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Analytical Study of the Foundations of Design Parameters and Fractal Geometry to Develop Design Thought

Prof. Mohammad Abdullah Almandrawy

Architecture and Design College, Jazan University, KSA

ABSTRACT

When designing products, designers look to nature for inspiration, exploring non-traditional approaches to problem-solving and formal treatments as a starting point for understanding and analyzing the engineering principles that underpin certain natural formal structures. Consequently, computer programs have to be used to figure out a new way to support this, leading to the development of new design techniques that rely on computer techniques. One of the most cutting-edge modern design trends is parametric design, which is based on computer programs. This notion is seen as an introduction to a brand-new platform for showcasing original, imaginative concepts. Its traits demonstrate how using parametric design has affected the design. With the need to comprehend the applications of parametric modeling techniques in design and strive to find alternatives and unconventional solutions to design and implementation problems, these methods do not adequately assist the novice designer in dealing with contemporary aesthetic, creative, and operational variables with ease and flexibility. Thus, the goal of the research is to clarify design ideas. Utilizing the foundations of parametric design to solve design problems and codify and deconstruct complex design elements by utilizing concepts inspired by natural sources, parameters, and their many possibilities and roles in enhancing the creative and innovative aspects of design can unleash the horizons and visions of designers and help them come up with novel solutions. With the integration of some other theories that carry some principles in common with barometric design, it is a theory Some of the most significant theories include fractal geometry and gradual modulation, which are ways of generation and gradual modulation that are most similar to contemporary approaches that are consistent with natural creations, by analyzing some mathematical forms from natural sources and tracing their structural systems and how to take advantage of it to create fresh, current design solutions . In the framework of the presumption that using the principles of parametric design and shapes inspired by natural sources helps in codifying design education to reach the development of design students' thought.

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INTRODUCTION

The relationship between mathematics and design dates back thousands of years. For example, gothic churches' windows, doors, mosaics, and tiles were all designed using mathematics. Geometric shapes were vital to the designer, and it wasn't until the last century that mathematicians established an understanding of everyday phenomena like snowflakes, clouds, coasts, lightning bolts, rivers, plant patterns, and particle paths in Brownian motion. This was influenced by parametric design, which debuted in 1971 and became one of the most significant design movements of the twentieth century. [(1)] What is meant by parametric design is the adjective that refers to "parametric" through a term derived from the Greek words para, which means addition, and meta which means measurement, implying that the measurement can be added, removed, or changeable. The variable factor, or parameter, is the property of relying on a variable number. Parametric design is a variable or standard

design that is founded on engineering foundations and mathematical logic. As a result, the parametric design can be regarded as a design that can be modified. Because a parameter is a standard element or a variable number within an equation, any change in its value will have an impact on the entire equation and produce various outcomes. [2] The mathematical term for parametric design is parameters, or variables. This indicates that a set of quantities is expressed with a number of variables in a parametric equation and that the results, or set of numbers, are clearly tied to the variables through functions. Despite the vast array and diversity of contemporary parametric design concepts, it is possible for the designer to work directly with the idea or material, in contrast to the well-known traditional methods. This results in more creative and innovative outcomes as well as design solutions. [3] The use of specific parameters or variables that may be changed to control and alter the equation's output is referred to as parametric, a term that originated in the mathematical sciences. As a result, a changeable mathematical design can be used to characterize the parametric design principle. The connections between design elements seem like formulas that can be changed to produce intricate geometric forms that can be further refined. [4] Additionally, Schumacher introduced his theory of parametricism, which he named parametrimetricism. This phrase emphasizes the idea that every design element becomes parametrically applicable, adjusting to the overall design idea as well as to one another. (5) The study found that parametric design has multiple definitions. The term that has gained traction is that parametric design refers to variable design, where parameters are software elements generated by mathematical algorithms. Other definitions include normative design, standardized design, and parametric design. Using a variety of digital media and applications, parametric is built on geometric foundations and principles with mathematical logic influenced by organic shapes found in nature. Digital programs and media have been employed in the design process in a variety of ways during the past few years. Given the foregoing, it is evident that parametric design has historical roots. However, modern digital parametric techniques are brand-new approaches that emerged at the start of the twenty-first century as a result of the advancement of digital systems and their application programs, which crystallized parametric design and improved designers' capacity to address problems. Ingenuity and design. Large mathematical computations that formerly required months or even years were also made possible by these technologies. One of the issues that limits the freedom of the creative side of the design is the complexity of the shape itself. As a shape gets more complex, the calculations get more complicated, take more time and effort, and become more difficult to apply.

