation to project representation. Accordingly, the domain of design research related to parametric architecture requires further development and the establishment of a coherent strategic framework. This study seeks to identify themes that, in comparison to pre-digital architectural research, have been neglected, transformed, or remain underdeveloped within the discourse of parametric architecture. To this end, it undertakes a comparative analysis between the conceptual constructs articulated in parametric architectural theory and those established in pre-digital design research, with the objective of categorizing the transformed concepts according to thematic and conceptual criteria.

MATERIALS AND METHODS

Since the early 1980s, methodological studies in design have increasingly shifted their focus toward the designer as subject, emphasizing the cognitive processes underlying design activity

(Dorst, 2015; Oxman, 2006). These investigations encompass concepts such as organization, ordering, structuring, and planning as intrinsic dimensions of design reasoning (Buchanan, 1992). Edward de Bono posits that design is fundamentally rooted in thinking itself, which he terms design thinking (De Bono, 2000; Faizi & Zand, 2006). Design thinking constitutes a mode of inquiry that examines the role of the human agent and the mental processes engaged in confronting design problems, establishing a productive balance between intuitive and analytical reasoning (Mohebati et al., 2019). From its inception, scholarship on design thinking has concentrated on processes of problem recognition, interpretation, and solution generation (Brown, 2009; Buchanan, 1992; Cross, 2006; Mohebati et al., 2019). It articulates the intrinsic relationship between design knowledge and professional practice (Cross, 2006; Lawson, 2006), and identifies shared cognitive patterns among individuals engaged in design activity, not solely expert designers, but anyone involved in design at any level of expertise (Kelly & Gero, 2021). Over several decades, architectural design methodology has undergone extensive scholarly investigation, resulting in a progressively codified and logically structured body of knowledge.

Parametric architecture was first introduced in 1940 by Luigi Moretti, who conceptualized it in terms of the influence of variable parameters on architectural form and the generation of morphological variation. By the 1960s, a group of architects anticipated the transformative impact of emerging computational tools on architecture, arguing that the discipline must evolve from a merely descriptive practice toward the production of predictive design systems capable of generating improved solutions through artificial intelligence and computational processes. They emphasized the necessity of systemic thinking in architecture, incorporating feedback, iteration, and regulatory control within the design process (Pantazis & Gerber, 2019). From the 1980s onward, formal differentiation emerged as a strategic objective in architectural design. With the integration of computational technologies during the 1990s, simultaneous advancements occurred in both theoretical discourse and practical application. These transformations were reflected across diverse design disciplines, contributing to the consolidation of digital design theory and to efforts aimed at bridging theory and practice within this emergent paradigm. Publications, competitions, exhibitions, and academic events since the 1990s document the progressive construction of a new theoretical framework within architectural research. In contrast to the first generation of digital design which primarily emphasized formal innovation contemporary perspectives conceptualize digital design as a novel technological and media-based condition that redefines the very concept of design. Emphasis has shifted toward the influence of digital media on design processes and modes of thinking (Oxman, 2006). “Parametric” has become the most prevalent term within the discourse of digital design and functions as a central keyword in the field (Caetano et al., 2020). It is frequently regarded as a principal manifestation of digital design, exerting influence on architectural processes, tools, and fabrication techniques. Accordingly, in order to apprehend the defining characteristics of digital design, it is both logical and methodologically sound to examine parametric studies as the most comprehensive expression of digitally mediated design practices. Simultaneously, identifying deficiencies within parametric architectural research necessitates a systematic review of existing scholarship.

To date, research in parametric architecture has addressed topics including its definition and origins (Pantazis & Gerber, 2019; Peteinarelis & Yiannoudes, 2016; Oktan & Vural, 2017); its advantages, limitations, intellectual roots, challenges, and theoretical foundations; comparative analyses with other design methodologies (Oxman, 2017; Zarei, 2012); and attempts to formulate cognitive or conceptual models of

parametric design thinking (Oxman, 2006, 2017; Hudson, 2010; Peteinarelis & Yiannoudes, 2016; Zarei, 2012; Bhooshan, 2017; Alves, 2020; Stavric & Marina, 2011; Woodbury, 2010). Comparative investigations between parametric architecture and pre-digital design methodologies can be traced within scholarship in both domains. This discourse was notably foregrounded at the Ninth International Architecture Exhibition in 2004 under the theme Metamorph, which explicitly sought to theorize the transitional and evolutionary nature of digital design in both theory and practice. Similarly, the 2005 DAM exhibition in Germany addressed the impact of digital technology on design thinking.

More recently, Kelly and Gero (2021) examined differences in designers' cognitive approaches between pre-digital and parametric architectural methodologies. Their comparative framework focused on the designer's orientation toward the design problem, including the nature of proposed solutions and strategies of problem framing. Although their findings provided an initial analytical point of departure for the present study, the distinctions between these two design paradigms extend far beyond problem framing and solution strategies. Such differences encompass a broader spectrum of epistemological, methodological, and cognitive dimensions that can be traced throughout the existing body of research in both fields.

Comparative Analysis of Parametric Architecture and Design Methodology

Studies in the methodology of parametric architecture indicate that, despite significant overlaps with pre-digital design approaches, notable distinctions have emerged. While the centrality of the designer within the design process remains preserved (Nasir & Kamal, 2023), and cognitive attributes such as exploration, reflection, and iterative refinement continue to characterize the process as in earlier design models—the logic and sequencing of components within parametric methodologies differ substantially (Lee et al., 2013; Lee & Ostwald, 2020; Oxman, 2017). Moreover, the designer's role is reconfigured: control over processes and inherent complexity increasingly depends on the interaction between the designer and the computational model (Wynn & Clarkson, 2018). Digital technology introduces a new agency for the designer, shaped by the nature of interaction with the digital medium. This agency encompasses control, mediation, and modulation of processes and mechanisms. Through programming and scripting, designers are able to customize software behavior in accordance with their unique cognitive strategies (Oxman, 2017), thereby assuming an additional role as tool-maker (Abdualee & Mohammed, 2024; Oxman, 2006).

