



Proposed Digital System to Measure Innovation Levels of Creativity Inside Frontier Architecture Design

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Abstract

This paper aims to investigate the extent to which parametric design tools contribute to increasing innovation in interior furniture design. The research methodology measures creativity criteria based on the theoretical background and previous studies in this field. We use Statistical Package for the Social Sciences (SPSS) software with samples (40 professionals) of architects, designers and specialists to analyze the survey outcomes. Our methodology consists of three stages. In the first stage, a questionnaire and survey on the main concepts, familiarity and applications of parametric design in furniture and interior design is done. Then, the stage of measuring the success and extent of fulfillment of parametric design characteristics criteria and indices in the modern parametric furniture. Finally, comparing the levels of creativity in some proposed types of traditional and parametric furniture (i.e., chairs and tables) in furniture interior design. The results show that; adoption of parametric design in interior furniture achieves good flexibility and streamlining. Also, it fulfills a good and perfect aesthetic, functional and innovative value, where the highest innovation index of 53% (good) is achieved. For parametric chairs the highest innovation index percentage is 38% (creative), while for traditional chairs is 41% (normal). The parametric tables highest percentage is 40% (creative), and for traditional tables is 57% (normal), The Validity and Reliability of the questionnaire was carried out before its completion, and the accuracy and stability of all survey and questionnaire axes were confirmed by using the SPSS approved statistical analysis program. Reliability Statistics for Part One (Survey) was 0.808, Part Two (Measurement) was 0.85, the Part Three (Comparison) was 0.891 It is good acceptable rate for testing the validity and reliability of the Survey, finally we recommend and suggest applying in a larger scale the applied research study on all parametric interior design elements and not just some types of furniture and examining the psychological impact on the user behavior.

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1. INTRODUCTION

The design process greatly and strongly affects human feelings and their psychological state. For psychological comfort, it is very important to make diversity, creativity, and renewal in all external or internal design elements. Remarkably, the parametric architecture concept may be known to all professionals in the architectural or design activities. The parametric design is the establishment of a parametric model using the computer and by referring to the primary elements that formed each other through a number of clearly defined variables and constraints. Therefore, the parametric model can be changed or modified and re-established within the limits of compliance with the predefined conditions. Also, it can be updated by changing the parameters values while maintaining the relationships between its constituent elements. Continuous development and renewal of specialized engineering parametric design software enables users and designers to work with the parameters of new standard geometric shapes. During the design process, the parametric design passes through important stages, starting from developing ideas about the external construction of the building, as well as the internal design stage. There is much modern software which enabled architects to ease the formation and configuration of furniture. Also, it has provided a range of ideas that were not possible before and enabled mathematicians to reach and understand non-traditional shapes. These shapes have different characteristics from the traditional shapes and form the parametric topology.

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2. RESEARCH PROBLEM

The research problem appears by answering the following question: Does the trend of parametric digital architecture affect the generation and production of new and innovative ideas in the field of furniture and interior design? To what extent is this achieved successfully and flexibly? This is in the absence of clear boundaries and a typical standard methodology about the various and multiple aspects of parametric modeling adopted by digital architecture in interior design and furniture.

3. RESEARCH HYPOTHESIS

The research assumes that following and adopting the parametric digital architecture in the interior design and furniture leads to the generation and the creation of new and diverse design ideas and methods in the field of the interior design and furniture.

4. RESEARCH OBJECTIVES

4.1. The main objective

To investigate the influence of parametric design tools on increasing creativity of furniture designers.

4.2. sub-objectives

1. Formulating the proposed numerical methodology for measuring innovation levels in parametric architecture in interior design.
2. Monitoring the most important applications of parametric architecture in the field of interior design, whether that includes interior wall cladding or interior design of the space with all its elements, including interior and exterior furniture, and what are the latest used computer programs.
3. Monitoring the cultural and cognitive returns of specialists and users of internal parametric architecture concepts in design and their pros and cons and their impact on the beneficiaries.

5. METHODOLOGY

A deep analysis has been done through available literature, research followed the descriptive analytical approach in addition to the questionnaire approach by surveying the opinions of specialists and reaching their knowledge about this modern concept and clarifying its most prominent pros, cons and characteristics, The methodology of this paper was first to conduct a questionnaire about the basic concepts of parametric architecture in the interior design of furniture analysis, secondly to conduct a protocol to find criteria for creativity to be able to create a measurement scale to evaluate the creativity of parametric design furniture, and in the third step a comparative study was conducted between the furniture that was designed by Parametric design tools versus furniture that are designed with a geometrical model-based design as there is no better way than to always compare to understand and clarify the differences between parametric and traditional design. A survey was prepared and distributed to 40 architects with experience in furniture design to assess the level of creativity for each furniture, which included three categories (chair, table). Participants were 27 males and 13 females. Using the SPSS statistical analysis program to analyze the data generated from the survey.

6. THEORETICAL BACKGROUND OF THE RESEARCH

6.1. Definition of parametric digital architecture:

It is the architecture that uses information technologies to control its parts and in the operation of its various functions and it also converges with the concept of smart architecture. It can also be defined as the architecture that results due to the dependence on information systems in various life activities, which may change in its various aspects, whether in shape or in function or in construction. This is the new and independent aspect of informational digital architecture, as it was able to integrate all the architectural elements and transform them into determinants or logarithmic elements that are easy to transform and form. This helped to strengthen the relationships between the components and shapes of the project and the building relationship with what surrounds it away from the traditional classical engineering models such as the cube, cylinder, pyramid, ball and other forms on which the traditional architectural formation relied, while parametric architecture was distinguished by the presence of harmony, flow and strong modern uncommon overlap between the elements and components of its buildings [1].

6.2. Principles of digital architecture

The new forms in contemporary digital architecture appear to be moving, unstable, broken, fluid, bending, with morphological and topographic characteristics, whose space overlaps each other and does not have specific masses, and if any, their materiality is reduced to turn into high transparency, rejecting traditional principles such as designing classical shapes with inflexible structures and such as repetition or symmetry in shapes. Parametric architecture calls for inspiration from natural organic shapes inspired by natural shapes such as water, clouds, plants, animals, space, and the universe [2].

6.3. Parametric model

The term parameter is used in a variety of specialties such as mathematics and design, as the parameter represents a measurable factor that defines the system or determine its limits. The parametric model can be defined as a geometric representation of the design that contains fixed and variable properties as the variable characteristics represent the parameters that are modified without deleting and redrawing any of its geometrical components. Using parametric models makes changes in the design entity easier and could adapt to the user and the site. Parametric modeling has enabled the capture and rationalization of the design intent and the design of buildings and the development of building solutions using a rational, prior, and integral rationale. Multiple design alternatives can be generated and evaluated according to various criteria and choose the best solution. There are many tools available that are designed to create parametric architectural models [3].