Parametric design as a new technology for teaching design

The parametric design approach is a novel and inventive method that involves providing numerous specifications for the products to be designed, such as dimensions, weight, height, material, and even the symbols, codes, techniques, and parameters involved in the design. This gives the designer a wide range of options from which to select in order to accomplish the design's purpose. Making changes to the design by removing, adding, or changing the parameters it contains, such as the dynamic canopy, which was created using the BIM parametric approach and whose kinetic philosophy is based on comparison with the movement of the butterfly's wings, allows the construction to be designed in the shape of hexagons, like bee habitats. You may regulate how far it spreads to cover the areas exposed to the sun's heat by adjusting its expansion or contraction. [6]

These applications function similarly to 3-D MAX, but they do so in new and enhanced ways with easier-to-understand commands. They do not use 2D elements, but 3D ones. This implies that the designer will employ prepared three-dimensional shapes and apply the aforementioned characteristics to them rather than utilizing lines, arcs, curves, etc., to create the final design. Parametric design relies heavily on these parameters, and since it may modify each one's value and create new relationships and design forms as a result, these parameters become units. As a result, one of the key tenets of parametric design is its modular aspect. [7] As a system that uses an element as a unit of measurement, it is arranged in various repeating patterns to create a wide range of designs. Therefore, parametric design is a design approach that relies on the systems of generation and modularity. It may be utilized to generate ideas since it can produce fresh, inventive, and workable design solutions. Because of its features, contemporary design is among the most straightforward approaches utilized in the design process overall and when examining design elements in particular, which are distinguished by intricate structural details. [8] This highlights the significance of parametric technology's role in generating fresh, creative solutions that support the advancement of the design process that designers rely on. Numerous tools enable parametric modeling to speed up the design process and provide designers with more leeway, freedom, and adaptability when working with blocks and intricate, organic shapes.

This allows designers to experiment with unfamiliar designs thanks to these applications. [9] Parametric design programs are new applications developed by many companies and software developers. The most important of these programs is the Rivet program, which works with an algorithmic editor, Dynamo, and the Rhino and Catia programs, which work with an algorithmic editor, Grasshopper. These programs are used as algorithmic editors. A graphical model for creating a parametric model is linked to another modeling program, such as Rhino. Parametric modeling depends on the parameters that produce the design elements. This means controlling the output and modification of the elements within the design using specific rules created by digital algorithms, so that the elements are created based on the data entered by the user. [10]

Generally speaking, parametric design is predicated on breaking down all of Euclidean geometry's pillars by breaking designs down into their component pieces. The pioneers of this trend, despite their differences and contradictions, agree on one fundamental point: parametric design is different from everything that is familiar and traditional because it relies on the algorithm system, which implies that the fundamental existential transformation that makes up the design units has taken place. [11]

There are various mathematical operations that allow the expression of variables and rules that define and clarify the relationship between the design goal and the design response, and the effect on one of these variables affects all of them [12]

In order to strengthen the interconnection of design elements within complicated settings, programming is used to achieve distinction and interconnection between design elements and components. It operates using an algorithmic framework that enables the designer to generate a wide range of complex and multifaceted solutions. Because these algorithms can solve a wide range of challenging mathematical issues, parametric design is thus primarily dependent on computational and algorithmic systems, which in turn makes it one of the most significant generative and modular design systems. We have a large study field to investigate various design solutions that create, through these variables, a sequence of dependence interactions that emerge from each other because algorithms use parameters by changing their values. [13] Lines, points, subdivisions, and particle systems are the new primitives of algorithmic systems, replacing the traditional and modern reliance on geometric shapes such as straight lines, rectangles, cubes, cylinders, pyramids, and spheroids. [14] In other words, parametric modeling is made up of components, shapes, and arrangements that are linked by variety, interconnection, flexibility, and continuity, as well as composition and complexity. As a result, we discover that free, continuous, changeable, dynamic, and constructive geometric production is an essential component of parametric modeling of natural shapes. [15] Parametric modeling is made up of components, shapes, and arrangements that are linked by variety, interconnection, flexibility, and continuity, as well as composition and complexity. As a result, we discover that free, continuous, changeable, dynamic, and constructive geometric production is an essential component of parametric modeling of natural shapes.Digital shapes can be considered those shapes that are based in their design on the use of the digital language and the computer as a basis for design. . [16]

This was followed by the spread of these shapes in various design fields. It represents a new trend that is becoming more widespread and expresses a new generation of design thought. This new thought has been reflected in various fields of design, and the reasons for the emergence of this new approach at the global level can be explained through the following points: [17]

- Continuous computer program development-
- Emergence of a new and expanding information network.
- The application of modern technology to the development of new technologies and industry systems.
- The advent of new materials was one of the grounds for attaining a favorable climate for carrying out works in digital formats.
- The acceptance, responsiveness, and absorption of digital culture by users in the spread of this method at all levels of design and execution.
- The rise of a new generation of designers who interact and stay up with this new idea.

