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Research Article

Revealing the gap between modernism and parametricism in architecture

Qasim Ali Shah[1] | Ihteram Ali*[2] | Muhammad Zeeshan Khan[1] | Zineb Hanine[1]

1. School of Architecture, Tianjin University, Nankai, China.
2. Department of Mathematics and Statistics, Women University Swabi, Pakistan.

*Corresponding Author Email: ihteramali60@gmail.com

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Abstract:

Examining the relationship between humans and the natural world and the effects of interaction between them has deep roots in our understanding of society and culture. Cities, therefore, are a direct reflection of their citizens, as expressions of their architecture directly influence the living conditions of their people. The gap between architectural design ideas and their interpretation in a real built environment can be addressed differently by the opposite process and effect. Parametric design strategies propose manageable and flexible solutions at an early-stage process that respond to given conditions and outcomes. A method in designing buildings and other architectural forms, parametric modelling techniques often result in certain distinctive formal expressions that attract attention to themselves. This article describes how formal representation of this sort affects how things appear to the eye. However, during the design process, this issue is not considered objectively. One may now explore several design choices quickly and easily with the help of parametric design. The research explores the potential of using this technology to parameterise a constructed space's formal look, which would then affect how people perceive it and their decisions in the future, leading to a more comprehensive approach to build-space design.

Keywords: Statistical design, Visually perceiving, Designed space, Parametric Design, Material innovation, Design ideologies, Geometric complexity, Design choices.

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1. Introduction

Architectural students must participate in architectural design studios. Its customs and procedures are well known. Courses and seminars are used to inform and augment the studio, which can help the studio's learning objectives. Beyond pure creativity, studio talent development involves contemplation and knowledge generation. However, there is a disconnect between the application of knowledge and the development of abilities in the studio environment.

This is true in regard to digital media courses, where it is one thing to explain the fundamental ideas of architectural design through digital communication means and quite another to train students in software skills and technical knowledge (Kvan, 2004). Because basic skill acquisition inhibits a thorough examination of design and theoretical concerns, the integration of a digital media course into a design studio frequently fails. In the relationship to digital media courses, where on the one hand, the underlying concepts of architectural design using digital communication tools are presented; on the other hand, software skills and learning of technical issues have to be trained (Kvan, 2004). The integration of a digital media course into a design studio often fails because the basic acquisition of skills prevents a deep exploration of design and theoretical aspects. Only long after participants have learned and gained sufficiency are they able to employ digital media tools within a studio context. Yet by then, the studio may not consider these skills any longer. A dilemma of semester-based teaching is that students have the highest level of skills and experience at the end of a term when they leave for their break and are not able to apply their knowledge. At the beginning of the next term, however, the gained knowledge and skills are either inactive or not employed because the learning focus of the next semester shifts to other aims.

The parameter design is not an unusual area for architects. From ancient pyramids to modern centres, buildings are designed and built in accordance with a variety of dynamic forces, including climate, technology, usage, character, location, culture, and atmosphere. The computer did not develop a parametric design, nor did it redefine the properties or function; it provided an important tool that has helped architects to design and build intelligent buildings with extremely high-quality standards and values.

Involvement of parametric design in Architecture as generic as it sounds; the more it has been over the period. Understanding the parametric design, the reason behind its very first use, its rise over time and the purpose of it being used now. Behind every ‘road not taken’ there rise a lot of complications and tranquilities which need to be understood and dealt upon. To broaden our perspective about Parametric Design, its complications, challenges, and how it serves the purpose and how the designers would, we investigated five types of literature which helped us to analyse and comprehend this topic in much greater depth.

This research study focuses on how the architectural space has changed during the parametric design style period compared with the previous modernist architectural style. Related to Patrick Schumacher, who sees that modernism has a number of prominent lived influences, such as postmodernism, DE constructivism, and minimalism. This style closes the traditional period of uncertainty for modernism, and he sees that parametricism is a great style after modernism (Thomann, 2022). This can be achieved through studying the works of the pioneers of both styles, including Le Corbusier (Mujahed, 2022), who is one of the main pioneers of modern

architecture. Zaha and Patrick Schumacher, who were partners and founders, coined the parametric design style (Schumacher, 2009). Parametric design has changed architectural space in different ways, such as aesthete and functionality enhancement, complexity space management, main design tools, and the third industrial revolution (Dursun, 2009). In this research paper, the study will focus on the aesthetic part, including the visuality, and the functionality, including the material used for both period style architects, to understand how the architectural space has changed and improved through the specific architectural periods.