6.4. Significance of the parametric model

The parametric model is the backbone of the parametric design process, as the process of creating the parametric model is considered as an important stage in the digital design process in general and in the parametric design process in particular. The parametric model allows the designer to accomplish changes and re-geometry without erasing and re-drawing, as well as helping in exploring design alternatives, as it has a level of flexibility that allows it to be constantly updated when adding, changing or deleting one of the components within the parametric model structure. Parametric modeling systems became standard tools to assist in the design process in the academic field and in real practice. In the beginning, the parametric modeling systems were employed in the aviation industry and then it made its way into the architectural field due to its ability to describe and produce multiple alternatives and cases with a single parametric model diagram capable of interacting and responding to the variables imposed by the designed environment or according to the designer's desire as it is characterized by an expansion in exploring the design in the early stages of the design process. It also provides flexibility to design parts and assemblies of a complex nature. It provides reliable systems for testing various design situations resulting from a single model. Studies confirm that the process of creating the parametric model represents an important stage in the parametric design process. At this stage the designers put the variables and the flow of digital data and they adjust the parameters values and refine the rules accordingly and instead of the traditional methods of molding and shaping of the same entity. The designing of a set of generative rules and their logical relationship are the main focus of design thinking. In this way, more alternative solutions can be explored by changing the parameters of logical relationships [4].

6.5. Definition of parametric design

Parametric design is the setting up of a parametric model using the computer, whereby the elementary elements that form the model together are referred to using a number of clearly defined variables and constraints. Thus, the completed parametric model can be changed, modified, and regenerated within the limits of conforming to the predetermined conditions. The parametric model can be updated by making a change in parameter values while preserving the relationships between its component elements. The continuous development and renewal of the specialized engineering parametric design programs enables users and designers to work with the parameters of the new standard geometric shapes. The parametric design passes through important stages from the beginning of the design process in the stage of developing ideas for the external composition of the building as well as the stage of interior design. Modern software multiplied and enabled architects to facilitate the molding and shaping and opened a wide range of ideas that were not possible before the use of multiplicity in modern parametric design software. Mathematicians were able to reach and understand non-traditional shapes and these shapes have characteristics different from the traditional shapes that are called topology shapes [5].

6.6. Importance of parametric design

Parametric design represents the medium that strongly influences the creation and emergence of new digital design methods in a wide range of architectural, industrial and fashion design fields. Parametric design not only

affects the formal properties of modern designs, but also produces a new model for design thinking, and the research can limit the importance of parametric design within the following axes [6]:

6.6.1. Generating and exploring multiple design alternatives:

Parametric models result in multiple design alternatives, each of which is achieved by modifying one of the model's parameters, as a single model can produce a countless number of other parametric models. The parametric design is characterized by diversity and the application of the tool that uses the parametric system depends on the different geometric conditions to apply the design modifications that appear different. Parametric design provides the ability to generate and test many design alternatives and then choose the optimal ones. It also allows the designer to explore a wide range of design options over time and reconsider previous design alternatives. Here, the importance of generating and exploring multiple parametric design alternatives becomes evident.

6.6.2. Flexibility and adaptability

One of the main features of the parametric design systems that users refer to most of the time is the ability to review and change previous modeling processes. The results of these changes are automatically published through the form without the user needing to delete and redo, so the main benefit of parametric design is flexibility and ability to accomplish changes. It has therefore been described as an effective tool for its ability to improve workflow, its ability to quickly adapt to changing inputs all the time, provide accurate geometric data, and the ability to adapt and respond to standards of changing design requirements, which enables the exploration of dynamic, flexible, free, and new shapes.

6.6.3. The possibility of using parametric design in different stages of the design and construction process

Where the phases of generating shapes can be controlled by representation and manufacturing or the stages of construction and building through the same parametric definition that allows testing different experiments, various types of space or the properties of disparate materials. The parametric design is characterized by the possibilities of entering it in any stage of the design from the initial design idea to the implementation stage. In the early design stage, parameters are set, their relationship with each other is determined, the beginnings of the idea are determined, and in the idea development stage the environmental data or other determining factors are interpreted as the parameters that affect the design and modification. In the manufacturing and implementation stage, the principles of parametric manufacturing techniques also affect the content, shape and behavior of the building that becomes a dominant part in the stage of realization and implementation on the ground.

6.6.4. The role of the parametric design approach in both designing and constructing:

Parametric design combines the initial architectural design of the project with the constructive design. The designer can be guided by the parametric model of construction and design together during the performance evaluation and to modify the geometric model in any stage from the design stage to the implementation in a way that leads to successive parametric generative processes to improve the performance of the project. The structural principles are considered as an integral part of the design process, through the creation of parametric models, new capabilities are created that allow for more integrated design processes. The architect and structural engineer can communicate via parametric models that allow for structural analysis and help the structural designer make informed decisions by obtaining geometrical explanations and constantly changing design requirements.

6.6.5. Applying parametric modeling in a variety of design scales such as urban design, building design, interior design, furniture design and details:

Parametric design allows designers to achieve complete fluidity in all design stages, from preliminary drawings to construction. The urban and architectural potential of parametric design has been explored in the parametric urban expansion presented by Zaha Hadid in a series of projects. Parametric design dealt with various measures of parametric design applications in cladding and outdoor furniture, parametric design applications in interior design, the application of parametric design in home furniture and so on, and the application of parametric design at the level of town planning, neighborhoods and residential neighborhoods as well.

6.6.6. Representation and modeling of complex geometric shapes

The parametric design system helped to model complex geometrical shapes, as parametric architecture is characterized by the rejection of traditional fixed geometrical shapes such as circles, cubes, rectangles and pyramids, which aims to develop an architectural and civilizational repertoire directed towards creating complex, new and multi-centered areas of civilization and architecture. Parametric design allowed the exploration of complex geometry and in-depth exploration of traditional design methods. Parametric design provides easy identification and control of curves and complex surfaces. Parametric modeling has the ability to generate complex shapes with components interacting intuitively, allowing designers and architects to express difficult to implement and complex geometrical structures and manufacturing it. Rigid shapes that have no ability to change are rejected during the shift towards parametricity, where the lines move to form intricately organized, compound variable

forms, internally and externally. Therefore, the parametric design tools have the ability to deal with the models through specialized programs and understand their structural systems and complex technical characteristics, which structure was impossible to be understood previously, and to follow the structural system to its forms, and to employ those concepts and capabilities in dazzling designs that are extremely complex and keep pace with the modern era.

6.6.7. *The participation of many specialties in the parametric design process*

Among the advantages and importance of parametric design is that it allows the participation of many specialties in the parametric design process, where the participants in the design process are the manufacturer, engineer, designer, scientist, as well as the user, as parametric design programs provide the ability to give the user an opportunity to participate in the design process and choose the appropriate design for them.

