An Analysis of the Factors and Elements Associated with Parametric Design Method in the Field of Interior Design*

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Abstract

This research was conducted to explore and analyze the factors associated with the use of the parametric design method in interior design with the main focus on the design and installation processes. Grasshopper parameterization modeling technology was applied to create design, generation, and installation. The adoption of the parametric method was crucial because it offered a potent approach to efficiently generate designs by dynamically adjusting initial parameters and sequencing codes. This method allowed for the rapid creation of forms necessary to achieve an optimal design. The technology has been used widely in different fields, specifically engineering, and architecture, as well as interior, product, and fashion design with several others, due to the advantages of computational and generative design methods. This practical research was used to divide method, thought, design, and manufacturing processes into five parts including data collection and analysis, design and development, experimentation, implementation, and delivery. Moreover, the experiment was used to explore the parametric design process through the design of an interior staircase with due consideration for the conditions, limitations, as well as design and installation processes.

The research findings unveiled in this study can serve as a valuable guide for advancing architectural, interior, and product design. By leveraging the conceptual foundations and methodologies established in this study, designers can enhance their approaches within these disciplines. Additionally, the conceptual framework and educational methodology presented an in-depth exploration and analysis of design principles employing parametric design. This research conducts a comprehensive examination of the application of parametric design, providing insights into the development of innovative interior design methods through parametric models. It serves as an illustrative example of seamlessly integrating parametric design across diverse designs through systematic processes and methodologies. This article aims to elucidate the concepts, design processes, and techniques associated with parametric interior design. The focus extends from the initial design phase to the installation process, offering significant advantages for precision and efficiency in a wide range of design projects.

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Keywords: Factor and Elements; Parametric Design; Interior Design

Introduction

Technology is evolving rapidly in the 21st century, causing the development of tools to meet new challenging areas requiring precision and speed in the design industry. This can be observed from the application of software such as Rhinoceros 3D, Maya, and Autodesk Dynamo developed based on parametric equations to create algorithmic modeling. The word “parametric” originates from mathematics and is defined as using specific modifiable parameters or variables to obtain the result of an equation (Frazer, 2016). The application of this concept focuses on using computer algorithms to generate and optimize design. Designers often use these computer-aided tools to build models and visualize ideas (Jabi, 2013), thereby leading to the continuous development of parametric design methods. For example, the algorithm allows designers to overcome the limitations of traditional CAD (Computer-Aided Design); to be a software and 3D models by providing the opportunity to reach a complexity level and control that exceeds manual human capabilities (Tedeschi, and Wirz, 2014). Parametric modeling or parametric design involves creating digital models using predefined rules and algorithms called "parameters" (Wang, and Chen, 2022). One of these features is the 'form-finding' processes normally implemented through propagation-based systems to optimize specific design goals against a set of constraints to ensure the final form of the designed object is "found" based on constraints (Beesley, Williamson, and Woodbury, 2006). Parametric design is often defined as an arithmetic concept for generating diverse design options while aiding decision-making in the entire process (Blosiu, 1999). According to Davis, a parametric model is a set of equations that expresses a geometric model as explicit functions of several parameters. (Davis, 2013). It has also been noted that parameters and rules determine the relationship between design intent and response (Jabi, 2013). Moreover, parametric equations explicitly express quantities in terms of functions of independent variables, known as parameters (Weisstein, 2003).

Parametric design is widely known in engineering, architecture, design circles, and industry. The aspects and dimensions of architectural design considered parameters include location, orientation, shape, and solar radiation (Eltaweel, and Yuehong, 2017). Furthermore, parametric design also has a beneficial impact on the development of production technology due to the opportunity it provides for designers to create unique and different designs for production processes requiring different tools and technology to make the work visible. An example is the application of CNC machines on workpieces instead of using humans or some designs with complex shapes in the manufacturing process. The parametric method is effective in developing a series of products due to its ability to quickly generate several design schemes by creating a series of primary parameters and dynamically editable logic programs (Sun, and Huang, 2019). It is constantly evolving and currently being used in a wide range of design fields.

The concept is summarily explained as the design principles with varying proportions controlled by an algorithm or series of equations. It is also a method where a set of rules, parameters, and algorithms are defined to create adaptable and changeable designs based on certain inputs and variables. Scripting is a transformative tool for designers, enabling customization, automation, innovation, and expanded possibilities in the design process (Burry, 2011). The technology is a method to create flexible, adaptable, and responsive designs based on evolving conditions. Therefore, this research focuses on studying parametric design principles in interior design, specifically the design and installation processes, in order to create a new method considered applicable to other design works.