1.2. Subproblems

The first subproblem is the definition and history of the architectural space and how it has improved through time, especially during the modernism period, represented in Le Corbusier's work, and the parametricism period, which is represented in Zaha Hadid and Patrick Schumacher's works. Besides, this subproblem includes what are the characteristics of the architectural space in each architectural period, and how each architect defined and expressed the meaning of architectural space.

The second subproblem is the visualizing aesthetic and functional orientation and details of the architectural space, including the material of the modern architectural style in Le Corbusier's building design.

The third subproblem focuses on the visual aesthetic and functional material used in the parametricism period, which is found in the architectural buildings of Zaha Hadid and Patrick Schumacher. This subproblem includes the characteristics, and details used to achieve the visual aesthetic of the architectural designs and the material choosing and using processes for the whole design process.

The fourth and last subproblem includes the differences between the two architectural style periods specializing in the visual aesthetic and material of the architectural design spaces. This subproblem also focuses on how the architectural space has improved through time, and what are the main characteristics for improving the architectural space.

1.3. Hypothesis

An emphasis on volume, asymmetrical compositions, and little adornment are characteristics of the modernist style, while parametricism is an approach of blending complexity and variety, thus rejecting homogenous utilitarianism. In modernism, a focus is on horizontal and vertical lines, as well as components that are 90 degrees apart. Using steel and reinforced concrete. Instead of concealing structural features, use visual expressiveness. The most contentious technique, parametricism merges the design intention with the design product through an algorithm. However, it has the ability to draw attention since it produces complex geometries and structures through the interaction of its constituent parts.

1.4. Definitions of terms

- Parametric design: This is a new technique used in architectural and interior design that is based on information and functions by entering the information required for a building to be created using technology and computers. The information is entered from

the length, height, weight, width, and codes so that the object can be identified precisely (Kamara & Adullah, 2013).

- The modernist architectural movement priority's function and a streamlined design above adornment (Wafiqe & Alslik, 2019; Heidari *et al.*, 2018).
- Architectural space: the theory and practice of designing and building inhabited environments in outer space, responding to the deep human drive to explore and occupy new places (Schumacher, 2009).
- Visual Aesthetic: the beauty or the pleasing appearance of things (Eytam *et al.*, 2021).
- The style is based on digital animation methods. Parametricism's most recent improvements are built on sophisticated parametric design systems and scripting methods (Suzuki, 2020).

1.5. Importance of the study

Three features of parametric design thinking are thinking abstractly, thinking mathematically, and thinking algorithmically (Chokhachian, 2014). Thinking abstractly provides the foundation for parametric design, which may be utilized to generate parallel alternatives and reuse some components of the parametric model. The theorems and structures that define the scripting language for design representation and generation are examples of mathematical thinking. By using algorithmic thinking, scripting languages can add, repeat, change, or remove components from parametric designs. Characteristics of modernist construction Functional design states that "form follows function." compositions that use geometric shapes and are asymmetrical, frequently with flat roofs. Lines with a horizontal emphasis.), Less is better (Minimal or no ornamentation, with a tendency towards a white or a neutral palette.), contemporary materials (Modern materials: reinforced concrete, steel frames, curtain walls and ribbon windows.), open-concept rooms (Light filled, open plan interiors, with a feeling of spaciousness.)

Modern architecture and sculpture are combined in parametric design. The smooth, flowing lines of the parametric approach give the design a distinctive shape that grabs attention. It draws attention to other design motifs that were historically impossible and unattainable. Architecture evolved and was updated, relying on the parametric framework to make distinctive art and attract attention. All architects want to create something that is dependent on the most recent technological advancements, so engineers start learning how to use the tools created for animation and modern technology. Because so many of them have used parametric design, architecture has separated itself from other fields and is in higher demand than anything that has already gained widespread acceptance.