Shape features in parametric design:

In the digital world, design concepts are frequently born out of dynamic process approaches that are made possible by the application of new technologies. Early in the kinetic design process, when modifications to the element may be made directly through the use of different materials, components, and structures, as well as by replacing the design dimensions, the shape can be viewed in the digital environment. Consequently, conventional design practices. Therefore, using parametric design enables the designer to: [18]

- Modify the design at any point to find the best answers to issues that arise, whether during the implementation or design phase.
- Making adjustments to the values of the parameters involved in the design and arriving at a new design based on these adjustments without having to repeat the steps or draw again.
- Giving the designer input that explains any issues that might come up during the design or implementation stages so that they can be fixed and solutions can be identified.
- Handling unusual shapes and incorporating them into the design
- Giving the computer software the instructions it needs to determine the different materials needed to carry out the design and execution process.

Figure (1) parametric units by simulating nature and understanding the structural systems on which the structures of shapes are based

The most significant advantages of parametric design are as follows: [19]

- The design is primarily based on fluid and curved lines that resemble fabric and are defined by softness and movement, which is what gives the design its distinct shape and draws attention.
- This form of design is distinguished by its dependence on living geometric entities rather than employing standard geometric shapes such as a cube, cylinder, pyramid, etc., among the most fundamental principles and basic priorities of parametricism (dynamism, appropriateness, and adaptation).
- It is distinguished by the ability to adjust and change at any time. When you make a change to any component of the design, it is automatically reflected in the rest of the parts, saving you time and effort in manually implementing and testing these changes.
- Parametric design allows you to identify flexible solutions to design problems within specific spaces.
- Creates the illusion of movement and space through repetition and extension.
- Provides 3D parametric modeling as opposed to standard 2D drawings.
- Capable of producing adaptable designs.
- Solid 3D models offer a variety of display options for enhanced product visibility.
- The opportunity to begin with simple designs with few details for easier integration with final applications.
- The ability to reuse current design data to build new designs, fast design transformation, and greater efficiency.

Parametric design is based on the three types of points used in the parametric model, anchored, bound and free, subject to some rules that must be followed regarding how they can be varied. Such as fixed points that cannot move, restricted points that move toward and against the center of the cell along a line, or free points to move anywhere within the boundaries of the basic unit. All points located on the outer edge of the repeating polygon are considered fixed points, and the rest are either bound or bound. Parametric transformations will begin at the same stage of the parametric model. This will help track how the parametric variations of the cell change. [20]

The first stage: The dimensions of the space and the basic and complementary design elements were assumed and determined. .

The second stage: Finding the general shape and form required for the design. One of the programs that supports parametric modeling was used, which is the Revit program, Rino, which is linked to a text algorithm program, which is HaGros Home. Through this stage, the desired shape was reached after several attempts and changes, and the production of many alternatives and design solutions.

The third stage: Determine the shape and details of the design, and suggest materials, colors, design complements, and other elements and components, taking into account the functional and aesthetic dimensions of the design.

The fourth stage: preparing the design to be implementable; Practical experience has shown that the design process using parametric techniques is flexible, accurate and logical

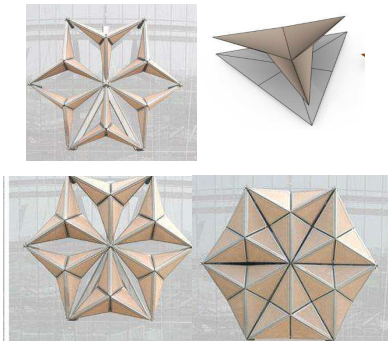

Figure (2) parametric transformation process for the hexagonal unit, where the hexagonal shape transforms into a six-pointed star during the interaction.

Fractal in nature parametric design

Fractal is a hypothesis devised by mathematicians in the late nineteenth century to track natural or human processes. As the theory developed, new discoveries arose, and fractals became an engineering learning tool. In addition, it is an experimental and unique contribution to the world of design. With modern scientific advancements in computer science and mathematics, this discipline has evolved into a tool for creating an infinite number of spectacular creative designs, leading to the discovery of a new sort of fantastic geometric composition known as fractal geometry. This unlocked pupils' creativity and imagination, and its training is considered very important in enriching and developing thinking.

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The term fractal is derived from the Latin word fractious, which means "to break or crumble," and it refers to strange clusters of lines, dots, and zigzags. The term fractal comprises two parts. The first is natural fractals, which are concerned with shapes and items connected to nature and science; and the second is mathematics, which is concerned with researching the group of fractals that are frequently It has its roots in chaos theory. Nature is man's first instructor, including its systems and relationships, the most notable of which are repeated systems. Fractal systems are commonly seen in nature in a different way, as they can be perceived in the stages of growth of organisms depending on the systems to which the nature of the creature is subject. (21)

Plants and the stages of their growth have repeating manifestations that differ from the repetition seen in human, animal, and bird development. Repetitive systems can also be found in natural elements, not only in their stages of development but also in their interactions with their surroundings, as seen in the repetition-based construction of those elements as well as the repetitions that form the basis of the surface appearance of natural elements. Nature's repetitive manifestations are not confined to what we can see with our naked eyes. Nature, with its many repeated structures, is merely a source from which the designer draws inspiration based on his perceptions, cultures and experiences. In nature, unique arrangements and approaches generate emotion and imagination in the designer, and this accounts for a significant portion of the designer's conscious orientation toward nature. .Fractal pictures of natural elements can be classified into the following categories: (22)