6.6.8. *The role of parametric design in modeling building data and information with specialized computer software:*

It is wrong to assume that parametric design is concerned only with form making. On the contrary, parametric design techniques give the designer new methods of efficiency compared to traditional methods and contribute to new ways to coordinate the construction process. Building information modeling is an intelligent method of design and construction found in the technological developments of digital modeling systems. A hypothetical three-dimensional parametric model is constructed for a building or group of buildings. This model contains geometric information in addition to all structural data in order to transform from a set of two-dimensional architectural drawings and other documents that only when put together can provide an incomplete perspective to solve the entire design and convert it into a single, three-dimensional parametric model with an integrated database that contains and includes the characteristics of parametric modeling, analysis tools, and spreadsheet functions. In addition to its ability to update and store all design and implementation information in programs such as the BIM program.

6.7. *Computer software used in the parametric design.*

Using computer-aided programs architects' and furniture designers' creativity was increased and they made innovative designs that cannot be drawn by hand easily and complicated problems were solved. Making the design a piece of art and special is the job of designers. While the designer should play a significant role in enhancing the cultural, social, environmental, and economic aspects of the site, computers play their role in increasing the aesthetic and creativity of that design. The range of creativity outcomes designed by these programs depend on the ability to use it. Integrating these with parametric tools will increase the flexibility of designers to choose the best model among unlimited opportunities of the design to make the right decision enhancing health and welling of the users. [7].

The continuous development and renewal of specialized engineering parametric design programs enables users and designers to work with the parameters of new standard geometric shapes. Here is a list to display the most important ones (Table1):

TABLE1: COMPUTER SOFTWARE USED IN THE PARAMETRIC DESIGN

the program	Description
1- Generative Components Program [8]	Bentley's Generative Components program is a parametric CAD program, it was developed in 2003, According to Aish, the Generative Components program is a parametric design tool that creates design rules that search for alternative solutions represented in multiple geometrical (complex) graphics associated with it. The program tries to give three-dimensional modeling capabilities to solid forms of architectural design by providing more diversification in them. The program is mainly used by designers and workers working on geometrical shapes in the design of buildings. The program supports many file extensions to interact with programs such as Rhino and AutoCAD. The program uses a simple coding language that allows creating custom programs (according to the user's desires). The parametric design created in this program is characterized by that each element of the 3D model can be constructed according to its relationship to the other element and numerical values can be changed at any time. Mathematical formulas for commands can be accessed in place of standard commands such as copying or repeating operations performed by a series of mathematical operations. The program is also characterized by the presence of multiple methods of defining and monitoring the parametric correlations between the elements of the model in a responsive and workable environment throughout the design process. Parametric correlations are characterized by flexibility in controlling the design elements.
2- Rhinoceros Program [9]	It is a programming environment from Rhino Script that was developed by Mc Neel, it is an easy and integrated method using 3D modeling and represents a well-known application and is used by many designers and architects and it is based on the Visual Basic programming language. It works with NURBS objects, and it has potential for collaboration between different environments.
3-Digital Project (CATIA) [10]	It is a computer-aided parametric design program developed by Gehry Technologies based on CATIA V5, The program uses the Visual Basic programming language and allows the user to develop additional applications, symbols, entities, and shapes, and at the same time allows the user to calculate the estimated budget and use of materials. The program provides well-designed tools for users to design components and assemble them into

	multiple (complex) formulations, as well as it allows the user to define the detail components it designed. Users can perform calculations and analysis on the model, and the program can be used interactively with programs such as AutoCAD.
4-BIM Revit [11]	It represents the Building Information Modeling System (BIM), It was developed in response to the need for software that can create three-dimensional parametric models that include both the geometric shape, geometric shape design and building information. It allows users to design the building, structure and its components in a 3D model. Modeling tools can be used with pre-made solid objects or imported geometric models. The program lacks the ability to handle NURBS entity and single polygon entity except for some specific entity types such as trellises, terrain, or bulk environment. The software assists with collaboration between teams and ensures that all information (floors, schedules, etc.) is updated whenever any changes are made to the model. It also assists to access construction information from the construction model database. Every change made to an element in the Revit is automatically published through the form to maintain the consistency of all the components of the Views, and the program has the ability to plan and track different stages in the building life cycle from idea to construction, subsequent maintenance and / or demolition, and Revit adopts programming language Python & Visual Basic.
5-Dynamo [12]	It is described as a tool that allows parametric design in the context of a BIM project, it represents a flexible and scalable tool because it can work as a standalone application or as an addition to other design programs, as it can work as an add-on for both Vassarl & Autodesk Revit. It represents the visual programming tool that aims to be in the reach of both non-programmers and programmers alike, with the ability to use various scripting languages, and the ability to formulate the way in which data is processed (numbers or texts). The graph and the results of the 3D drawing are displayed both in the workspace.
6-3DS Max UI. [13]	It is a parametric 3D modeling program that supports visual programming and provides modeling, animation, simulation, and rendering functions for games, movies, and animation. It uses the concept of wire ratios and parameters to control the geometry and gives the user the ability to write its Max Creation Graph. It is based on the Maxscript programming language, and has limited support for NURBS.
7-Inventor [14]	It is a Parametric 3D drawing and modeling program based on extruding, rotating, drawing of basic surfaces. It is a first-rate mechanical 3D modeling software known as manufacturing and production software specifically. The program shows all the work sequentially within the browser, unlike AutoCAD, which hides the work parameters and design results.
8-Marionette [15]	It is a visual programming environment for architectural, engineering, construction, outdoor spaces, and industrial design. It enables designers to create custom application algorithms (as per user desires) that build interactive parametric entities and simplify complex workflows, as well as build automated 2D drawing, 3D modeling and BIM workflows within Vectorworks software. It was created according to the programming language Phyton.
9-Maya [16]	This software was developed for the film industry (primarily for animation) and has been used in recent times by many architects in the conceptual design stage, This design approach requires programming or scripting knowledge and is inherent in mathematical algorithms where interactive design is not possible.
10- Modelur [17]	It is a parametric 3D software that is used to design Urban areas, as a plugin for Trimble Sketch Up. Its primary goal is to help users create conceptual urban clusters. It provides the design of the built environment through major urban parameters such as the number of floors and the total land area of the building, and it also calculates the main urban control parameters (such as the floor area ratio or the required number of parking spaces). It helps to make an informed decision during the early stages when design decisions have the most impact.

6.8. Parametric Interior Design

It is the modern technology emerging in the interior design and furniture software used in the parametric design by the computer (e.g., Generative Components, Rhinoceros, Digital Project, Maya, etc.) [18]. Which depend mainly on the use of a unit repetition system design. This results in impressive and innovative designs that are very complex and save time and effort, which previously seemed unrealistic and inapplicable [19].