2. Methodology

The methodology of this research is a mixed-method design including quantitative and qualitative methodologies. The quantitative research part includes studying five projects of each pioneer architect from different architectural style periods. The qualitative research part includes studying the aesthetic part analysis, including the visual aesthetic analysis, and the functionality of the architectural space, including the material used in each project of each architect. Besides using the qualitative, and quantitative methods analysis, the results will be compared, integrated, and interpreted using the method of triangulation. The analysis process includes studying the architectural drawings, analysing the architectural pattern, and thinking of the visual aesthetic of the architectural space, and the material which was used in each

project. Table-1 shows the projects on which this research paper will focus and study to find out the characteristics of each architectural style period.

Table-1: The study projects of this research paper

Le Corbusier's Projects	Zaha Hadid, and Patrick Schumacher's Projects
Villa Savoye	Capital Hill Residence
Unite d'habitation de Berlin	Spittelau Viaducts Housing
Villa La Roche	Kusnacht Villa
Villa Shodhan	D–Villa
Citrohan House	Nassim Villas

2.1. Participants

For the experimental part of this study, 53 students of the first year of architecture career of the National University of San Agustín of Arequipa in Peru were recruited. An archetype of student was determined for their participation in the experimentation whose characteristics were to be students of the recent entrance to the university, to be studying the subject of Architectural Design 1, not to know the chapel of Notre Dame du Haut in Ronchamp, neither by direct nor indirect experience and not to have colour blindness, partial blindness or others that hinder normal visualization. The participants were 28 men and 23 women, and the average age was 18.34 years. Before starting the experimentation, the participants were informed of the study and its aims and informed consent was obtained from each of them.

2.2. Display media and measuring instruments

For the experiment, we used the chapel of Notre Dame du Haut in Ronchamp, France, an iconic architectural work of the twentieth century designed by the architect Charles-Édouard Jeanneret, better known as Le Corbusier. This work stands as a manifesto within contemporary religious architecture because it offers the religious building the possibility of acting as an exploratory field for the visual arts and symbolizes a synthesis of his research and fundamental concerns.

2.3. Experimental design

The experimentation was designed by gathering the 53 students in a 60-minute session during the classes of the Architectural Design 1 subject of groups B (afternoon shift) and group C (morning shift). The session was conducted virtually and in real time through the Google Meet platform which is usual in the current type of teaching due to the restrictions of the pandemic caused by Covid-19.

The aim of this research was to explore the extent to which Parametric Design Procedures (PDPs) can be used as a computational methodology for generative form in the conceptual design stage. The specific questions were: (i) How can PDPs be used as a computational design generative system? And (ii) How can PDPs allow designers to formalize and generate solution spaces that can be explored? To answer the research questions an application was developed and evaluated with respect to the needs and goals of the conceptual design stage and parametric modelling. Grasshopper 3D was chosen as the software to design and develop the application of PDPs. This was because, currently, there is no suitable software like Grasshopper to support the PDPs approach. To ensure that the evaluation reflected a realistic scenario with respect to

site, aesthetic and other criteria, the brief (program) for architectural competition (USA: The 2nd Annual International Student Tall Building Design Competition) was selected as the context. Furthermore, a real site context was selected to design and locate the competition. The use of self-evaluation in the testing of the application has its limitations. However, it was not possible during the timeframe of the research to involve other specialists in the validation process. However, the process adopted has yielded useful insights into the potential benefits of PDPs.

2.4. Delimitation

The delimitations of this study are:

- This research focuses on specific determined parts of studying the architectural space, including the aesthetic visual perspective and the functionality through materials, and it will not cover other parts.
- This research reviews the reading sources including the journal articles from the last 30 years to keep up with the current studies in this field.

3. Characteristics of parametric design: analysis and discussion

He uses applications designed specifically for working with figures like Grass Hopper and Maya, and he comprehends systems with complicated structures that were previously challenging to comprehend. Even after the design components have been completed automatically, it can still make adjustments. Spend less time and effort layering manually. Designers might research the connections between the fundamental elements of real buildings, production methods, and structural design. When used in dynamic designs, it can turn into a dynamic design and become either an interior or exterior design. Because it is an integrated design and each component is accountable for the design's success through the reuse and recycle principle, it was deemed to be a sustainable design. It is durable and simple to switch, install, and disassemble.