- Fractal appearances in natural element production.
- Fractal manifestations in surface treatment of natural components.
- Fractal manifestations in the structure and management of natural element surfaces.
- Fractal manifestations occur when natural elements are grouped together.
- Examples of fractals in natural events.
- Fractal Aspects of Physiology
- Fractal expressions in microorganisms.
- epetition is an engineering formation that results from the continual repetition of an element at various levels, sizes, and scales. Typically, the output can be separated into numerous components, each with identical construction. Nature contains a variety of recurring, form-forming patterns that are reproduced in many mathematical situations. Featuring symmetrical patterns, waves, and spirals. Shape finding: Parametric design is used to replicate models that are extremely repetitive in nature, such as the structural composition of trees, coral reefs, and human organs. (23)

Fractal geometry includes the geometry of miniatures, fragments, repeats, nature, and fractures or fractals.

Despite the several translations of the term, the majority of meanings focus on the properties and methods of creating fractal geometry shapes. Fractal geometry seeks to describe the attributes of shapes in nature; hence, it is concerned with proving the mathematical features of particular natural shapes and phenomena and attempting to explain them based on their fractal characteristics. Hence, fractal geometry is related to the world around us. [24] Mandelbrot also views fractal geometry as "a group of geometric shapes with refractions, such that any shape can be divided into parts, each of which is a reduction of the shape to many scales." Julia describes them as "complex geometric shapes resulting from the successive application of some mathematical equations to one or more points in the complex plane." It is accepted that it is "a group of points with a similar structure and usually contains some measurements that are self-similar, so any part within it is considered a miniature image of the whole group." [25] Fractals can be defined as those geometric structures in natural things, and these structures have characteristics that distinguish them from other geometric dimensions, and thus they are related to research into fractals (the small and even infinitesimal parts that make up those things in nature). They include features of the concept of infinity, and it has the property of self-similarity. [26] There are plenty of creative pieces in the world of digital design that stimulate the imagination, but few offer the complex style of fractals. To create these virtual fractals - which are characterized by an algorithm of a fundamentally mathematical nature that displays symmetry and limitations, it also has distinctive features, styles, and elements, and three other principles: sequence, repetition, and selection, in addition to the meaning of infinity resulting from the formative relationships that bear the characteristic of diversity and multiplicity. [27] Design are created by repeating certain geometric shapes indefinitely. Design are produced by successively repeating various mathematical equations at specific places in the complex plane. Fractal shapes are an experimental, expressive, and creative design component. One of its distinguishing features is that every component of it, no matter how small, resembles the overall shape. These forms are made up of pieces that share certain similarities with the overall shape. Fractal design is accomplished through mathematical calculations of visually rendered fractal objects, employing self-similar transformations that are generated and manipulated with various custom geometric properties to produce multiple variations of the shape in ever-reducing patterns. It may appear highly technical, but equations make some of the most gorgeous and inspiring works of art to come out of the digital art industry. [28] The rules that govern their formations to exist throughout the natural world. Pineapples grow according to fractal rules and snowflakes are formed in fractal shapes, the same shapes that appear in river deltas and veins inside the human body.

Figure (3) Models of the plant filled with spirals rotating at a fixed angle

Fractals are classified into several categories, which are as follows:

- The first classification separates the fractal into three major groups. Fractals are classified based on two features of recursive functions: This group has a defined geometric substitution rule for each fractal. Fractals in this group are characterized using recursive relationships for each point in space, as seen in the complicated levels: In this category, fractals are created using well-chosen processes. Random, rather than specified.
- The second classification divides fractals based on. Similarity: Self-similarity indicates that any part of a shape is identical to the whole. If we add an integral part to the fractal shape and then extend it numerous times, we will eventually get the original shape. [29]

  An example of an equilateral triangle that is divided to form four equilateral triangles within the original geometry. By repeating this system, we get a fractal sequence, and the self-similarity becomes obvious. Every part of the fractal system is identical to the original shape in the series. It's divided. Self-similarity is classified into three groups as follows:

- Apparent self-similarity: It is a loose pattern of self-similarity. The fractals appear somewhat identical (but not completely apparent self-similarity on miniature versions of the whole) at different magnification scales. The fractals contain the original fractal but with distorted shapes, which is a type of Fractals depend on the use of recursive relationships, so they have apparent self-similarity but not identical self-similarity. [30]
- Statistical self-similarity: It is one of the weakest types of self-similarity, as fractals appear to have constant numerical or statistical measurements at different scales of magnification. Statistical self-

similarity: It is one of the weakest types of self-similarity, as fractals appear to have constant numerical or statistical measurements at different scales of magnification. (31)