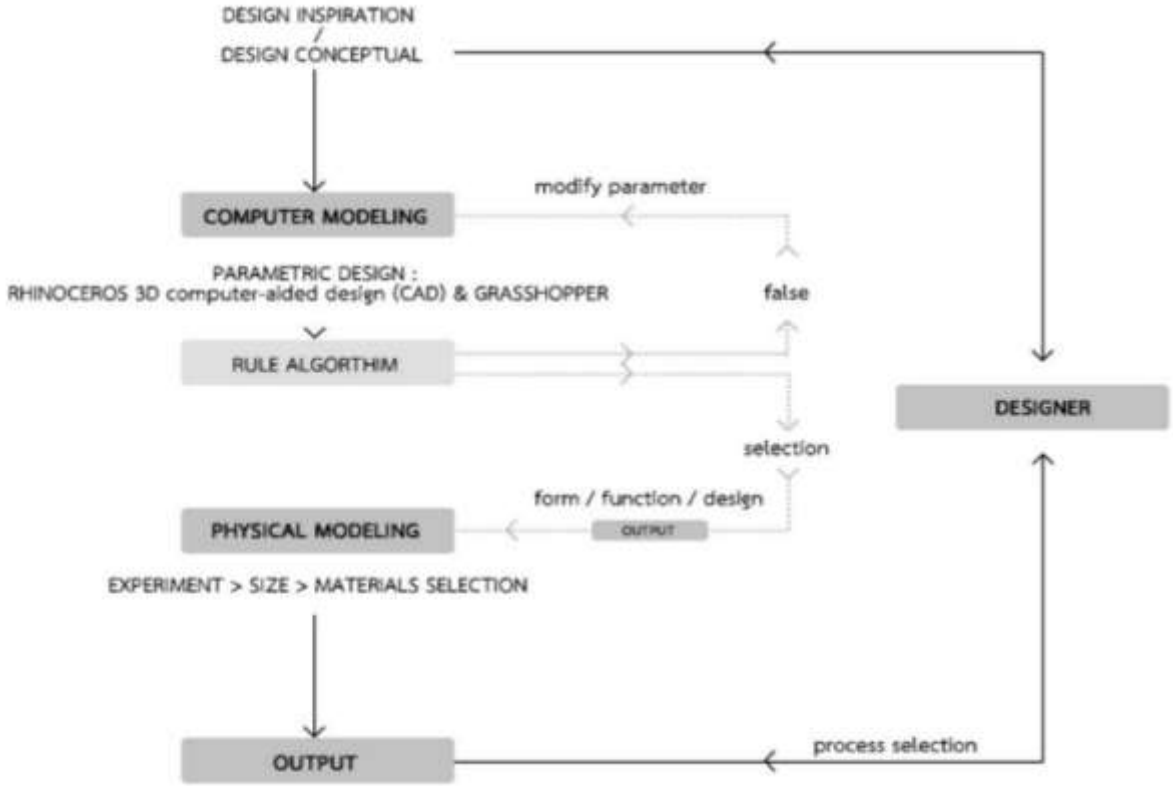

Figure 1: Parametric Design Process
Source: Authors

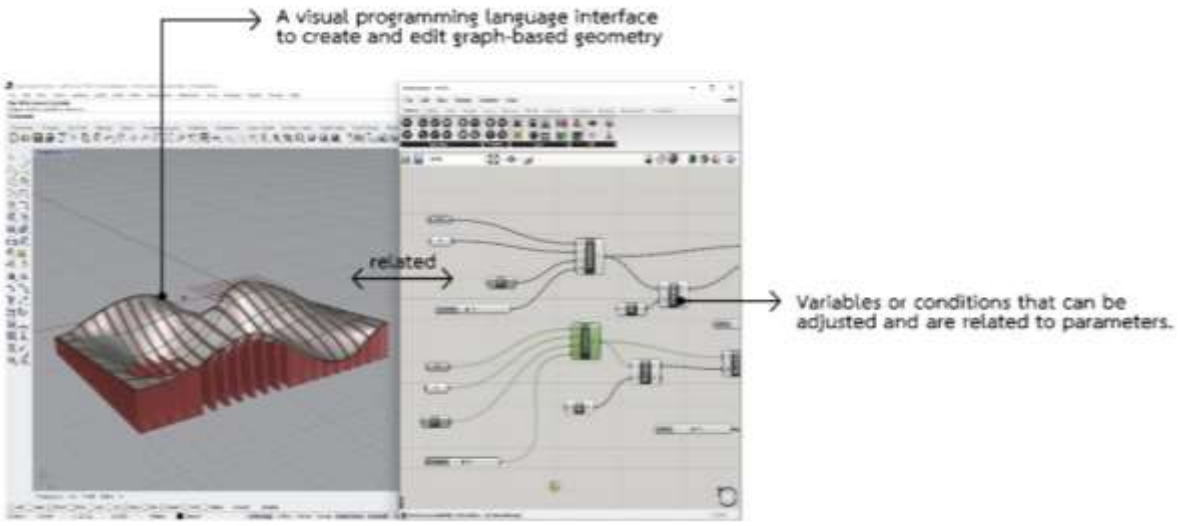

Figure 2: The Processing Screen and Script during the Design Using Parametric Method.
Source: Authors

Objectives of the Research

1. To study and analyze parametric design principles.
2. To create a new parametric method for interior design.
3. To apply the parametric of interior design and other design works

Research Methodology

This research was conducted practically in line with the combination of the objectives. The process focused on studying and using parametric methods to create design based on condition, and limitation, as well as design and installation processes to gather knowledge to influence interior design. Moreover, design equations were studied and developed through a parametric method combined with the materials used to conduct trials in order to select the most appropriate. The guidelines were based on the design process framework divided into five steps. Part 1, it was the collection of data and analysis of parametric design principles. Part 2, it was design and development with a focus on creating equations to simulate shapes using computer models. Part 3, it was the experiment process through a physical model projected to be developed into a size considered usable by humans after being confirmed successfully. Part 4, it was the application through the presentation of the design in form-finding, form-following function, material selection, and installation process. Finally, Part 5, it focused on the delivery of the new concepts in geometric design, parametric method constructs, and a script or an equation that could be used further by those interested. This part also allowed the presentation of the designs and art products in a new way.

The ultimate outcome was to produce a new design method with a script to create shapes using the parametric method for future use and application in interior design with due consideration for the proportion of human use and behavior as well as essential functions.

Previous similar research has been conducted to analyze the feasibility of parametric design and this served as a further development of the structure using practical experiments through computer and physical models to provide a deeper understanding. The intention was to ensure method application to various designs based on the respective use. The survey and data collected to be analyzed were expected to provide more clarity in the design process. Moreover, the design and development were also considered quite important due to the capability of the parametric method to simulate a three-dimensional (3D) model and the opportunity provided for the designer to adjust or modify the equations and parameters to suit the functional proportions or aesthetics. The experimentation was also highly significant to the assembly or production process by ensuring the genuine feasibility of materials and tools for the design and production work. Another valuable result expected to be produced was the scripting format and algorithm to create suitable designs predicted by designers and usable as well as to select appropriate materials and install effectively on site by the builder. The parametric design process was required to consider every step and a possible challenge to achieve appropriate results for thinking; design, and manufacturing processes.