In contrast to traditional approaches where design frequently begins with the selection or conception of form parametric design initiates form generation through the definition of relationships among design variables, often structured through parameters or geometric constraints such as relational dependencies, dimensional logics, and embedded data structures (Erhan et al., 2010; Schumacher, 2012; Zarei, 2012). This methodology is intrinsically linked to associative geometry and topological relationships, enabling interdependencies among design components (Caetano et al., 2020; Giurea et al., 2014), and thereby facilitating the production of complex geometries (Castelo-Branco et al., 2021; Henri, 2003; Schnabel, 2007). Within parametric design processes, computational methods become inseparable from architectural thinking. The formulation of rules and their logical interrelations in constructing three-dimensional visualization models constitute a central dimension of design cognition (Oxman & Gu, 2015; Alalouch, 2018). Computational design systems (Semjén & Szép, 2025), simulation processes (Gao et al., 2022), evaluation protocols, and digital fabrication logics (Banihashemi et al., 2024) are integrally embedded within the design workflow. This reconfiguration of scientific and conceptual infrastructures has introduced

new directives, procedures, and methodological frameworks into existing exploratory–cognitive models of design thinking (Çalışkan et al., 2024; Clay & Sha, 2025; Hsiao, 2019).

Transformations in design methodology inevitably reshape the designer's mode of thinking (Brozovsky et al., 2024; Hadjadji et al., 2024; Manzoor et al., 2021; Vazquez, 2024). In parametric paradigms, the final artifact emerges through gradual evolution and iterative transformation; unlike earlier approaches, outcomes are often indeterminate at the outset. Design thinking thus becomes incremental, adaptive, and continuously evolving (Lee et al., 2014; Lee & Ostwald, 2020; Oxman, 2017; Oxman & Gu, 2015; Rezk et al., 2023). Parametric architects require, in addition to foundational architectural knowledge, a broader epistemic repertoire enabling them to comprehend the mathematical structure underlying digital tools (Hudson, 2014) and to navigate reciprocally between intended spatial effects and the generative mathematical processes that produce them (Hudson, 2010). In other words, parametric designers must extend beyond conventional architectural literacy in order to cultivate alternative modes of thinking (Hudson, 2010). The distinct operational logic of parametric practice consequently establishes a differentiated methodological foundation (Lee et al., 2014). Effective engagement with this paradigm demands familiarity with traditional design processes, architectural typology, and geometric relationships, alongside knowledge of iterative evolution, theoretical mathematics, and computational principles (Alalouch, 2018; Hsiao, 2019; Lee et al., 2014; Réka, 2019).

The use of parametric tools without an understanding of their underlying theoretical logic may be technically feasible, yet conceptually futile (Pektas, 2023; Rezk et al., 2023). Indeed, insufficient comprehension of parametric architecture and its supporting algorithms can complicate rather than streamline design and fabrication processes (Semjén & Szép, 2025; Stavric & Marina, 2011; Nasir & Kamal, 2023; Réka, 2019). In light of technological advancements impacting architectural design, both design theory and its procedural structures require epistemological revision and reformulation (Aburamadan & Trillo, 2020; Ammon, 2017; Elbony, 2019). Among emerging cognitive models, parametric design thinking constitutes a distinct category of design cognition enabled by digital technologies. It has the potential to enhance creative processes while incorporating competencies such as computational programming, exponential logic, and process-based scripting (Caetano et al., 2020; Çalışkan et al., 2024; Oxman & Gu, 2015; Ponzio et al., 2020). The transformation of the designer's role, performance, cognitive orientation, and required knowledge base renders the systematic study of new forms of design thinking particularly parametric design thinking both timely and essential (Oxman, 2017; Sreenivasan & Suresh, 2024).

A structured categorization and comparative review of selected studies in architectural design methodology and parametric architecture reveal that, despite shared theoretical foundations, several conceptual distinctions emerge:

a)Certain concepts are articulated within parametric architectural methodology that had no precedent or relevance in pre-digital architectural studies and therefore remain underexplored.

b)Some themes present in earlier architectural methodology have been neglected or insufficiently systematized within parametric discourse.

c)Other concepts have been transformed under the influence of digital technologies and are now articulated in redefined forms (Tab. 1).

All of these dimensions emerge from the convergence of the human cognitive apparatus and digital systems within parametric design processes. The three aforementioned categories collectively indicate areas that require systematic examination in order to advance and complete the methodological foundations of parametric architecture (Fig. 2).

Table 1: Thematic domains in parametric architectural studies

Topic	Common	New	Transitional or changed	Omitted
Example from the text	Designer centrality Existence of traditional design process Existence of intuition, creativity and decision-making	Designer interaction with the design model, Constructive role of being a tool, How to think in a new way	Addition of simulation, evaluation and construction process in previous cognitive exploration models, Use of rules and instructions to define form Gradual and unpredictable evolution	Place of intuition Place of creativity Integration of new knowledge How to interact

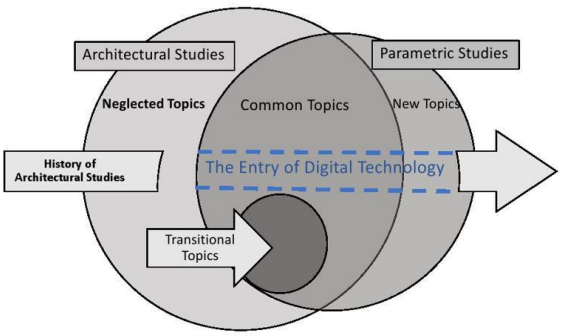


Figure 2: Design Methodology and Parametric Paradigms

Given that the identified themes are neither homogeneous in nature nor uniform in structure, it is necessary to subject the selected conceptual expressions to rigorous analysis, coding, and interpretation. Through this process, they can be thematically and conceptually classified according to the analytical codes derived from the data. Accordingly, with the integration of digital technology into the architectural design process, it becomes imperative to reassess the modes of operation and patterns of thought that characterize architects' design activity. Such a reassessment enables the precise identification of the position and agency of digital technology within the design process. On this basis, the notion of parametric design thinking along with its principles, structural components, and epistemic foundations can be systematically articulated, grounded in the transformations that digital media have introduced into architectural cognition and methodology.