Regular fractal: It is a regular fractal and is characterized by the self-similarity property discussed previously, meaning that some part of the shape Ideally, a fractal resembles a complete shape, and this type actually represents a structure of what we find in nature (mountains, rivers, etc.) Or in science (polymers, ice, etc.), and the closest example of this type is the two-dimensional triangular mesh (Sierbinski carpet). It is a well-defined fractal, starting with an equilateral triangle, then three triangles side by side, then repeating the fractal, and so on. (32)

An example of this is the well-known fractal system (Koch's snowflake), which consists of large triangles with small triangles overlapping on its sides, and the sequence continues. The farther away we are from the triangle, the smaller the examples, etc. (33)

- Irregular fractal: "It is an irregular (random) fractal that is characterized by statistical similarity, meaning that some part of the shape is statistically similar to the shape itself. (34)

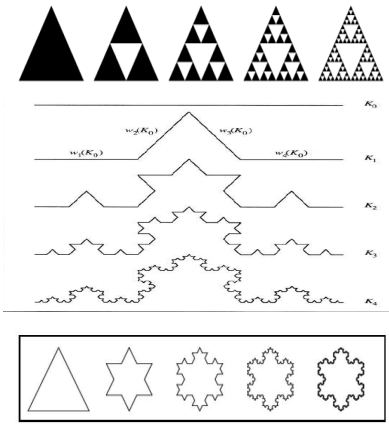

Figure 5 The end points of the generated line segments are part of the final curve

As shown above, fractal design plays a vital role in teaching product design, particularly in developing curves, forms, and complex patterns. Fractals are self-similar patterns that recur at various scales. They can be found in nature, art, and mathematics. Fractal geometry can be utilized in product design to generate organic structures that are both visually appealing and useful. Fractals can also result in more efficient designs because they allow for the creation of complex structures with fewer pieces. Fractal geometry is an area of mathematics concerned with the study of complex patterns and structures that repeat themselves at various levels.

Table (1) Combining the principles of parametric design and fractal geometry

The face of comparison	Parametric design	Fractal geometry
important principles	• Dynamism, suitability, and adaptation, • It relies on flowing and curved lines that resemble • All of its elements are interconnected in a smooth, soft and harmonious way with each other despite their different shapes • The basic concept is based on parametric modeling, data, variables and their relationship to other elements	They are geometric elements that are divided into parts, each part of which is similar in shape to the larger part from which it is derived, which is known as self-similarity resulting from repetition. Every important part is small, so in its form it resembles the larger part. They are complex shapes in mathematics that are built by simple repetition of shapes whose area is reduced. Each time it is repeated, it is usually interested in studying the structures composed of molecules and patterns that exist in nature
Students began to think about design problems in different ways.	In this study, students solve a typical design problem using applications that focus on parametric dependencies and directing and constructing design ideas that achieve functional values. Opening up vast and diverse horizons of design, thus enhancing the designer's creativity in producing thousands of unconventional designs that he could not. In the past it seemed unrealistic and unattainable	Characterized by an algorithm of a fundamentally mathematical nature that displays symmetry, restrictions, sequence, repetition and choice, in addition to the meaning of infinity resulting from plastic relationships that carry the character of diversity and multiple possibilities to break out of familiar traditional frameworks.

The difference between traditional, parametric and fractal design	Use of scripting to define and document the design concept, which leads to flexibility and ease of modification, change, and generation of complex and unusual shapes, and thus greatly enhances the creative aspect of the design process. Using parametric algorithms to create implementation files, the design ideas were designed and implemented	The ability to modify and manipulate design ideas based on instructions and their dependencies. From parts and miniatures, fragments or fragments, the geometry of repetitions, the geometry of nature, and the geometry of fractions or fractals. The flexible organizational, morphological and dynamic behavior of the thought-provoking model has been simulated. Organic designs are created that are full of curves and contain harmonious, flowing relationships, compositions and lines.
Model transformation rules	The great ability to change, modify and develop design vocabulary and elements Diversity in providing solutions: The parametric concept demonstrated that there are flexible solutions to design problems in any design and in various environments. Create blocks and shapes using simple units. Giving the illusion of movement and expansion as a result of repetition and extension. Fluidity and achieving aesthetic values. The possibility of achieving diversity with harmony and rhythm using unity, which makes it apply design standards in an integrated manner.	The ability to develop and change to meet standards on an ongoing basis. - The ability to make modifications to part of the design and then automatically apply it to the rest of the design. Ease of implementation and manufacturing due to the use of repetitive units. The possibility of adding a fourth dimension (movement) by controlling the composition. The possibility of compatibility of the design with the required function.
Preparing for implementation:	Parametric modeling provides multiple possibilities and characteristics to produce diverse and multiple design solutions. Algorithms are used to generate and produce unconventional and unusual shapes, and new and innovative design relationships were explored by designers based on computer simulation and creating a model of a virtual digital environment Experience showed that the mechanism of parametric modeling depends on Algorithmic relationships and parametric links between design elements and components,	It contributes to highlighting the aesthetic aspects of mathematics. This is because fractals provide us with shapes that have great aesthetic value and are directly related to how the world around us is organized. Fractals can be defined mathematically as "sequential functions of real variables, but they are not differentiable at any point".
Possibility of change after design:	- The most important principles of parametrics are searching for nature's methods in how to build and construct, achieving complexity, interconnection and overlapping of components, and working to transfer these methods to design with the aim of adding a little systematic complexity in building the form.	- These are special mathematical groups of numbers that show similarity through an integrated set of gradations, meaning that they appear similar, no matter how large or small
Inspiration is the security of nature	The relying on one of the parametric design tools in constructing the form, which imitates in its formal behavior the behavior of nature in producing shapes.	- Fratical geometry in nature: a theory developed by mathematicians to codify some natural phenomena. With the development of this theory, molecular