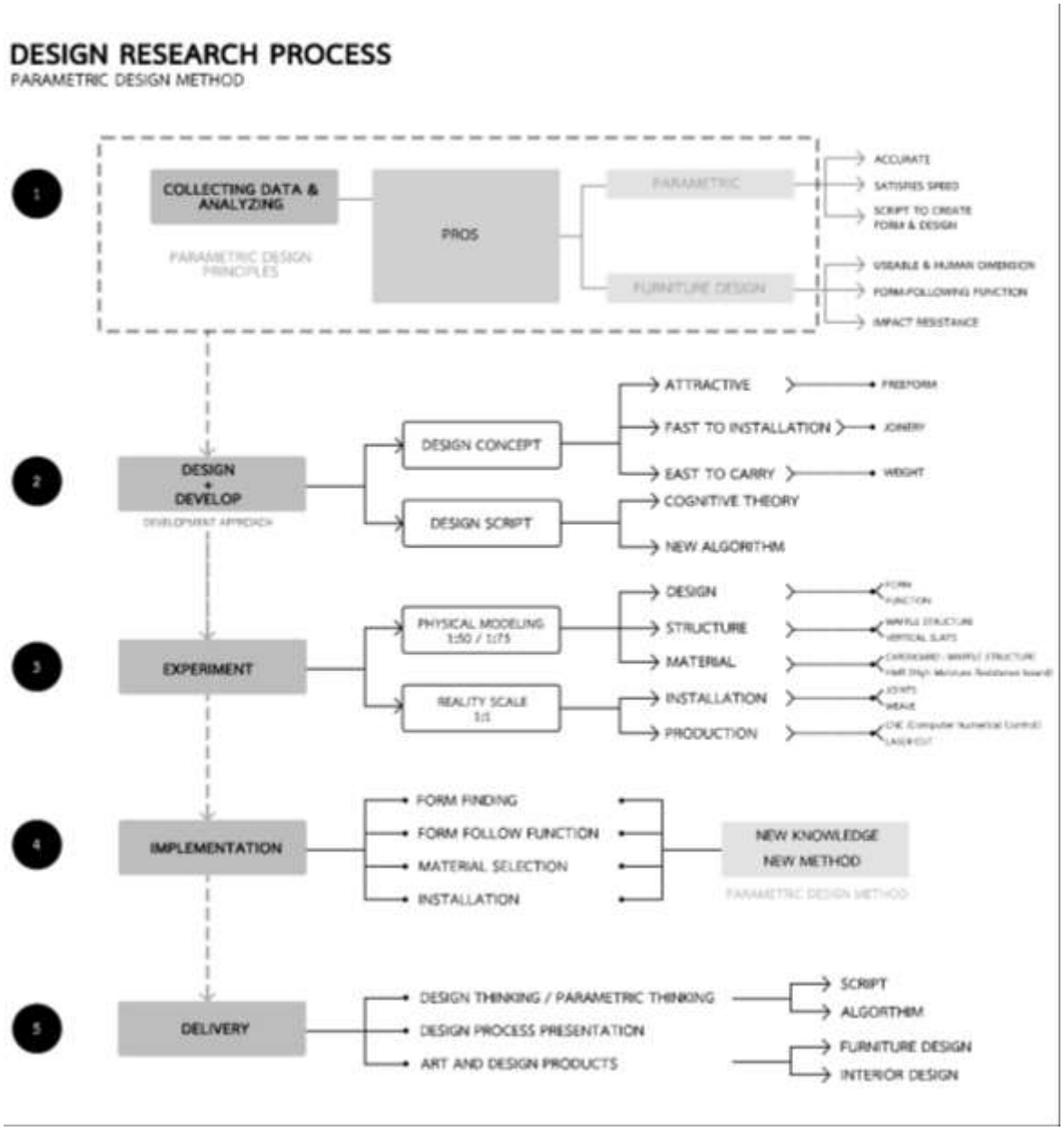

Figure 3: Design Research Process
Source: Authors

The design guidelines were expected to consider parametric principles and method as well as the different types of work. Designers were also required to be carefully note the feasibility, space, utility, time, complexity, and installation method in the manufacturing process. Moreover, real-world design problems need to be defined and parametric thinking and digital parametric design tools should be applied where is necessary (Assasi, 2019). Code and parametric equations could also be used for several applications including architectural, product, furniture, and fashion designs.

This staircase at INNSiDE Bangkok Sukhumvit as shown in Figure 4-13 was designed using a parametric design method due to its complexity, both in terms of unique design and assembly. It was designed for only two weeks because of the limited design and installation

processes. Moreover, only one designer measured the site, designed, developed, and provided the detailed drawings for cutting. The parametric method was considered suitable to calculate the details and make quick adjustments in the parameters. Furthermore, the computer was used in determining the fluidity of parametric ladder degrees. The parametric design was considered beneficial because it allowed the transfer of detailed information about the workpiece to a new method. For example, HMR wood panels were cut to order from a convenient and fast CNC machine in the production process and were used in the staircase. The steps associated with the design of a staircase include 1. measuring the area, size, structure, and different limitations, 2. creating 3D virtual models from a computer using parametric equations, 3. printing 3D physical model to understand the size and proportions, 4. calculating the fluidity of parametric ladder degrees using a computer, 5. drawing and numbering files for CNC cutting, assembly, and installation, 6. sending the file to the CNC machine for cutting, 7. determining the steps to install scaffolding for fixing panels to the main staircase and painting, and 8. delivering the work.