The Impact of Parametric Architecture on Design Methodology

Research in design methodology and design thinking has predominantly concentrated on the analysis and formal modeling of the behavioral, procedural, and cognitive dimensions of design activity. Some of these foundational studies may today provide an appropriate basis for identifying, comparing, and translating the differences between hand-drawing–based design approaches and computer-mediated design environments (Oxman, 2006). The themes identified as new, transformed, or neglected within parametric architectural methodology relative to earlier architectural design methodology were conceptually coded and thematically categorized. This process was conducted with reference to established topics in pre-digital architectural design methodology studies (Li et al., 2025), enabling a comparative analytical framework. The resulting categories can be broadly organized into five principal dimensions:

1.The mode of the designer's thinking
2.Design models and theoretical frameworks
3.Design problems and problem structures
4.The philosophy and aesthetics of design
5.Design tools and technological mediations

These five dimensions collectively outline the structural domains through which the methodological impact of parametric architecture on design thinking can be understood (Fig. 3)

Impact on the Designer's Thinking (The Emergence of Parametric Thinking)

In order to facilitate the advancement of studies concerning the designer's mode of thinking within parametric design processes, the conceptual expressions indicating transformation

in this domain were classified into two principal categories:

1.Changes in the designer's perception and framing of the design problem;

2.Changes in the designer's mental processes and cognitive operations.

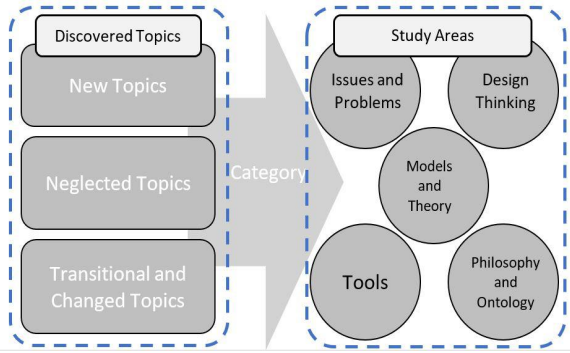


Figure 3: The Five Principal Dimensions of the Studies

Within parametric design, the centrality of the designer is maintained; however, through the convergence of human cognition and computational systems, the designer assumes additional roles as regulator, mediator, and modulator of processes and mechanisms (Oxman, 2006; Hudson, 2010; Monedero, 2000; Nasir & Kamal, 2023). The human mind does not relinquish authorship but instead operates as a process director in collaboration with computational intelligence (Fasoulaki, 2008; Nicolas-Alonso & Gomez-Gil, 2012). The flow of information across components and between stages diverges from the sequential structures characteristic of traditional architectural thinking and increasingly unfolds in simultaneous and networked configurations (Oxman, 2017). In these emergent design paradigms, the architect must comprehend the relational logic that structures the design system (Mohammad, 2012) and shift focus from the final form toward the generative mechanisms that produce it. This shift is deeply contingent upon the designer's cognitive and perceptual capacities (Betancourt et al., 2014).

Within parametric methodologies, practice generates theory (Oxman & Gu, 2015), and typological thinking is gradually supplanted by evolutionary process-based thinking (Réka, 2019). Whereas traditional design methods often follow a top-down trajectory from whole to part (Pantazis & Gerber, 2019) parametric design is predominantly governed by bottom-up logic in the formation of architectural form (Bhooshan, 2017). The position of intuition and creativity is likewise redefined (Réka, 2019). Rather than being conceived solely as spontaneous formal invention, creativity becomes the designer's capacity to construct, manipulate, and interact with explicit, codified representations of knowledge (Oxman, 2017). Designers operating within parametric paradigms require a fundamentally new mode of thinking (Oxman & Gu, 2015), one that shifts their orientation from purely formal concerns toward performance-driven optimization of form and function (Peteinarelis & Yiannoudes, 2016). Algorithmic thinking (Caetano et al., 2020) and parametric philosophy (Branco & Leitão, 2017) increasingly shape the cognitive landscape of design. In sum, within parametric methodologies, the architect transitions from an intuitive form-giver to a regulator of data-driven systems an agent who orchestrates relational logics, computational rules, and evolutionary processes in the production of architectural form.

Impact on Design Models and Theories (The Emergence of Parametric Design Models)

Transformations in the designer's cognitive processes, along with other implicit shifts introduced by digital technologies, have inevitably altered the operational logic of emerging design methodologies and, consequently, have reshaped design models and theoretical frameworks. Although parametric design models retain stages analogous to those found in traditional design processes, their sequencing and hierarchy differ significantly and are dynamically configured by the designer (Janssen & Stouffs, 2015). In parametric design models, computational design systems, simulation processes, evaluation mechanisms, and fabrication logics

are integrally embedded within the design process itself (Caetano et al., 2020). This reconfiguration of scientific and conceptual infrastructures has introduced new protocols, procedures, and operational logics into earlier exploratory cognitive design models (Çalışkan et al., 2024; Clay & Sha, 2025; Hsiao, 2019; Oxman, 2017). Parametric design models thus comprise hybrid states of exploration, iterative modification, and associative relationships within a geometric solution space (Oxman, 2017). These shifts in design modeling have also transformed designers' strategic approaches to addressing design problems. Rather than directly shaping form, designers define a set of rules and instructions within the system, structured in accordance with contextual and project-specific conditions (Mohammad, 2012; Schnabel, 2007). Flexibility, variation, informational control, and sustainability parameters are regulated throughout all design stages (Betancourt et al., 2014). Unlike pre-digital methodologies where geometry was explicitly represented and governing principles often remained implicit parametric models invert this relationship: rules, constraints, and relational logics are explicitly articulated, while geometric form emerges implicitly as a consequence of these encoded relationships (Bettig & Hoffmann, 2011). In other words, rules (Erhan et al., 2010), classifications of qualitative attributes, and conceptual design intentions previously conveyed intuitively are now formally embedded and explicitly represented within computational design models (Mohammad, 2012).