6.8.1. Parametric Interior Design Features [20]

- Smooth and flowing lines, like a piece of cloth.
- Lack of decorative elements in the furniture.
- Curved geometric lines.
- Diversity of texture and external appearance of the furniture (e.g., rough, smooth, glossy, matte, etc.).
- Avoid normal geometric beginnings (e.g., squares, triangles, rhombus, etc.).
- Avoid simple duplication of elements.
- Maximum environmental sustainability.
- Enormity in the furniture dimensions compared to the traditional and classic style.
- Practicality and versatility where, at the same time, the piece of furniture can be a chair, table, and wall shelves.
- Ease of cleaning the parametric furniture compared to the traditional one that has many details and decorations.

6.8.2. Parametric Interior Design Materials

The parametric design idea is to protect the buildings and users as much as possible from the harmful effects of unnatural materials, so the main materials for furniture and decoration are often wood and natural stone. They are easy to use and eco-friendly, and their prices are relatively low. There are no additional treatments required due to the diversity of the natural colors and pattern of wood and stone [21]. In addition, plastics, glass, paper, cloth, rubber, and other materials are also used in endless combinations and colors [22].

6.9. Parametric Design Patterns

Parametric design provides a number of formal patterns that simulate shapes in nature, such as shape structure, surface optimization, configuration and distribution of structure, that the designer can use in simulating nature.

6.9.1. The Synthesis of Form:

Through parametric design, many design methods have been developed, which aim to build different and complex design structures that are close to optimization in shape, such as the behavior of formation in nature, where these structures are produced computationally and their outputs vary. According to a wide range of parameters related to the physical, structural and structural requirements, loads and other requirements that the designer aspires to achieve in the industrial product, as it allows the designer to enter the specific design objectives, including functional requirements, type of materials, manufacturing method, and performance standards for design space. To install it from a procedural point of view and evaluate a large number of alternatives that were produced to meet those requirements [23]. as shown in Figure (1).



Fig. 1 The formal alternatives for designing a chair according to the performance parameters [24].

6.9.2. Lattice and surface optimization

A method that aims to build an industrial product that is more strong, durable and lighter in weight by converting the mass of the structure from a solid mass to structural filaments connected along the surface of the structure, forming a triangular shape [25]. as shown in Figure (2).



Fig. 2 A table structure resulting from the optimization property of the structure and surfaces [26].

6.9.3. Topology optimization:

This approach depends on reducing the weights of the elements used by conducting the necessary analyzes, reducing unnecessary materials, and maintaining performance standards [27] as shown in Figure (3).



Fig. 3 Reducing the time of unnecessary elements and raw materials for the product body table [28].

6.9.4. The distribution of trabecular structures:

This method aims to form formations that mimic the weight, strength, and shape of bones, and can be used to inspire shapes for industrial products, [29] as shown in Figure (4).

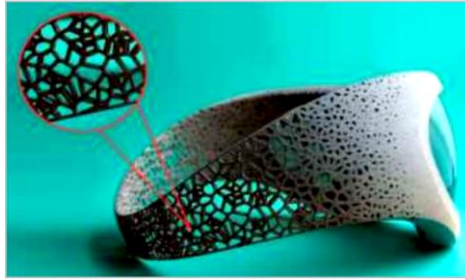


Fig. 4 Benefiting from the distribution of the structure in the design of an industrial product (glasses) [30].

6.9.5. The parametric patterns in nature – (In organic Systems) Fractal Pattern:

These patterns are called inorganic, in reference to the formation of shapes in nature through self-formation processes. The inorganic natural systems have been used as inspiration models or sources of inspiration in formulating perceptions and building shapes, as these systems are usually made of homogeneous natural materials such as sand dune formations, such as dynamic fluid structures, or a homogeneous fluid design that provides many forms of strength. Nature, which enables the designer to apply creative formal treatments to the product, as well as the ability to simulate the self-more integrated forms with its function as it is the state of formation behavior of patterns in nature in order to build [31] as shown in Figure (5), Figure (6).



Fig. 5 Depiction of the parametric patterns in nature - waves and sand dunes [32].



Fig. 6 Inspiration from industrial product design [33].

6.9.6. The parametric patterns in nature - Fractal Patterns in living Organisms.

Parametric has another image in nature, as it appears in the dynamic repetitive patterns, which are meant by the patterns that perform vital functions such as bee-free [34] as shown in figure No. (7), where the model is produced using the genetic design algorithm, which is one of the most important parametric design tools.



Fig. 7 Depiction of the parametric patterns in nature – hives [35]

6.9.7. The parametric patterns in nature - Pattern from Form Generation Finding

Parametric design is used to simulate models of a highly iterative nature, such as biological iterative structures Structure Fractal, which is found in the structural composition of trees, coral reefs, and organs of the human body as they are, with an abundance of tools-algorithms-producing shapes that simulate patterns of growth in nature, which can be employed in industrial products as unique form processors, [36] such as the lighting units shown in Figure (8), Figure (9).

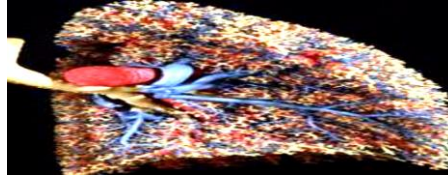


Fig. 8 A pattern of a bio-structural image provided by the Institute of Anatomy at the University of Bern [37].



Fig. 9 Employing a dynamic structural pattern in Lighting unit using Algorithm Genetic algorithm [38].

6.9.8. The parametric patterns in nature - Pattern from Swarms

Swarms or flocks in nature consist of a flood of living organisms governed by the rules of behavior that maintain the path and consistency of the movement of the swarms and as a result, the swarms behave in a similar behavior to a fluid or liquid as shown in Figure (10), so when simulating this shift in design, the results are similar and simulated. For nature, because the simulation of these systems focuses on the shape resulting from the collective behavior of the swarm and not the individual behavior, as shown in Figure (11), and the swarms usually move homogeneously, such as fluids and air, creating simple curved lines forming organic masses. Which are employed in functional design outputs as shown in Figure (12). [39]



Fig. 10 The behavior of swarms in nature.



Fig. 11 Hypothetical model of swarm behavior.



Figure (12) Design generated by the swarm algorithm [40].

6.10. Previous studies and Theories of parametric design

6.10.1. Fractal Geometry in Nature - Benoit Mandelbrot

Clouds are not balls, mountains are not cones, and lightning does not travel in a straight line. The complexity of the forms of nature differs in type, and not only in degree, from the forms of ordinary geometry, and the

geometry of fractal shapes, it is a theory developed by Benoit Mandelbrot, a mathematician, about Fractal Geometry in Nature. [41] A theory developed by mathematicians to codify some natural phenomena, and with the development of this theory, molecular engineering became an entry point. Experimental and expressive trend in the visual arts, which are simply defined as the elements of engineering that are divided into each part by each part. It is similar in shape to the bulk of it from which it was derived, and it can be used in designing industrial products as it is clarified. Figure No. (13), which is clear through the concept of similarity from the result of repetition, as every part is small, it is in Its shape is similar to the larger part, as it is complex forms in mathematics that are built by simple repetition of the following forms of a mass whose area is in the whole Once you repeat it, you are usually interested in studying the structures composed of molecules and patterns that exist in nature and describe the many situations Nor structures that cannot be inexplicable or studied by geometry can explain classical mathematics.