3.1. Variable parameters

- Design elements can be adjusted through parameters, allowing for flexibility and adaptability.

"Variable Parameters" in parametric design refer to the ability to adjust and manipulate specific aspects or attributes of a design through changing numerical values or parameters. This characteristic allows designers to create variations, explore different possibilities, and adapt the design to meet specific requirements.

For example, in a parametrically designed facade, the height, width, curvature, or other geometric properties could be variable parameters. By adjusting these parameters, designers can explore a range of design options and study their impact on the overall form and function of the structure. This flexibility is crucial for achieving adaptability and responsiveness in the design process, allowing for dynamic and customized solutions. Variable parameters are often controlled through algorithms and computational tools, enabling designers to experiment with different configurations and find optimal solutions easily.

3.2. Generative processes

- Designs are generated through iterative processes, often with the help of computational algorithms.

"Generative Processes" in parametric design involve the use of iterative and computational methods to create and refine designs. This characteristic emphasizes the dynamic and evolving nature of the design process. Here is a breakdown of this characteristic:

- Iterative processes: Design iterations involve the repetition of a series of steps, where each cycle results in an improved or modified version of the design. Designers iteratively refine their concepts, making adjustments based on feedback, analysis, or changing requirements.
- Computational algorithms: Generative processes rely on computational algorithms to automate design generation and optimization. These algorithms can be programmed to respond to specific parameters, allowing for the exploration of numerous design possibilities.
- Exploration of design space: Designers use generative processes to explore a vast design space. By defining parameters and constraints within algorithms, they can systematically investigate a wide range of design variations, helping discover innovative solutions that might not be apparent through traditional design methods.

3.3. Dynamic patterns

- Capable of creating dynamic and evolving patterns within the design.

"Dynamic Patterns" in parametric design refer to the creation of patterns that are not static or fixed but instead exhibit variation, movement, or adaptability. This characteristic adds an element of liveliness and responsiveness to the design. Here is a more detailed exploration:

- Variability and adaptability: the dynamic patterns are not constant; and they can change anytime based on specific parameters or external factors. This adaptability allows for designs that respond to dynamic conditions, such as environmental changes or user interactions.
- Parameter-driven changes: The dynamic nature of patterns often stems from the manipulation of parameters within the design. By adjusting these parameters, designers can induce variations in the pattern, creating visual interest and diversity.

3.4. Continuous evolution

- Designs can evolve over time, responding to feedback, usage patterns, or changing requirements.

"Continuous evolution" in parametric design refers to the ongoing and iterative development of the design process. This characteristic emphasizes that the design is not static but rather evolves over time, responding to feedback, changing requirements, or new insights. Here is a more detailed exploration:

- Iterative Refinement: The design undergoes continuous iterations and refinements, with each cycle building upon the previous version. Designers revisit and adjust aspects of the design based on feedback, analysis, and insights gained during the development process.

3.5. Simulation and analysis

- Involves rigorous simulation and analysis to validate and refine the design based on performance criteria.

"Simulation and analysis" in parametric design involve the use of computational tools to simulate and analyse various aspects of a design. This characteristic emphasizes the integration of data-driven insights into the design process. Here is a detailed exploration:

- Computational modelling: Parametric design relies on computational models that represent the geometry, behaviour, and performance of the design. These models are created using specialized software tools capable of handling complex algorithms and data structures.
- Structural analysis: Simulation tools are employed to assess the structural integrity of the design. Engineers can analyse how different parametric variations impact factors such as load distribution, stress levels, and overall structural stability.
- Environmental analysis: The parametric design allows for the simulation of environmental conditions such as sunlight exposure, wind patterns, and thermal performance. This analysis helps optimize the design for energy efficiency, comfort, and sustainability.
- Material performance: Simulation tools enable designers to analyse the behaviour of materials under various conditions. This includes considerations for durability, elasticity, and other material properties, influencing decisions on material selection and usage.
- Daylighting studies: For architectural projects, daylighting analysis can be performed to understand how natural light interacts with the built environment. Parametric tools assist in optimizing the placement and characteristics of openings to enhance natural lighting.
- Energy efficiency: Simulation and analysis tools are crucial for evaluating the energy performance of a design. This includes assessing the impact of design variations on heating, cooling, and overall energy consumption, contributing to sustainable and energy-efficient solutions.
- User experience and ergonomics: Parametric design can simulate user interactions and experiences within a space. This includes considerations for ergonomics, accessibility, and the overall usability of the design.
- Iterative optimization: The simulation results drive iterative optimizations. Designers can modify parameters based on analysis outcomes to improve specific aspects of the design, ensuring a data-informed and performance-driven approach.
- Visualization of data: The simulation and analysis tools often provide visual representations of data, making it easier for designers to comprehend complex information. This visual feedback aids in decision-making and communication among project stakeholders.

- Risk mitigation: By identifying potential issues early in the design process, simulation and analysis contribute to risk mitigation. Designers can proactively address challenges related to structural integrity, environmental impact, or other critical factors.
- Interdisciplinary collaboration: Simulation tools facilitate collaboration between architects, engineers, and other specialists. This interdisciplinary approach ensures that different design aspects are considered comprehensively during the simulation and analysis phases.

4. Conclusion and recommendations

To sum up, we want to add that the transformation is occurring quickly and that we must adapt. Today's architects prefer to work in their comfort zones where they can create. Peacefully and calmly. We must extend our perspective on our profession. If something is being developed, we must understand why it is being developed and how we might improve. More architects need to use parametric design, which may be complex and simple for some. However, whether we are architects or not, we all perceive things differently. We all acquire the same knowledge, but because our experiences vary, we will construct it differently and have a different narrative. Therefore, this paper presents the parametric design studio, a computational design principle for architecture that has recently impacted architectural production. This studio activity investigated producing unusual solutions through novel means of architectural expression, form-finding, and communication. It combined a studio learning environment with a comprehensive digital media assignment to bridge the gap between skill acquisition and knowledge reflection and investigate new ways of framing and integrating complex design concerns.

Students might well pass all their study subjects mastering BIM software, and later on, even in professional practice, to limit themselves to an artisanal fashion, but adding parametric modelling as another one, completely different in its approach, would escalate their creative potential and could result in more creative compositions. This idea keeps its pace with the notion that the progression of architecture towards advanced means that the new construction way is information modelling. Architectural studies previously had taken parametric design and modelling courses as advanced knowledge and thus to be implemented only in later study courses, in the first study years concentrating attention to BIM-related tools. Contrary to this opinion, an experiment is carried out in the architectural study program at Kaunas University of Technology to introduce modelling practice to undergraduates during their first architectural design course with the help of 3ds Max software. The hypothesis that the work overload and simultaneous teaching of two different concepts and approaches to design would be a challenge was denied because the enthusiasm of young students proved to cope with technological issues easily. Also, survey data proved that students are ready to master software parallelly from the beginning of their studies. The process shows that the decision to conduct an experiment was right and allows Architectural studies to keep pace with technologies.

The research aimed to develop a new computational methodology for form generation focusing on the conceptual stage of the design process. This was pursued by identifying the goals and objectives of parametric modelling, the particular features of the conceptual design phase, and the limitations of existing generative systems. Results showed that PDPs have the potential to achieve the goals for which they were designed. PDPs provide designers with an environment where design solutions can be easily and quickly generated in a relatively short time using the

same parameterized model. Although the assessment of the approach was based on predefined goals of parametric modelling and the needs of the conceptual design phase in the design process, the assessment was a kind of self-assessment, which is a limitation of the study. Another limitation was related to the implementation environment, as currently, only Grasshopper software supports this approach. The need to develop and assess PDPs using other software environments and tools is a logical step for future research. As a recommendation, PDPs, as a collaborative computational methodology for form generation, can be applied to parametric systems and software architects use. Given the potential of PDPs in the conceptual design phase, it is reasonable to assume that they will be appropriate for other phases of the design process. However, further research is required to explore this.

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