In traditional design models, the transition from exploratory phases to exploitative refinement typically occurs through experiential judgment; by contrast, contemporary computational-cognitive models enable the anticipation and strategic calibration of this transition within design teams (Bhooshan, 2017). Such developments have generated new data-driven design models predicated upon variables and their interrelationships (Schnabel, 2007). Design in this paradigm becomes fundamentally dependent upon parameters (Caetano et al., 2020), with multiplicity of parameters generating expanded degrees of freedom within the design space (Branco & Leitão, 2017). Within this framework, the designer assumes the role of editor of instructions and regulator of generative rules to produce appropriate forms (Mohammad, 2012). The logic of "connecting and repairing" (Kelly, 2011), revising rules, associations, and algorithms (Oxman, 2017), and internally generating form (Mohammad, 2012) replaces earlier additive–subtractive logics of externally composing geometry. Consequently, the concept of form shifts toward formation toward the configuration of gradual, system-based morphogenetic processes (Oxman, 2006; Peteinarelis & Yiannoudes, 2016). In this mode of design, the architect configures the governing logical structure of the process itself (Betancourt et al., 2014). These transformations necessitate further integration within the broader continuum of architectural methodology studies, calling for the articulation and recognition of new models and theoretical constructs. The changes encompass processes such as form-finding, the designer's interaction with the problem space, strategic decision-making during design development, and the hierarchical organization of design stages. Overall, parametric design models signify a paradigm shift: the design process transitions from linear and experience-based to algorithmic, networked, and adaptive systems. Correspondingly, design models evolve from form-centered paradigms toward rule-based and structure-oriented frameworks.

Impact on Design Problems (The Nature and Framing of Parametric Design Problems)

As living conditions and user demands have grown increasingly complex, architectural design has been confronted with correspondingly complex problem structures that necessitate new modes of thinking such as parametric thinking. These problems are typically highly structured and often recur in modified forms; their formulation requires well-structured

solution frameworks, frequently in the form of algorithms, capable of adaptation and reuse in analogous contexts. Within parametric design models, the approach to ambiguity and complexity diverges fundamentally from traditional paradigms. The design problem is framed differently (Kelly & Gero, 2021): complex challenges are decomposed into discrete yet interrelated components (Kelly & Gero, 2021), addressed in layered and modular manners, and examined through the relational logic that connects them (Schnabel, 2007). The decomposition of design problems into smaller entities serves not merely to simplify them, but to uncover the underlying logical structure that governs their interdependencies. In this paradigm, the designer's task shifts from proposing a singular "correct" solution toward formulating the "right" questions a structured set of inquiries that probe multiple dimensions of the design condition (Betancourt et al., 2014). Through such interrogative structuring, the designer is able to program relational frameworks effectively (Kelly & Gero, 2021; Kelly, 2011) and maintain comprehensive oversight of the parametric model, including evaluation, decision-making, and systemic control (Erhan et al., 2010). Parametric design operates according to principles of self-organization, adaptability, and generative addition, rather than relying solely on reductive strategies of complexity management (Oxman, 2017). The conceptualization of complexity, flexibility, and differentiation within parametric design is informed by Deleuzian philosophy and theories of complexity science (Peteinarelis & Yiannoudes, 2016; Oxman, 2017). Accordingly, the definition, framing, and resolution of design problems within parametric models demand renewed theoretical and methodological examination. Overall, the conceptualization of design problems and strategies for addressing them have evolved from incremental and linear models toward dynamic, multi-layered, and relational frameworks.

Impact on the Philosophy and Aesthetics of Design (The Emergence of Parametric Philosophy)

Transformations in the theoretical foundations of design have precipitated corresponding changes in design methodologies, design models, and problem definition. These shifts inevitably generate different types of outputs and responses to design problems. Rather than producing predetermined and repetitive components, parametric design becomes contingent upon specific, contextual, and probabilistic variables (Stavric & Marina, 2011). Such differentiated responses, together with the enhanced integration between design and fabrication, support a new depth of conceptualization grounded in performance-oriented design thinking (Oxman, 2006). Parametric systems exhibit greater capacity for variation (Gallas et al., 2015), adaptability, and responsiveness to complex conditions (Erhan et al., 2010), as the logic of associative design and internal geometric relationships is embedded directly within the generative structure of form (Caetano et al., 2020; Oxman, 2017). Over time, these transformations influence collective taste, societal acceptance, and the philosophical and aesthetic principles underlying architectural production. With the integration of digital technologies into architectural design, even the external evaluative criteria for assessing solutions and defining design objectives have evolved. Within traditional design philosophy, functional, climatic, or structural considerations were often applied subsequent to formal development. In contrast, within parametric design, data and performance criteria are embedded from the outset as integral components of the generative logic of form. Form thus emerges as a direct response to multiple performance-driven inputs. Consequently, design philosophy shifts from an autonomous aesthetics toward a performance- and data-driven aesthetics. In pre-digital methodologies, form frequently preceded function; in parametric paradigms, however, form, performance, and other constraints are generated simultaneously. Aesthetics, functionality, and systemic requirements co-evolve within a unified generative framework.

Impact on Design Tools (Modes of Representation and Expression)

The transformation of design and thinking tools represents the most immediate and foundational shift in architectural practice under the influence of digital technologies, serving as a catalyst for broader methodological and epistemological changes. Design tools have not only evolved but have also diversified significantly. Gradually, manual drawing instruments and paper-based representations have been supplanted by computational environments and parametric software platforms. This shift has expanded the designer's role to include that of tool-maker (Oxman, 2006), adding a new dimension to architectural authorship. Parametric software is sometimes employed not merely as a representational instrument but as a cognitive medium for thinking itself (Oxman, 2017). Such developments have engendered profound changes in both the cognitive processes and operational strategies of designers. These transformations require further consolidation, refinement, and critical reassessment within parametric design studies, building upon and extending prior methodological research in architecture.

Methodology

This qualitative study was conducted employing a Grounded Theory methodology, following the procedural stages articulated by Zamani and Babaei Salanghooch (2024) in their methodological framework for grounded inquiry. The principal objective of the research is to identify domains within parametric architectural studies that require further elaboration, in light of the transformations that have occurred in architectural design methodology under the influence of digital technologies. In the first phase, theoretical sampling was undertaken through a systematic content analysis of specialized methodological literature across two primary domains: design research and parametric architecture. During this stage, emphasis was placed on selecting scholarly works that examined the design process from both theoretical and empirical perspectives. In the second phase, a comparative analysis between the selected bodies of literature was conducted. Core concepts representing points of divergence were extracted and subjected to open coding. Subsequently, the identified indicators of transformation derived from the data were categorized according to multiple analytical dimensions. Through the identification of existing gaps in the literature and the systematic classification of concepts indicative of disciplinary shifts, this qualitative approach establishes an analytical framework for a deeper understanding of methodological transformations. It facilitates the recognition, explication, and categorization of overlooked or reconfigured characteristics within parametric design discourse. Ultimately, the findings contribute toward the refinement of methodological studies and a more coherent articulation of the epistemological identity of parametric design thinking (Fig. 4).