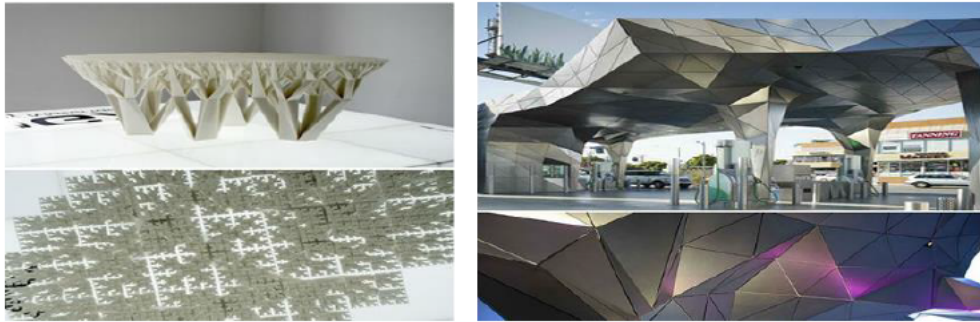


Fig. 13 Design and implementation of an alpha using molecular geometry theory [42].

6.10.2. VORONOI Theory - The Concept of "VORONOI Diagram":

"VORONOI diagram ". The new concept emerged as an important mathematical principle in the field of architecture, and the development of computer algorithms affected the concept of the VORONOI diagram significantly. The VORONOI diagram is one of the most common structural network systems in nature, due to its abundance in nature through plant and animal shapes, ground cracks, tree branches, and lines Blood vessels in humans, animal fur patterns, and beeswax tablets. Its use dates back to the year 1644 AD when Rene Descartes used it in describing the partition of space by means of the stars. And Johann Gustav in 1850 AD, while studying mathematical quadratic equations, the term "VORONOI diagram", taken from the name of the Russian mathematician George VORONOI diagram varies in shapes and patterns and ranges from random to structured form. Architects and designers used the aesthetic features and structural systems of the VORONOI diagram inspired by nature. Figure No. (14) and applied them to their various projects and designs.



Fig. 14 VORONOI patterns in nature [43].

Steps to create a VORONOI diagram:

1. Define a set of generated points.
2. Connect these lines with straight lines.
3. Define the points that refer to the middle of the previous lines.
4. Draw vertical lines on the previous lines from their midpoints (averages).
5. Averages intersect with each other to form a new grid known as the "VORONOI diagram".

Inspiration from nature in the design process is a very commonly used tool. Designers can take advantage of the aesthetic characteristics and structure of the objects contained in nature. The VORONOI diagram is a structure that divides space into sub-spaces in an organic way. The VORONOI diagram can be used to construct various scenic designs appropriate Fig. 15.

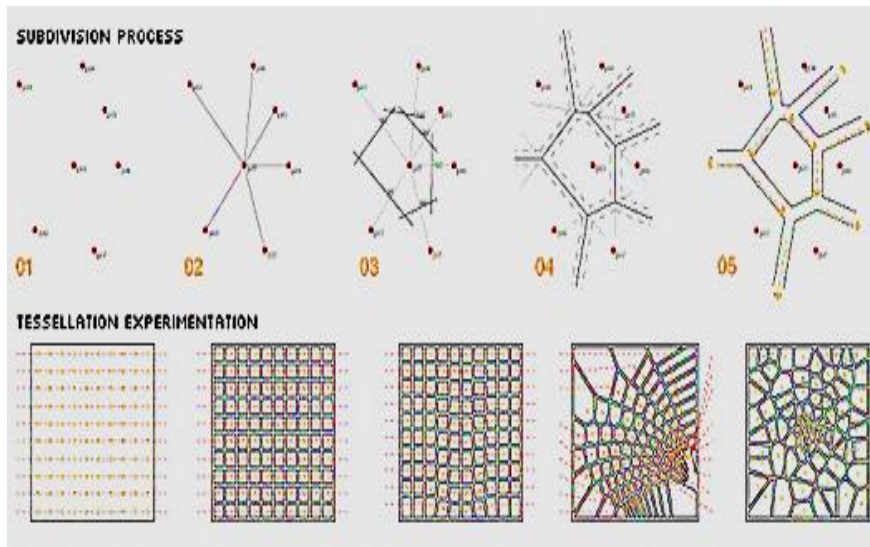


Fig. 15 Steps of drawing Voronoi diagram [44].

VORONOI furniture:

The furniture designers were inspired by the VORONOI Diagram. Figure 16, and some designers designed a series of furniture inspired by the Beehive in the VORONOI pattern using special mathematical algorithms, the honeycomb seat bears large weights even though the material used in the manufacture is very thin and allows light to penetrate from which. The seat is on display at Taiwan Land Corporation Cultural Salon in Taipei, Taiwan Other designers have designed a project that explores using a generative design based on mathematical algorithms of the VORONOI Diagram iteratively to create complex shapes that are created iteratively innovatively many designers use the VORONOI Diagram in designing [45].

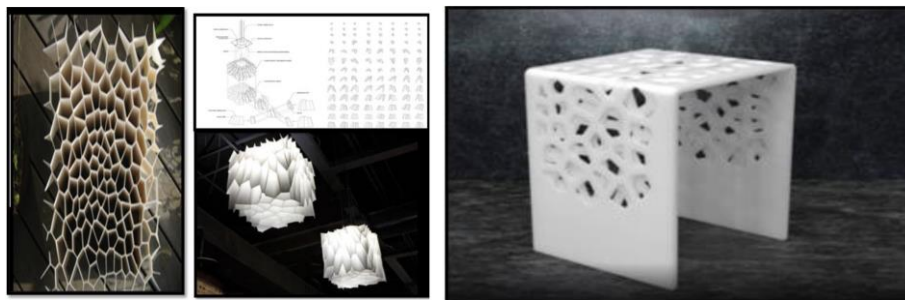


Fig. 16 A series of furniture inspired by a VORONOI honeycomb structure [46].

6.10.3. Creative Solution Diagnosis Scale (CSDS) "CROPLEY & KAUFMAN":

Creativity in Engineering focuses on the Process, Person, Product, and Place to understand when and why creativity happens in the engineering environment and how it can be further encouraged. Creative Solution Diagnosis Scale (CSDS) is Identifying the extent and nature of the creativity of new products is a key for innovation management. (CSDS) is a 27-item scale based on a theoretical model of functional creativity, consisting of five main criteria: 1. Aesthetics Index, Elegance Index, Originality Index, Innovation Index, Functional Index. The author narrowed down the scope of these specific criteria from 27 sub-items, and the evaluation was limited to the five main indicators. As suggested by CROPLEY, Kaufman, and CROPLEY (2011), so creativity can be measured through these indicators (Fig. 17), [47]

Criterion	Kind of Product				
	Routine	Original	Elegant	Innovative	Aesthetic
Effectiveness	+	+	+	+	-
Novelty	-	+	+	+	+
Elegance	-	-	+	+	?
Genesis	-	-	-	+	?