The results were ultimately expected to serve as a guideline to present designs, art products, and interior decorations based on new methods for future applications. The findings were also projected to be the conceptual design principle with scripting to create shapes using parametric method in order to produce a different and unique piece.

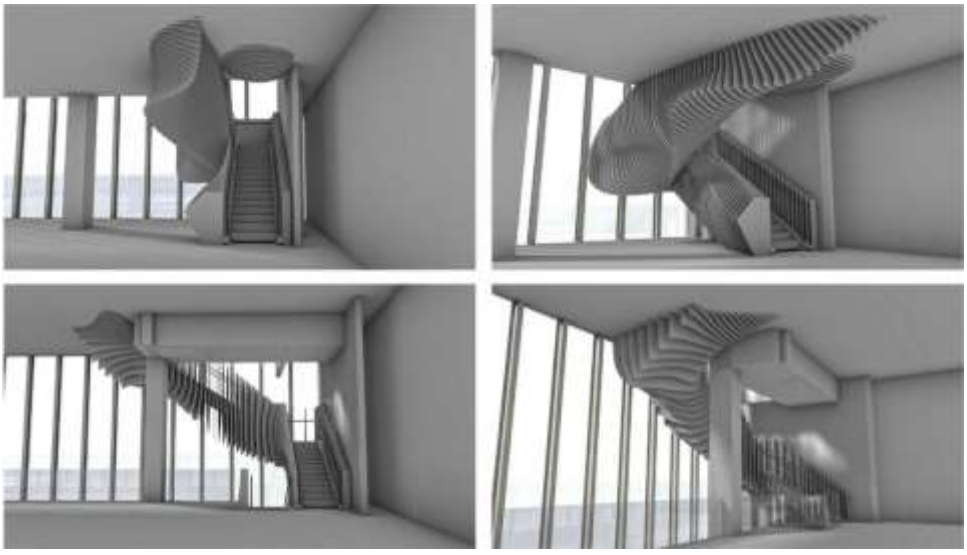

Figure 4: The Process of Creating a 3D Virtual Simulation Model of Staircase.
Source: Authors

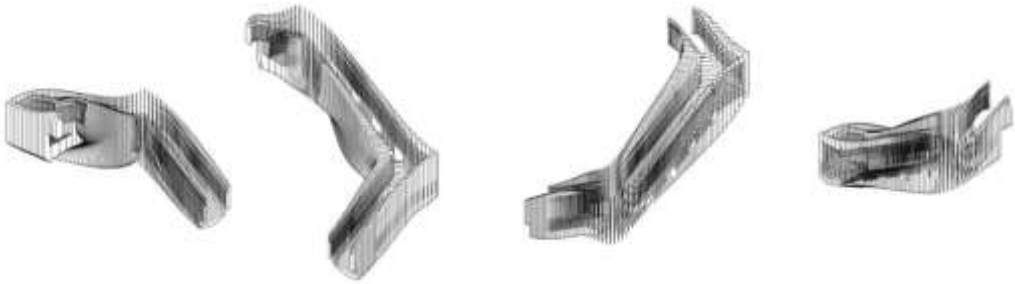

Figure 5: 3D Virtual Simulation Model of Parametric Staircase Design.
Source: Authors

Figure 6: 3D Printed Physical Model to Simulate Scale and Proportions.
Source: Authors

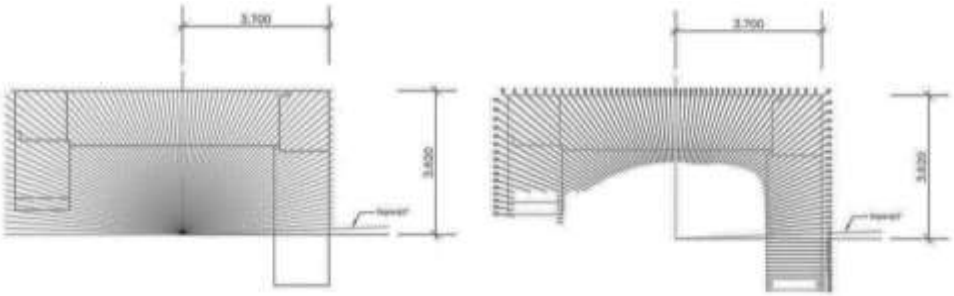

Figure 7: Computer-Aided Calculation of Parametric Stair Degree Fluidity.
Source: Authors