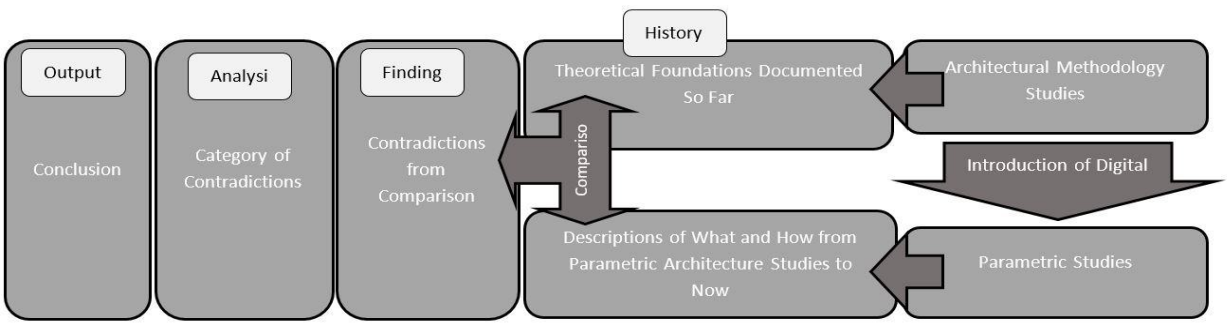


Figure 4: Research process stages

DISCUSSION AND FINDINGS

Studies in design methodology have evolved across successive generations, following a coherent intellectual trajectory and achieving a relatively systematic codification that today constitutes the foundational framework of architectural methodology. With the advent of digital technologies in architecture, transformations have occurred not only in design tools but also in the designer's mode of thinking, professional performance, and the structure of design models across multiple domains. These shifts necessitate further research aimed at identifying and critically examining the impacts of digital technologies on architecture, and at advancing the methodological foundations of parametric architecture as the most significant manifestation of these transformations. Although the theoretical underpinnings of parametric architecture are partially articulated within existing literature, a comparative review against the broader corpus of design research reveals several domains that remain underdeveloped and require further investigation to complete the epistemological and methodological understanding of this design paradigm. Through a comparative analysis of existing studies, principal themes were extracted, identified, and conceptually as well as thematically categorized along axes of transformation. Broadly, these transformations can be organized into five primary domains:

1.Impact on the designer's thinking, encompassing both the designer's perception of the design problem and the transformation of cognitive processes;

2.Impact on design models and theories, including form-finding processes, the designer's interaction with form and computational systems, the hierarchy of design stages, and strategic approaches to structuring and managing design information and relational logics;

3.Impact on design problems, involving their definition, structuring, and modes of engagement;

4.Impact on design philosophy and aesthetics;

5.Impact on design tools and representational media.

These five axes of transformation (Tab. 2) delineate the principal areas requiring further theoretical articulation and empirical investigation in order to consolidate and advance the methodological discourse of parametric architecture (Fig. 5).

Table 2: Categorization and Thematic Axes of Studies Derived from Conceptual Analysis

Categories	Axes	Code	Data-driven concepts
Design Thinking	Designer's mental process	Where the designer's brain works	-Changing the role and function of designer intuition and experience
	(Designer's idea)	Incremental and dynamic thinking instead of static thinking	Changing the role and function of designer creativity
Design Models and Theories	Attitude	Attention to the process of formation instead of form	Thinking about the relationships of components rather than the components themselves
	Form-finding process	Setting rules instead of direct design	Mathematical algorithmic thinking
	Designer's performance	Rules instead of intuition	Changing typological thinking to evolutionary thinking
	Interaction	Setting connections instead of steps	-Changing the concept of standard to non-standard and customization

Issues and Problems	Strategy	Asking questions instead of providing answers	-Changing static thinking to dynamic and flexible thinking
	Process hierarchy	Breaking down and solving complexities instead of intuition	-Thinking about how to produce a product instead of what the product is
Philosophy and Ontology	Obscurities	Comprehensive response	-Replacing top-down (whole-to-part) thinking with bottom-up (part-to-whole) thinking
	Complexity	Possibility of providing new geometry	-Parametric philosophy, changing clouds, indefinite, dynamic, unpredictable, component-dependent
	Answer	Comprehensive response	-Moving from purely descriptive designs to predictive design
Tools	External measurement criterion of the solution	Digital environments	-Computational design based on principles of self-organization, adaptation, and addition, rather than just complexity reduction approaches.
	Goal	Digital environments	-Dynamic and two-way relationship between form and function

An examination of the axes of change indicates that the impact of digital technology on architecture is not limited to the level of tools and forms, but has led to fundamental changes in cognitive structure, mental processes, and design models. These developments strongly emphasize the need to complete studies in parametric architectural methodology, the need to revise educational approaches and theorizing.

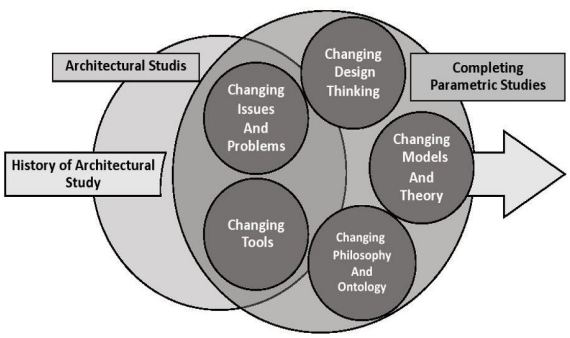


Figure 5: Study areas that need to be completed in parametric architecture studies

CONCLUSION AND RESULTS

The results of examining the major transformations introduced by digital technologies into the architectural design process reveal a series of challenges confronting design researchers—challenges that call for further and more comprehensive investigation. These include:

•The transformation of the designer from an intuitive creator into a regulator of data-driven systems;

•The shift of the design process from a linear and experience-based model toward algorithmic, networked, and adaptive structures, with design models evolving from form-centered to rule-based and structure-oriented paradigms;

•The redefinition of design problems and modes of engagement, transitioning from static models to incremental, dynamic, and multi-layered frameworks;

•The evolution of design philosophy from autonomous aesthetics toward performance- and data-driven aesthetics;

•The transformation of design tools from manual, paper-based media to computational systems.