	Algorithms for shaping organic natural phenomena illustrate inorganic natural phenomena that mimic natural forces. The formal results of parametricism resemble in their form the natural organic and inorganic phenomena that resulted from the processes of self-organization and development of the elements. This is in contrast to the formal results of previous design movements, as parametricism often gives formations that are similar in form to natural formations.	geometry became an experimental approach and an expressive design direction. One of the most attractive things about fractals is their presence everywhere in nature.
Intellectual development of students	Through this way of thinking, it can be said that design results from the graphical and textual editing processes of parameters that the designer controls during the initial stages of work, and it is the designer who decides what parameters should be used - when and how - by following certain main steps Relying on design programs alone makes the designer lose his manual innovative ability Parametric design is compatible with modern designs while only being compatible to a very limited extent with older and popular models and legacies. -It requires a high cost in implementation due to its innovation and use of automatic cutting technology and the use of many materials. Some non-specialists look at it with a boring, repetitive look. This shift in design thinking and creativity allows for spaces that accommodate change and diversity without defining specific functions. In addition, these designs can provide unexpected events in relation to the overall design framework	-The lack of interest from many designers due to the fear of change and the necessity of training and teaching new programs such as Maya, Revit, Rhino, and Grasshopper. It requires high skill in using custom programs. - It can be built through scripting in interactive computer environments that are similar in nature to the laws of nature, affecting the entire formation, creating a kind of intelligent differentiation in the external form, enriching the internal formation, and achieving interconnection with the outside. Difficulty in dealing with specialized programs for those who do not have a mathematical background and experience in the fields of computer design - On geometric foundations and concepts with mathematical logic, which can be found in nature in different scales and materials.

Applied study

Proposed study methodology:

The study focused on analyzing the sources of parametric and fractal design in terms of their participation in terms of inspiration from nature and their submission to mathematical laws, and they are diverse and compatible with the methodology and objectives of the study. According to the concept of parametric design and using parametric programs and techniques, the design ideas of these works are distinguished by being inspired by organic elements and shapes found in nature. The goal of choosing these models is to know the extent of the relationship between the sequence of presenting ideas to second-level students and students of the Department of Applied Arts at the College of Design and Architecture as prominent reference models in this field and to benefit from studying these samples in the proposed applied model for design studio topics in a way that enables students to employ skills. Early in the studio experience and expand their understanding and communication around design issues. The students were divided into two groups of fifteen students each. The studio content was organized into five stages linked to each other. To work on acquiring and integrating parametric design knowledge and using it as a basis for creating proposed designs. The studio is built on students exploring appropriate design methods and tools. The proposed program was divided into several stages, as follows:

The first stage:
This phase involves collecting and understanding design data, guiding the design rules, and providing the students with a description based on the dependencies and interrelationships of the relevant information. It helps students understand the influences and variables on design strategy.

- Design studios are an essential learning experience for students that feeds into their learning outcomes. The studios go beyond the application of knowledge within a studio context and provide training in design skills, software, and other technical topics, enhancing student contribution to construction processes based on parametric design creation.
- The design studio focuses on integrating the learning experience from the beginning by focusing on the basics that create the design.
- The goal of this "parametric design" is to allow students to understand the impact of each step and variable on the design and track their impact on the project.
- Students develop and communicate their understanding of design standards by utilizing training within a design studio environment. In order to build a design philosophy around parametric relationships, students used digital tools that allowed them to create and express their designs. Using these tools creatively in design.

The second stage:
This phase focuses on analyzing parametric concepts and acquiring skills that allow for rule-based design. During studio time spent creating 3D models, parametric jobs require a different understanding of the concepts and design methods. Establishing rules and dependencies, which then create the design, engages students in higher-level problem breakdown and modeling of complex shapes that may result from non-traditional design data, with students using their parametric and rule-based design analyses from the first component and then examining the use of Software operation, rule creation, and parametric design are generated during this phase. After three weeks of training on interactive digital media, students reach an advanced level of skills that enable them to use parametric software as a tool for analysis and create their own designs.