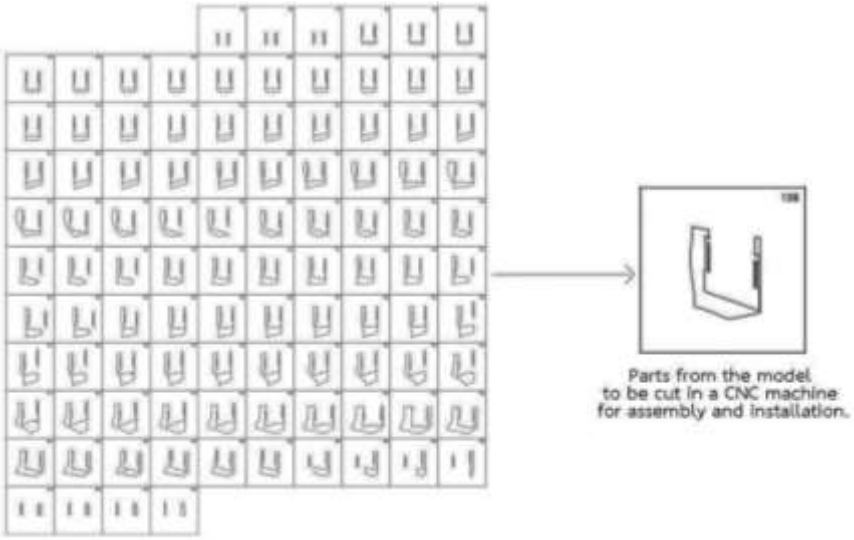

Figure 8: Drawing and Numbering to use files for CNC Cutting, Assembly, and Installation.
Source: Authors

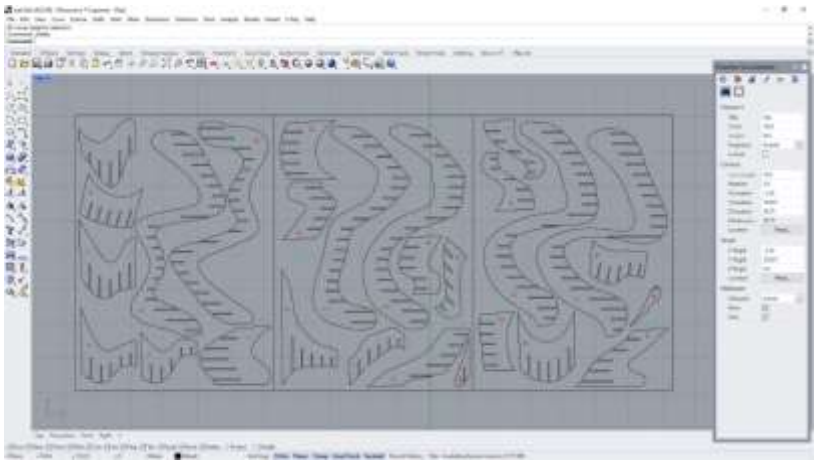

Figure 9: Example of Drawing and Numbering to send to CNC machine.
Source: Authors

Figure 10: Measuring to Check the Area and Structure before design Parametric Staircase
Source: Authors

Figure 11: Process for Installing Parametric Stair
Source: Authors

Figure 12: Final Parametric Staircase Installation.
Source: Authors

Figure 13: Final Parametric Staircase
Source: Authors

Research Results

The 1st objective is to study and analyze parametric design principles. From the research result, it was found that Parametric design is a new method that uses scripts or variables and adjusts parameters to create various shapes, which still allows the designer to act as an intermediary for controlling the design, determining the direction of the piece, and controlling the editing of equations and parameters. The designer needs to know the fundamental limitations of space or design limitations each time, the materials used in the design to know the size, weight, strength, and installation, and other essential things in the Production and installation process. Designers need to consider the product's production

process and the tools for consistent and realistic production. This process needs to be taken into account from the design process or the steps of creating computer simulation models and writing equations.