These transformations have not occurred as discrete ruptures, but rather as a spectrum of changes characterized by gradual, layered, and non-discontinuous evolution (Tab. 3).

Table 3: The Spectrum of Transformations Across Architectural Dimensions in the Parametric Paradigm

Aspects	Parametric Architecture	Middle ground	Traditional design
Design Thinking	Algorithmic, Data-Driven, System-Building	Combination of intuition and data analysis	Intuitive, experimental, personal creativity
Design Models and Theories	Nonlinear, Network, Parameter-Based, Structure-Driven	Combination of form and structure	Linear, manual, based on idea development and form-driven and rule-driven
Issues and Problems	Dynamic, Multi-Layer, Scalable, Parametric	Concurrent redefinition during design	Clear from the start, dependent on texture
Philosophy and Ontology	Function-Based Aesthetics	Combination of function and beauty	Independent aesthetics
Tools	Digital Tools	Combination of sketching and digital tools	Pen and paper, handwriting

Although many designers currently occupy positions between the two poles of the spectrum—neither fully traditional nor fully parametric, but rather engaged in processes of adaptation, experimentation, and learning—the trajectory of transformation is not linear. Instead, we are confronted with a cognitive–design network rather than a set of isolated and independent axes. Linear representation serves merely as an analytical simplification for purposes of clarity; it must be acknowledged that such linearization risks obscuring the complex interactions among components, as a substantial portion of the essence of digital and parametric design manifests precisely within these networked interrelations. A network-based understanding of these transformations reveals that shifts in design methodology are intrinsically intertwined with changes in problem definition. When design processes move toward nonlinearity and parametric logic, the notion of a fixed and predefined problem becomes untenable; instead, the problem itself evolves concurrently with the design process. Consequently, as designers actively construct the problem while designing, their cognitive orientation must adapt to the generation of problems—not merely their resolution. Similarly, transformations in tools cannot be reduced to mere changes in representational environments. Alterations in tools fundamentally reconfigure cognitive structures and redefine the role of the designer. The medium is not neutral; it actively reshapes thought processes, strategic decisions, and the organization of design knowledge.

Understanding these changes as interconnected and networked phenomena enables future research to apprehend their simultaneity and reciprocal influence. Therefore, advancing methodological studies in parametric architecture requires the concurrent examination of all identified axes of transformation rather than their isolated investigation. The findings indicate that design in the digital era demands novel competencies, reconfigured cognitive frameworks, and educational paradigms distinct from traditional approaches. Further research is required to enhance both theoretical understanding and practical implementation of these emerging methodologies. This necessity is particularly pressing in architectural education and in the development of future design strategies, where comprehensive recognition of new paradigms and deliberate alignment with the emergence of artificial intelligence in architecture assumes critical importance. Moreover, conceiving these transformations as a spectrum facilitates a more nuanced understanding of the transitional process from pencil-and-paper–based design to

digitally mediated environments, as well as the inevitable resistances accompanying this shift. Such an approach can play a significant role in reformulating design pedagogy, conducting comparative research, and critically reassessing educational systems in architecture.

REFERENCES

Abdualee, A. H., & Mohammed, K. H. (2024). Digital transformation in design and the impact of modern tools and technologies. Global Prosperity, 4(1). https://gprosperity.org/index.php/journal/article/download/126/104/106

Aburamadan, R., & Trillo, C. (2020). Applying design science approach to architectural design development. Frontiers of Architectural Research, 9(1), 216–235. DOI: https://doi.org/10.1016/j.foar.2019.07.006

*Alalouch, C. (2018). A pedagogical approach to integrate parametric thinking in early design studios. *Archnet-IJAR: International Journal of Architectural Research, 12*(2), 162–181. DOI:https://doi.org/10.26687/archnet-ijar.v12i2.1425*

Alves, R. (2020). Cruise ship itinerary design (Master's thesis). Técnico Lisboa, Portugal. https://fenix.tecnico.ulisboa.pt/downloadFile/1126295043838273/Resumo%20alargado%20Renato.pdf

Ammon, S. (2017). Why designing is not experimenting: Design methods, epistemic praxis and strategies of knowledge acquisition in architecture. Philosophy & Technology, 30(4), 495–520. DOI: https://doi.org/10.1007/s13347-016-0231-4

Banihashemi, S., Assadimoghadam, A., Hajirasouli, A., LeNguyen, K., & Mohandes, S. R. (2024). Parametric design in construction: A new paradigm for quality management and defect reduction. International Journal of Construction Management, 1–18. DOI: https://doi.org/10.1080/15623599.2024.2447653

Betancourt, M. C., Quintero, L. M., & Cereceda, G. (2014). A discussion on algorithmic thinking in product design process. Proceedings of the DESIGN 2014 International Design Conference (pp. 1035-1042).https://www.designsociety.org/publication/36162/A+DISCUSSION+ON+ALGORITHMIC+THINKING+IN+PRODUCT+DESIGN+PROCESS

Bettig, B., & Hoffmann, C. M. (2011). Geometric constraint solving in parametric computer-aided design. Springer. DOI: https://doi.org/10.1007/978-3-642-20382-1

Bhooshan, S. (2017). Parametric design thinking: A case-study of practice-embedded architectural research. Design Studies, 52, 115–143. DOI: https://doi.org/10.1016/j.destud.2017.05.003

Branco, R. C., & Leitão, A. (2017). Translating algorithmic design from CAD to BIM. In Proceedings ofKINE[SIS]TEM'17. https://web.ist.utl.pt/antonio.menezes.leitao/ADA/documents/publications_docs/2017_TranslatingAlgorithmicDesignFromCADtoBIM.pdf

Brown, T. (2009). Change by design: How design thinking creates new alternatives for business and society. Harper Business. https://www.harpercollins.com/products/change-by-design-tim-brown

Brozovsky, J., Labonnote, N., & Vigren, O. (2024). Digital technologies in architecture, engineering, and construction. Automation in Construction, 158, Article 105212. DOI: https://doi.org/10.1016/j.autcon.2023.105212

Buchanan, R. (1992). Wicked problems in design thinking. Design Issues, 8(2), 5–21. DOI: https://doi.org/10.2307/1511637