Fig. 17 Levels and kinds of creativity in products, the five main indicators [48].

After presenting the previous studies, the research problem appears in the lack of research studies that measure the effect of using and applying parametric digital architecture tools on the generation and production of new and innovative ideas in the field of furniture and interior design flexibly. It was necessary to conduct the current study with its scientific addition to clarify and prove what digital architecture offers in the field of interior design and furniture. It is worth noting that it is one of the few and rare studies and has the lead in measuring the parametric levels of creativity for interior furniture in the Middle East, especially Egypt.

7. APPLIED STUDY

The proposed applied study is divided into three parts (Fig. 1). All its stages are applied to the proposed applied samples (40 professionals) of architects, designers and professionals in the field of architecture and interior design, were 27 males and 13 females, the statistical software SPSS is used to analyze the outcomes of the survey as follows:

- Part One: The stage of making a questionnaire and survey on the general parametric design concepts, the extent of familiarity and its applications in furniture and interior design.
- Part Two: The stage of measuring the extent of success and fulfillment of the parametric design criteria and indices in modern parametric furniture, which extracted from previous studies.
- Part Three: The stage of comparing the levels of creativity in some proposed types of traditional and parametric furniture (e.g., chairs and tables) in the furniture interior design.

Study sample:

Because the survey response is subjective in nature, meaning that its results differ according to the nature and conditions of the sample from one region to another, the following data must be clarified about the selected study sample:

- **The sample region:** The Middle East.
- **Country:** Egypt.
- **Sample number:** 40 persons.
- **Type of the sample:** (27 males), (13 females).
- **Specialties of the participants:** architects, designers, and specialists in the field of architecture and interior design of furniture.
- **Reasons for choosing the region of the sample:** The Middle East region, especially the third world countries such as (Egypt), includes the scarcity of self-survey and the lack of applied research studies in relation to parametric architecture in the interior design of furniture.

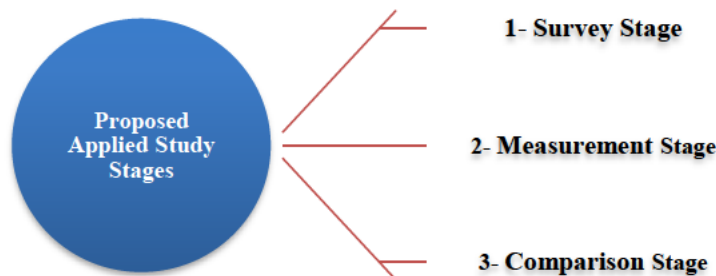


Fig.18: The stages of the proposed applied study, source: the researcher.

8. DISCUSSION

8.1. Part One (Survey Questionnaire)

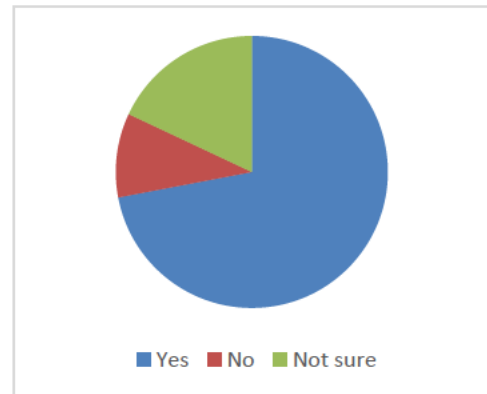
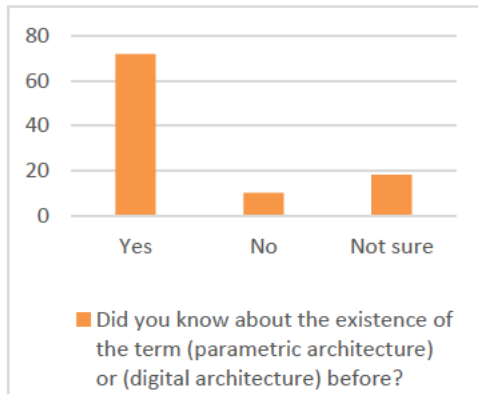
A questionnaire form (see Fig.23 in Appendix) is prepared on the parametric design concept and its applications in furniture and interior design. It is applied to a sample (40 professionals) of architects and specialists in this field, to know their theoretical background, information, awareness, impressions and influence on parametric design concepts.

Part one results:

1- Through the proposed sample, it is clear that 72% of the sample knows the existence of the parametric architecture, while 10% does not know, and 18% uncertainly knows.

No.	1- Did you know about the existence of the term (parametric architecture) or (digital architecture) before?	percentage (%)
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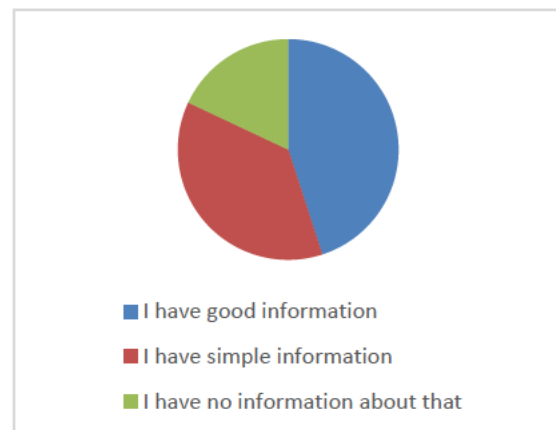
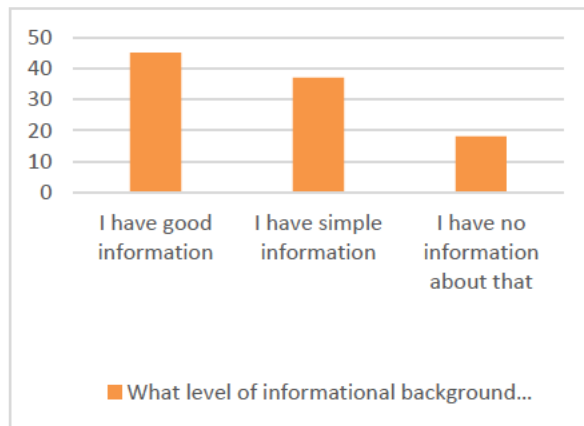
1	Yes	72
2	No	10
3	Not sure	18



Graph. No. (1) results of a question: (Did you know about the existence of the term (parametric architecture) or (digital architecture) before?), Source: researcher.