The 2nd objective is to create a new parametric method for interior design, specifically the design and installation processes. From the research result, it was found that form the initial stages of design, collecting data and discovering the features, advantages, and limitations of parametric, provided the designer has basic parametric programming skills. In addition, designers need to study the design space and the primary use of that design to know the scope and conditions for parametric design for each type of work. As for the design and development of the model, it involves experimentation where the equations for various shapes are designed, and then the production process must be taken into account, which may at least have to be tested on a small simulation model before being built on a scale for using real work. The experiment must consider the structure, materials, production, installation, And essential maintenance. As for the delivery, it was discovered that after the design process reaches the production process, a new design concept will be obtained that uses technology to help in various steps and, the subsequent discovery is design work that uses parametric concepts for various types of work.

The 3rd objective is to apply parametrics to interior design and other design works. From the research result, it was found that the results of using parametric design methods are not only novel shapes, but there are also many advantages of using technology in design, including the work being accurate as designed and reducing errors that may occur in the actual field. The design is quick and convenient for the production process, including installation, which can easily be checked with the installation manual. Therefore, the result of the objective of applying parametric to design work is the relationship from the design process to the manufacturing process and installation process.

The New Body of Knowledge

The idea from the basic parametric design was to write a command script instructing the computer to process using an algorithm or set of logic methods to obtain the results previously predicted by designers. The main advantage of this concept was its ability to design patterns considered complex for humans to process at a relatively better speed and with the possibility of adjusting the parameters or editing sets of equations while displaying the results. Another important observation was that parametric design allowed the transfer of detailed information about the workpiece to new methods such as 3D printing, Laser Cutting, and CNC (Computer et al.) considered to be convenient and fast for the production process. For example, CNC was applied on HMR wood and spray painting with more than 200 parts assembled on-site to create a parametric staircase design that perfectly matched the interior design.

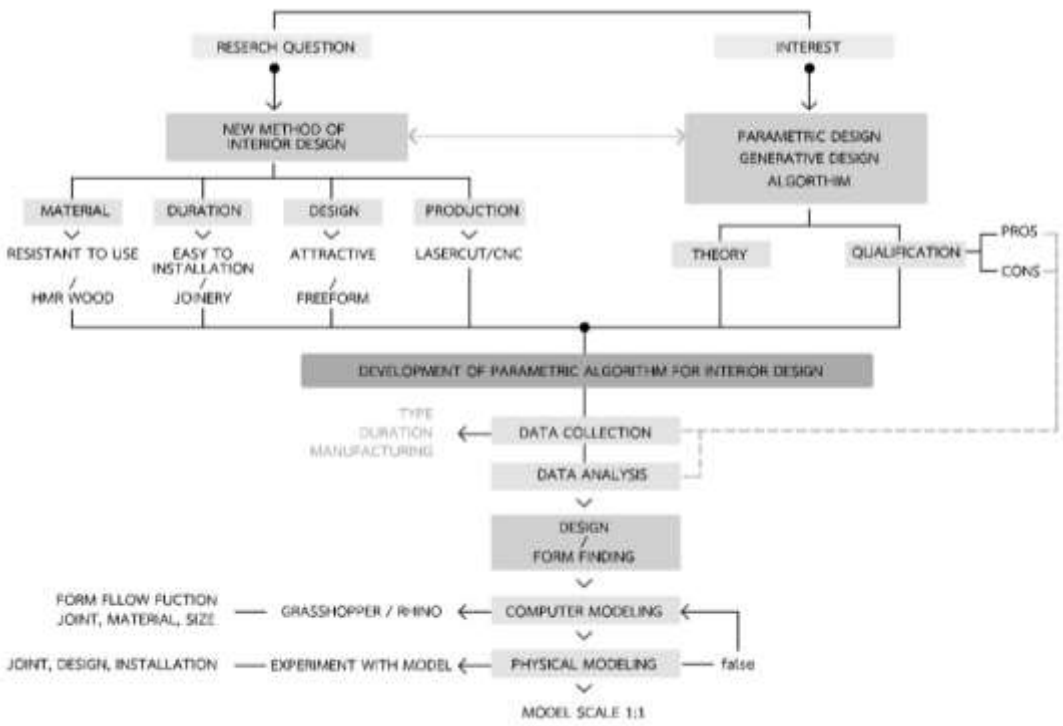

Figure 14: The Process of Research Framework including Problem Statement, Objectives, Questions, Method, and Outcomes.
Source: Authors

Discussion of Research Results

From research objective number 1, it was found that parametric design is a new design method that uses scripts or variables and adjusts parameters to create various shapes, which still has the designer as a medium for control. Design work, setting script direction, editing equations, and parameters is because of the working principles of parametric that are consistent with the concepts, theories, and research of (Wang, and Chen, 2022) that said parametric modeling or parametric design involves creating digital models using predefined rules and algorithms called "parameters" and algorithm allows designers to overcome the limitations of traditional CAD software and 3D models by providing the opportunity to reach a complexity level and control that exceeds manual human capabilities (Tedeschi, and Wirz, 2014).