Caetano, I., Santos, L., & Leitão, A. (2020). Computational design in architecture: Defining parametric, generative, and algorithmic design. Frontiers of Architectural Research, 9(2), 287–300. DOI: https://doi.org/10.1016/j.foar.2019.12.008

Çalışkan, O., Barut, Y. B., & Ongun, G. (2024). Parametric urban design thinking: Shared patterns in design by algorithm and design by drawing. Journal of Planning Education and Research, 44(3), 1010–1029. DOI: https://doi.org/10.1177/0739456X221145678

Castelo-Branco, R., Brás, C., & Leitão, A. M. (2021). Inside the matrix: Immersive live coding for architectural design. International Journal of Architectural Computing, 19(2), 174–189. DOI: https://doi.org/10.1177/1478077120988200

Clay, J., & Sha, Z. (2025). Paradigmatic design thinking: How generative AI changes the role of human designers. Proceedings of the De-

sign Society, 5, 2571–2579. DOI: https://doi.org/10.1017/pds.2025.257

Cross, N. (2006). Designerly ways of knowing. Springer. https://link.springer.com/book/10.1007/1-84628-301-9

De Bono, E. (2000). New thinking for the new millennium. Viking. https://archive.org/details/newthinkingforne0000debo

Dorst, K. (2015). Frame innovation: Create new thinking by design. MIT Press. https://mitpress.mit.edu/9780262324294/frame-innovation/

Elbony, F. A. (2019). The effect of technological development on architecture: Nanotechnology and architectural design. Fayoum University Journal of Engineering, 2(2), 65–77. https://fuje.journals.ekb.eg/article_40302.html

Erhan, H., Salmasi, N. H., & Woodbury, R. (2010). ViSA: A parametric design modeling method to enhance visual sensitivity control and analysis. International Journal of Architectural Computing, 8(4), 461–483. DOI: https://doi.org/10.1260/1478-0771.8.4.461

Fasoulaki, E. (2008). Integrated design: A generative multi-performative design approach (Doctoral dissertation). MIT. https://dspace.mit.edu/handle/1721.1/44443

Feizi, Kh., & Zand, Kh. (2006). Design Thinking in the Architectural Design Process. *Bagh-e-Nazar, 2*(4), 13–23. https://www.bagh-sj.com/article_2867.html

Gallas, M. A., Jacquot, K., Jancart, S., & Delvaux, F. (2015). Parametric modeling: An advanced design process for architectural education. In Proceedings of the 33rd eCAADe Conference (Vol. 1, pp. 213–222). https://www.semanticscholar.org/paper/Parametric-Modeling%253A-An-Advanced-Design-Process-for-Gallas-Jacquot/c1ed2b4d5a6c11ab2a9634a53cb1eea8bbc0e38c

Gao, Q., Yang, Y., & Wang, Q. (2022). An integrated simulation method for PVSS parametric design using multi-objective optimization. Frontiers of Architectural Research, 11(3), 509–526. DOI: https://doi.org/10.1016/j.foar.2022.01.004

Giurea, D., Dumitrescu, C. G., & Malaescu, A. (2014). Educational means for the study of the geometry of architectural forms. *Procedia - Social and Behavioral Sciences, 116*, 13–18. DOI: https://doi.org/10.1016/j.sbspro.2014.01.170

Hadjadji, N., Toulan, N., & Dorra, M. (2024). Impact of digital architecture on ecological formations and identity in architectural design. Journal of Engineering Research, 12(3), 285–293. https://jer.kuniver.kz/journal/jer/article/view/1495

Henri, A. H. (2003). New design methods for computer aided architectural design methodology teaching. International Journal of Architectural Computing, 1(1), 72–91.https://journals.sagepub.com/doi/10.1260/147807703322460357

Hsiao, Y.-S. (2019). The impact of parametric design methodologies on creativity in hospital design process (Doctoral dissertation). Glasgow School of Art. https://radar.gsa.ac.uk/6799/

Hudson, R. (2010). Strategies for parametric design in architecture: An application of practice-led research (Doctoral dissertation). University of Bath. https://researchportal.bath.ac.uk/en/studentTheses/strategies-for-parametric-design-in-architecture

Janssen, P., & Stouffs, R. (2015). Types of parametric modelling. In Proceedings of CAADRIA 2015. http://papers.cumincad.org/cgi-bin/works/paper/caadria2015_184

Kelly, B. M. (2011). Parametric thinking. In ACADIA Regional 2011 Proceedings. https://www.academia.edu/17221179/Parametric_Thinking

Kelly, N., & Gero, J. S. (2021). Design thinking and computational thinking: A dual process model for addressing design problems. Design Science, 7, Article e8. DOI: https://doi.org/10.1017/dsj.2021.7

Lawson,B.(2006).Howdesignersthink(4thed.).Routledge.https://www.routledge.com/How-Designers-Think/Lawson/p/book/9780750660778

Lee, J. H., & Ostwald, M. J. (2020). Creative decision-making processes in parametric design. Buildings, 10(12), Article 242. DOI: https://doi.org/10.3390/buildings10120242

Lee, J., Gu, N., & Williams, A. P. (2014). Parametric design strategies for the generation of creative designs. International Journal of Architectural Computing, 12(3), 263–282. DOI: https://doi.org/10.1260/1478-0771.12.3.263

Li, Y., et al. (2025). A review of artificial intelligence in enhancing architectural design efficiency. Applied Sciences, 15(3), Article 1476. DOI: https://doi.org/10.3390/app15031476

Manzoor, B., Othman, I., & Pomares, J. C. (2021). Digital technologies in the architecture, engineering and construction (AEC) industry: A bibliometric qualitative literature review. International Journal of Environmental Research and Public Health, 18(11), Article 6135. DOI: https://doi.org/10.3390/ijerph18116135

*Mohammad, K. E. S. (2012). A closer perspective on fabrication realities. In H. Achten, J. Pavlicek, J. Hulin, & D. Matejovska (Eds.), *Digital Physicality - Proceedings of the 30th eCAADe Conference* (Vol. 2, pp. 169–179). Czech Technical University in Prague. DOI: https://doi.org/10.52842/conf.ecaade.2012.2.169*