2- The results show that 45% of the sample has good information about the parametric architecture, while 37% has simple information, and 18% has no information about the parametric architecture.

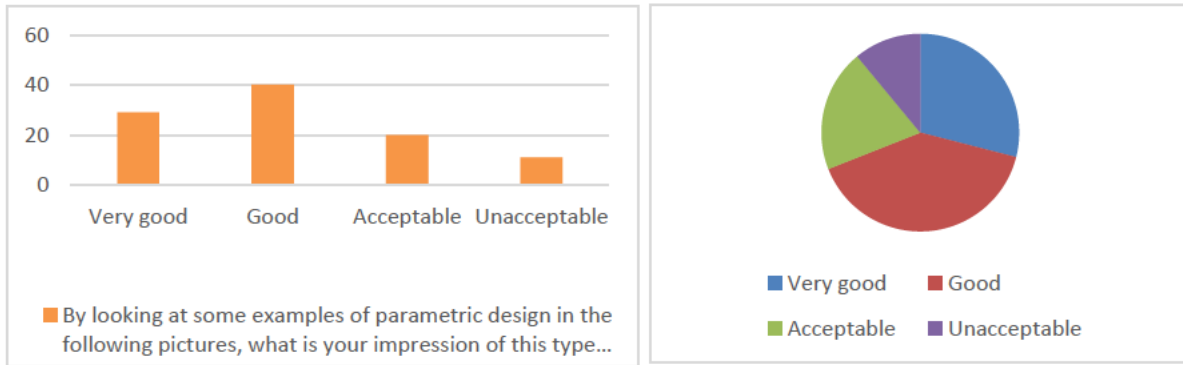
No.	2- What level of informational background do you have about digital architecture and parametric design?	percentage (%)
1	I have good information	45
2	I have simple information	37
3	I have no information about that	18



Graph. No. (2) results of a question: (What level of informational background do you have about digital architecture and parametric design?).

3- We found that 29% of the sample has a very good impression about the parametric architecture, while 40% has a good impression, 20% has an acceptable impression, and 11% has an unacceptable impression.

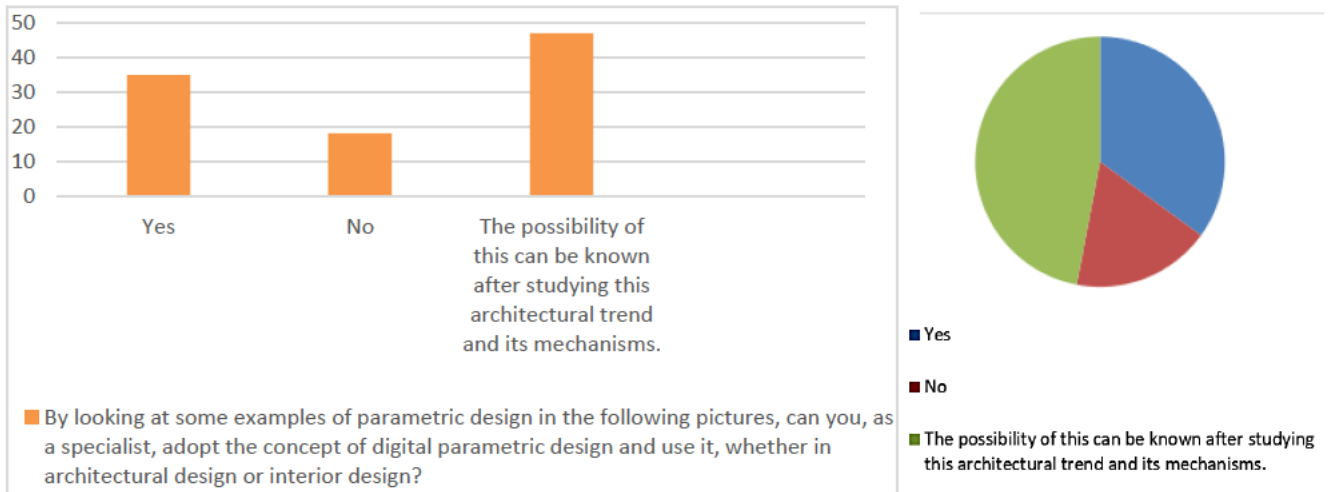
No.	3- By looking at some examples of parametric design in the following pictures, what is your impression of this type of design?	percentage (%)
1	Very good	29
2	Good	40
3	Acceptable	20
4	Unacceptable	11



Graph. No. (3) results of a question: (By looking at some examples of parametric design in the following pictures, what is your impression of this type of design?), Source: researcher.

4- It is clear that 35% of the sample can adopt and use the parametric digital design concept as a specialist, while 18% cannot adopt and use this concept as a specialist, and 47% can adopt and use it after studying that architectural field and its mechanisms.

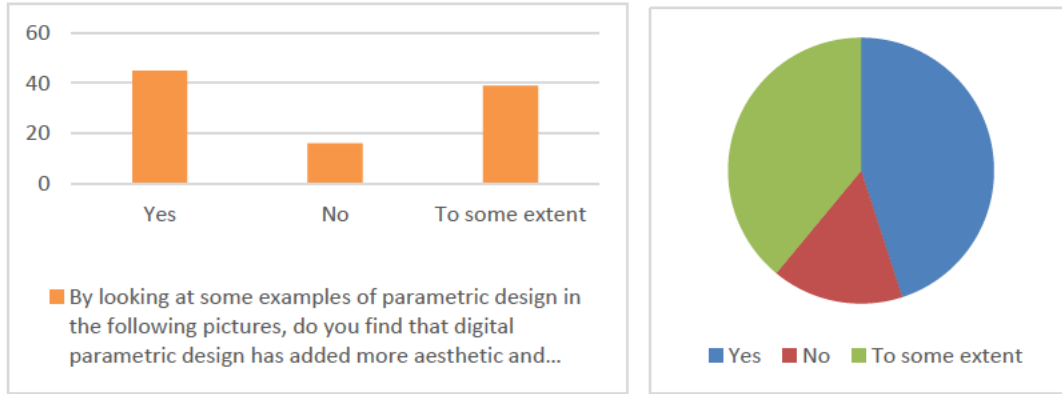
No.	4- By looking at some examples of parametric design in the following pictures, can you, as a specialist, adopt the concept of digital parametric design and use it, whether in architectural design or interior design?	percentage (%)
1	Yes	35
2	No	18
3	The possibility of this can be known after studying this architectural trend and its mechanisms.	47



Graph. No. (4) results of a question: (By looking at some examples of parametric design in the following pictures, can you, as a specialist, adopt the concept of digital parametric design and use it, whether in architectural design or interior design?), Source: researcher.

4- Through the proposed sample, it is clear that 45% of the sample finds that the digital parametric design has added more aesthetic and functional values to the furniture than the traditional design, while 16% does not find that, and 39% find that to some extent the parametric digital design has added more aesthetic and functional values to the furniture than the traditional design.