From research objective number 2, it was found that parametric design and each design work have a relationship from the design process to the production process because this type of work requires variables in the equation. After all, the design process is necessary. The design's size and proportions must be calculated to make the design as close to reality as possible. This theory is consistent with Zaha Hadid's architecture, which often uses parametric modeling software to make it possible to create complex and dynamic forms, fluid shape design and parametric design tools allow these complex shapes to be optimized for structural stability and beauty preservation. Parametric principles are also used in Zaha Hadid's work on

environmental aspects such as sunlight, shade, and ventilation, which improves energy efficiency. Material calculations can optimize the use of materials. In order to maximize the project's benefits, it can reduce waste and increase structural efficiency, resulting in a more sustainable and efficient design, as well as being an outstanding and unique example.

From research objective number 3, it was found that to apply parametrics to interior design and various design works, one must understand the working principles of parametric and the processes, especially those related to production and installation. This type is quite challenging to manufacture and install. Therefore, to apply parametric work to designs that are human-use, the designer needs to understand the principles of parametric work, the manufacturing process, and installation of this research, which found that once the workpiece has been created in a computer simulation model, a miniature model must still be created before the actual installation process for accuracy and in the numbering of each workpiece in order to be installed further.

Conclusion

In conclusion, the parametric design was observed to have wide application potential and continuous development in different fields such as engineering, architecture, as well as interior and industry design. The Phenomenon was associated with the unique and different shapes offered, its application in several forms of calculations, and many possibilities in design fields. The parametric design was proposed to serve as a guideline for designs requiring uniqueness and differences in shape and design method.

This research was conducted to design stairs using parametric design with the aim of understanding its principles and process, specifically in relation to manufacturing and installation. The results showed its ability to produce designs considered too complex for humans to process as well as to display the steps in the processed design while editing parameters or sets of equations. This allowed designers to visualize the finished product and make quick changes and adjustments. Moreover, the application of only humans to design could lead to errors but the use of the parametric method in the calculation assisted in producing efficient produce results. It was also observed to be different from traditional sketching or general molding methods. Therefore, the parametric design method was confirmed to be effective for designs with humans serving as mediators to control the variables, parameters, and conditions such as time, complexity of the work, assembling, and installation to achieve appropriate results for each area.

Suggestion

From the results of the research, the researcher has the suggestions as follows:

1. Suggestions from the research can be applied to the fields of architectural design, interior design, and various design works because the results of the first research objective, it

was found that searching for working principles and origins should be studied before research. From the second objective of the research, it was found that parametric design with interior design or various design work must consider the design process until the production process. This research result can be of benefit to organizations or companies. In architectural design and interior design, organizations and companies should study the working principles of the program for design work and experiment according to the steps. From research objective 3, it was found that applying parametric to various design works can be done. However, designers need to have programming skills and be aware of the limitations of space or design work for usability before designing.

2. Suggestions for future research related to the following points:

2.1 Parametric tools and techniques can be complex, and designers must have the skills and knowledge to use the programs.

2.2 Cost and resources are necessary for parametric work because this type of work is challenging to construct, and some forms of parametric work require advanced technology for the production process, which is currently unavailable. That is very widespread. Therefore, the price and resources used are critical considerations.

2.3 Designers should consider the actual construction for each type of work as well because parametric work can be designed through computer programs, but it is still a challenge for the development of modern production tools that may require advanced technology and complicated installation

2.4 Parametric work is a work that uses mainly computer programs to process and display results in real time. Therefore, if any is combined with traditional design techniques such as hand sketch drawing, it can be challenging and impossible because the principles and mindsets are entirely different.

Recommendations were made regarding the preparation for parametric design based on the results. The design and installation processes in spaces initially planned for something other than parametric work could limit the scope and possibilities of the implementation and delivery. The time for the design and installation steps also needed to be monitored effectively because the application of parametric work in the construction industry was quite challenging. This indicated that there was a need to ensure a longer time that was available for production considering the complexity of drawing details, installing pieces, and the manufacturing process.

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