Mohabati, A., et al. (2019). Analysis of the Characteristics of Visual Thinking and Its Function in the Design Thinking Process. Theoretical Foundations of Visual Arts, 4(1), 155–162. https://www.noormags.ir/view/fa/articlepage/1679317

Monedero, J. (2000). Parametric design: A review and some experiences. Automation in Construction, 9(4), 369–377. DOI: https://doi.org/10.1016/S0926-5805(99)00058-8 https://www.sciencedirect.com/science/article/pii/S0926580599000588

Nasir, O., & Kamal, M. A. (2023). Exploring the role of parametric architecture in building design: An inclusive approach. Facta Universitatis, Series: Architecture and Civil Engineering, 95–114. http://casopisi.junis.ni.ac.rs/index.php/FUArchCivilEng/article/view/11177

Nicolas-Alonso, L. F., & Gomez-Gil, J. (2012). Brain computer interfaces: A review. Sensors, 12(2), 1211–1279. DOI: https://doi.org/10.3390/s120201211

*Oktan, B. Ş., & Vural, S. M. (2017). Parametric modeling in architectural education: An experimental approach. *Journal of Design + Built, 10*(1), 1–12. https://www.researchgate.net/publication/360549217_Parametric_Modelling_in_Architecture*

Oxman, R. (2006). Theory and design in the first digital age. Design Studies, 27(3), 229–265. DOI: https://doi.org/10.1016/j.destud.2005.11.002

Oxman, R. (2017). Thinking difference: Theories and models of parametric design thinking. Design Studies, 52, 4–39. DOI: https://doi.org/10.1016/j.destud.2017.05.001

*Pantazis, E., & Gerber, D. J. (2019). A multi agent systems framework for integrating environmental parameters in the design of shell structures. In P. Geyer, K. Allacker, M. Schevenels, F. De Troyer, & P. Pauwels (Eds.), *Proceedings of the 26th International Workshop on Intelligent Computing in Engineering (EG-ICE 2019)* (Vol. 2394).https://ceur-ws.org/Vol-2394/*

Peteinarelis, A., & Yiannoudes, S. (2016). Algorithmic thinking in design and construction: Working with parametric models. In Parametricism vs. Materialism: Evolution of Digital Technologies for Development – Proceedings of the 8th ASCAAD Conference (pp. 19–28). http://papers.cumincad.org/cgi-bin/works/paper/ascaad2016_004

Pektas, S. T. (2023). Parametric design as a tool/as a goal: Shifting focus from form to function. In K. Ozcelik (Ed.), Transforming issues in housing design (pp. 221–232). Wiley. ISBN: 9781119855761 https://www.wiley.com/en.us/Transforming+Issues+in+Housing+Design-p-9781119855761

Ponzio, A. P., Sottile, S., & Calvo, F. J. S. (2020). Methods to optimize carbon footprint of buildings in regenerative architectural design with the use of machine learning, convolutional neural network, and parametric design. Preprint. https://www.mdpi.com/1996-1073/13/20/5289

Rezk, M., Elmokadem, A. A., Hussein, H. Q., & Badawy, N. M. (2023). The impact of digital tools on parametric architecture. Port-Said Engineering Research Journal. https://www.semanticscholar.org/paper/The-Impact-of-Digital-Tools-on-Parametric-Rezk-Elmokadem/75d57f0209f69c0d8e5c40bdf3ea77768f16ab2d

Schnabel, M. A. (2007). Parametric designing in architecture. In CAADFutures 2007 Proceedings (pp. 237-250). Springer. https://link.springer.com/chapter/10.1007/978-1-4020-6528-6_18

Schumacher, P. (2012). The autopoiesis of architecture: Vol. II. A new agenda for architecture. Wiley. https://www.wiley.com/en-us/The+Autopoiesis+of+Architecture%252C+Volume+II%253A+A+New+Agenda+for+Architecture-p-9780470666159

Semjén, Á. Á., & Szép, J. (2025). Integrating gener-

ative and parametric design with BIM: A literature review of challenges and research gaps in construction design. Applications in Engineering Science, Article 100253. DOI: https://doi.org/10.1016/j.apples.2025.100253

Špaček, R., Uhrík, M., & Hajtmanek, R. (2020). Architectural education: A reflection of three generations. Global Journal of Engineering Education, 22(3), 142–148. http://www.wiete.com.au/journals/GJEE/Publish/vol22no3/06-Spacek-R.pdf

Sreenivasan, A., & Suresh, M. (2024). Design thinking and artificial intelligence: A systematic literature review exploring synergies. International Journal of Innovation Studies, 8(3), 297–312. DOI: https://doi.org/10.1016/j.ijis.2024.05.003

Stavric, M., & Marina, O. (2011). Parametric modeling for advanced architecture. International Journal of Applied Mathematics and Informatics, 5(1), 9–16. https://www.naun.org/main/NAUN/ijami/2011/a042001-015.pdf

Vazquez, E. (2024). Teaching parametric design: Fostering algorithmic thinking through incomplete recipes. Open House International, 49(4), 736–751. DOI: https://doi.org/10.1108/OHI-06-2023-0135

Woodbury, R. (2010). Elements of parametric design. Routledge. https://www.routledge.com/Elements-of-Parametric-Design/Woodbury/p/book/9780415779876

Wynn, D. C., & Clarkson, P. J. (2018). Process models in design and development. Research in Engineering Design, 29, 161–202. DOI: https://doi.org/10.1007/s00163-017-0262-7

Zamani, B., & Babaei Salanghooch, E. (2024). Evaluation of the application of grounded theory methodology principles in Persian urban planning and design research. Motaleate Shahri, 13(52), 17–32. https://urbstudies.uok.ac.ir/article_62055.html

Zarei, Y. (2012). The challenges of parametric design in architecture today: Mapping the design practice (Doctoral dissertation). University of Manchester. https://www.research.manchester.ac.uk/portal/en/theses/the-challenges-of-parametric-design-in-architecture-today-mapping-the-design-practice(da1e8e4a-0d23-4feb-b82b-8b6a8e1b1e3a).html

HOW TO CITE THIS ARTICLE

Moradi,M. and Sharif,H. (2026). Challenges and Gaps in Parametric Architecture Methodology. (e734691). International Journal of Urban Management and Energy Sustainability, (), e734691 doi: 10.22034/ijumes.2026.2085758.1355

DOI: 10.22034/ijumes.2026.2085758.1355