The third stage:
The emphasis is placed on the creation, ideation, and communication of design proposals. Using the data of the first component and the skills of the second component, students then begin to create and visualize their designs in 3D forms that create spatial expressions of their findings and explorations. Given the focus on concepts, the studio was particularly interested in describing the design model by creating concept dependencies, which define the relationship of data to design expressions. With the use of the parametric viewer, it was easy to create design entities and connect these solids and spaces. This method made it easy to learn about design and explore alternatives by manipulating instructions, variables, and rules. This stage lasts for four weeks.

The fourth stage:
In this phase, students merge their individual designs and high-level dependencies into larger cluster files. This synthesis creates a complex and interconnected composite description, but the content and tool allow seamless communication with larger users using description rules and instructions.

This phase creates a co-authored design for all participants and allows students to study and understand the complexity and interrelationships of the design that they would normally not be able to grasp immediately. Changing one variable alters the entire design. Therefore, participants understand the complex dependencies that a single variable has on the overall design and can have an impact on the design. This phase lasts two weeks.

The five stage:
Students demonstrate the structure, for example, of a self-opening umbrella that interacts with the surrounding environment. In this phase of the studio, students provide in-depth sets of complex rules and dependencies that ultimately achieve the desired design. So that each student contributes by submitting a variety of design proposals. After that, the student will have reached a high level of experience and ability to use digital parametric tools as part of developing his idea in the design studio and will have used parametric knowledge that leads to generating thinking, learning, and creativity within parametric design, which requires a new and deeper understanding of the overall design goal and its expected results. This differs from traditional design methods, which deal with one problem at a time, regardless of its dependencies. This phase lasts three weeks.

This studio combines parametric methodologies in creating a product design and then introduces an exercise based on fractal geometry so that students gain skills and training within their studio and apply this knowledge to their designs, taking full advantage of the digital media component that addresses parametric modeling with fractal geometry in this This stage of the process is where variations in the parametric model are explored, both in the cell and

the pattern. By imitating existing traditional patterns, new patterns can be created from scratch. Since our parametric model is able to do both, the transformation will be used to conduct an exploratory study of geometric transformations of cells and their effects on new patterns.

Initially, when studying the difference between parametric design and traditional design, we find that there are many differences between design using parametric modeling and fractal engineering and design using the traditional method. The most important of these differences is the use of scripting to define and document the design concept, which leads to flexibility and ease of modification and change, and the generation of complex and non-complex shapes. Familiar, which enhances the creative side of the design process. Compared to traditional design methods, the beginning of the design is with pen and paper to create the initial idea (sketch), relying on many elements, including the visual and cognitive stock of creating details, using multiple media, including what is manual for the designer, then moving on to back to advanced stages of refinement and modification, and with the development of various digital tools, layered design has become popular, allowing the designer to deal with more complex problems, with each different layer playing an equally important role. The most complex design problems were divided into separate issues and dealt with one by one.

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Parametric modeling is a method of finding and discovering shapes and creating a geometric representation of the design to form its fixed and variable attributes. The variable attributes represent parameters that can be modified, copied, and changed without deleting or reshaping the elements and components of the design. Using the process of parametric modeling to determine the geometric and formal attributes of the design facilitates the process of changing and developing the design. Through the ability to adapt to user conditions and parametric modeling, design costs can be rationalized, and better design alternatives and solutions can be developed.

Based on the fact that parameters (variables) are programming spaces that contain one or more algorithms and mathematical operations, these concepts carry many methods of description and definition due to the overlap of these concepts with concepts related to contemporary digital trends and advanced computer programs. In this methodology, all elements of the parametric design and its components are interconnected in a flexible and fluid manner, and the effect on one of them affects all, and this is known as the elastic effect, as it creates an ontological shift in understanding the basic elements and components of the design.

Parametric Design Studio examples illustrate how design processes can lead to design expressions that differ from traditional approaches to design due to the different nature of creating design ideas.

Most important results

Through what was covered in the theoretical framework, it is possible to arrive at some concepts and principles that characterize parametric design:

- Parametric design is a new approach to design; through it, the designer can be more interactive with the design idea and its stages of development and make analyses, modifications, and changes by integrating the design requirements into parameters within the stages of formulating the idea in an integrated manner. Here, the designer is more capable of creativity, generating and flowing ideas, and finding solutions and design alternatives.
- Parametric design provides flexible solutions to design problems using shapes inspired by nature, which leads to the introduction of new models. The characteristics of the parametric method are characterized by the generative approach of organic, dynamic, complex shapes inspired by nature, which appear as a continuous and changing spread similar to a flock of birds.

- Parametric modeling techniques are an important input for providing creative and conceptual solutions and unleashing the thoughts and visions of designers. This trend did not crystallize and flourish more except with the emergence of advanced computer technologies in the 21st century by a group of prominent pioneers in this field.
- Parametric design relies on the new design methodology by entering all information and design parameters as parameters into the design program. Through algorithms managed by digital programming, all possible design possibilities are produced based on the information and data entered. This methodology is more effective if it is linked with manufacturing and implementation techniques.
- Parametric modeling is one of the processes through which a design problem can be described and analyzed based on a set of variables specific to this problem, and when the value of these variables (parameters) is changed, many alternatives and solutions to the design problem are produced.
- Algorithms and parametric links between design elements and components, through which unlimited options of parametric models and design alternatives can be created. Which work to enhance the creative aspect of design and help to draw inspiration from organic shapes in nature and benefit from them in contemporary designs.
- Parametric design has distinctive characteristics through its reliance on units that make it flexible and diverse, and any modification to part of the design is modified to the rest of the entire design automatically, which saves effort and time. It is also unique in its smooth dealing with complex blocks and highly complex building systems to employ these concepts. It has dazzling designs of great complexity that are in keeping with the times, and it also has the advantage of having a dynamic design.
- Parametric design has an important role in performance design and modeling applications and has the ability to represent and model complex geometric shapes.
- The possibility of using parametric design at different stages of the design process during design and construction, creating and discovering multiple design alternatives, flexibility, and adaptability.
- Parametric design opens wide and diverse horizons in design and enhances the creativity of designers in producing thousands of designs. It also allows the designer to explore unconventional shapes that he could not have imagined on his own and that, in the past, seemed unrealistic.
- The use of computer programs in parametric design helped designers provide us with wonderful and innovative designs full of dynamism and movement, through which they were able to express their ideas and embody them in attractive designs that are characterized by flexibility and flow and achieve aesthetic values.
- Parametric design represents the means that strongly influence the emergence of new methods of digital design in the design of contemporary products. Parametric design not only affects the formal characteristics of designs, but it also produces a new paradigm for design thought.
- Parametric design expresses a technical development in the form and style of design. It achieves flexibility and flow, as well as aesthetic and functional values, in an elaborate manner. Flexibility and quality in conducting the design process when a modification is made to part of the design and then applied automatically to the rest of the design.
- The necessity of applying modern design programs as an essential part of the educational regulations system in specialized colleges such as engineering and applied arts so that students keep pace with modern technology and labor market requirements.
- Parametric design is based on geometric foundations and concepts with mathematical logic inspired by nature. It also provided a modern, malleable, and flexible tool that enabled the designer to deal with objects, especially those with complex structures, whose structure was previously impossible to understand and trace.
- Parametric design is the new technology introduced in computer-aided design programs through Maya and Rhino programs, and it works by including many design parameters, from length, width, height, weight, material, and even the symbols and codes used, for each element of the design.
- Advanced digital technologies and programs have become a reality, and their spread has expanded in recent years. Therefore, the necessity of teaching digital technologies in the field of

design, especially parametric modeling programs in design education, and developing cognitive processes in design should be emphasized.

- The term parametric design has many meanings. There are those who define it as parametric design, design modeling, standard or normative design, that is, it can be defined as "variable design." Parametric design is also based on engineering foundations and concepts with mathematical logic inspired by nature. It also provided a tool. Modern, malleable, and flexible, it enabled the designer to deal with models, especially those with complex structures, whose structure was previously impossible to understand and trace.
- Parametric design is a new and important style that emerged after modernity. It takes care of finding an appropriate size for various fields and relies on computer programs that allow modifications in any part of the design to appear automatically in the rest of the parts, reducing the significant time and effort required to implement and experiment with these modifications manually.
- Fractal geometry is defined as a group of points whose divided dimensions are integrated, or any group with a similar structure. Fractals are considered a group with infinitely complex structures and usually contain some similar measurements. Any part they contain within them is considered a miniature image of the entire group.
- The outputs of parametric design vary from a wide range of parameters related to the physical, structural, and structural requirements, loads, and other requirements that the designer looks to include as design goals from alternatives and from the design structure of the product that is compatible with its functions.
- Parametric images in nature are also evident in formations of a repetitive nature or with a complex repetitive pattern, which are known as molecular formations with a repetitive geometric character that are easy to analyze into their primary formal components.
- Parametric design differs from traditional design in that it is a procedure for a specific task through several specific steps, the most important of which is parametric scripting to define and document the design concept. By dealing with an organized network of texts, the main data model, which is in the form of programmed code, can provide great flexibility, efficiency, and coordination ability, especially in the context of complex design problems that extend to implementation, and in complex and large projects, flexible parameters can respond to constantly growing and evolving variables in a flexible, easier, and faster manner.
- It is not suitable for all functional purposes, as the use of parametric design suggests movement and activity in the place, which may not be appropriate for some spaces, such as sleeping and hospital spaces, as it may not achieve comfort and visual calm if used in an exaggerated manner.

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