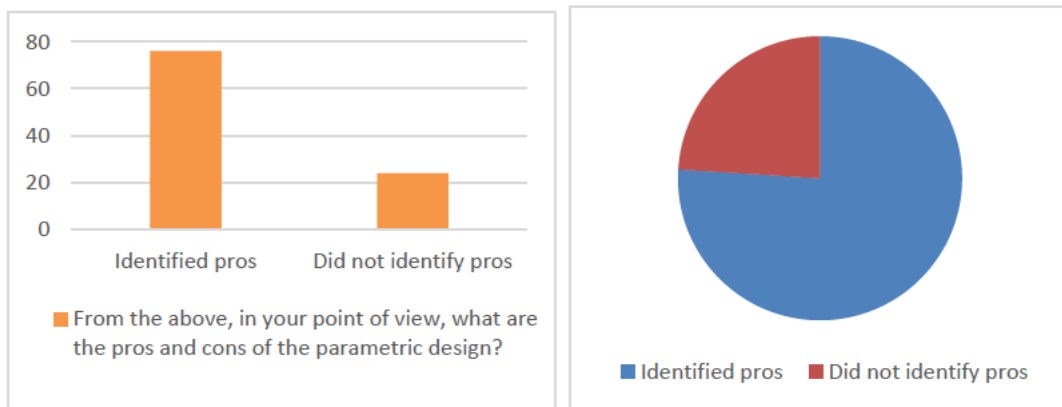
No.	5- By looking at some examples of parametric design in the following pictures, do you find that digital parametric design has added more aesthetic and functional values to furniture than traditional design?	percentage (%)
1	Yes	45
2	No	16
3	To some extent	39



Graph. No. (5) results of a question: (By looking at some examples of parametric design in the following pictures, do you find that digital parametric design has added more aesthetic and functional values to furniture than traditional design?), Source: researcher.

6- The results show that 76% of the sample could identify specific pros for using the digital parametric design, while 24% did not specify pros because they did not fully know the concept, its determinants, and problems.

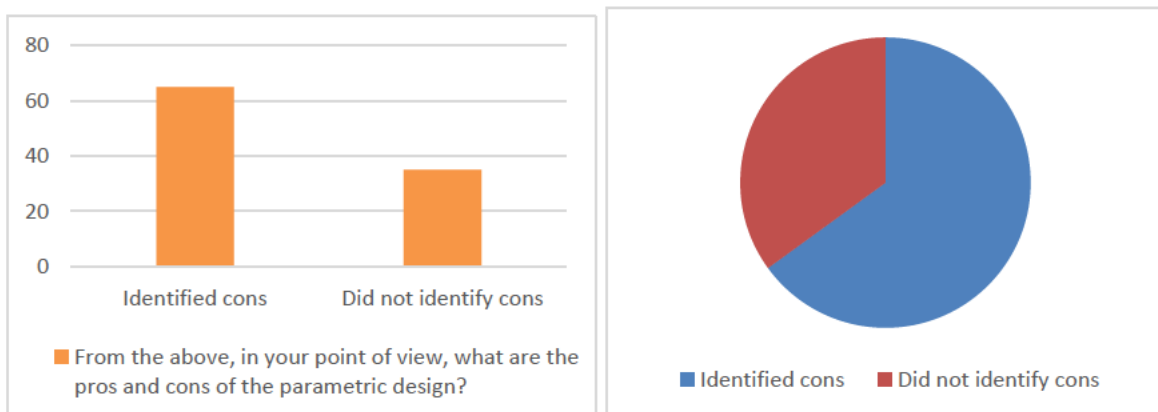
No.	6- From the above, in your point of view, what are the pros and cons of the parametric design?	percentage (%)
1	Identified pros	76
2	Did not identify pros	24



Graph. No. (6-1) results of a question: (From the above, in your point of view, what are the pros of the parametric design?), Source: researcher.

- Also, 65% of the sample could identify specific cons of using the digital parametric design, while 35% did not specify cons due to their lack of full knowledge of the concept, its determinants and problems.

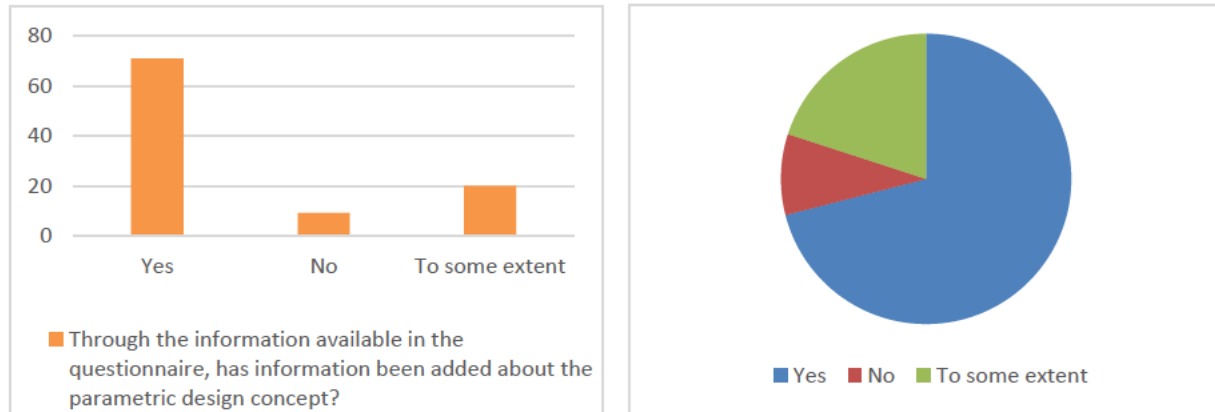
No.	6- From the above, in your point of view, what are the pros and cons of the parametric design?	percentage (%)
1	Identified cons	65
2	Did not identify cons	35



Graph. No. (6-2) results of a question: (From the above, in your point of view, what are the cons of the parametric design?).

7- It is clear that 71% of the sample finds the information in the questionnaire add information about the parametric design concept, while 9% finds that it did not add information about the parametric design concept, while 20% finds that it adds to some extent information about the parametric design concept.

No.	7- Through the information available in the questionnaire, has information been added about the parametric design concept?	percentage (%)
1	Yes	71
2	No	9
3	To some extent	20



Graph. No. (7) results of a question: (Through the information available in the questionnaire, has information been added about the parametric design concept?), Source: researcher.

Part One (Reliability Statistics):

a. Reliability Statistics has been done for collecting data from the participant responses for the Part One as shown in Table (1): Cronbach's Alpha of the answers was 0.808.

TABLE (1): RELIABILITY STATISTICS OF PART ONE, SOURCE: RESEARCHER USING SPSS.

Reliability Statistics	
Cronbach's Alpha	N of Items
.808	7

From the results of the previous: Questionnaire results, it was shown that the parametric interior design of furniture has many pros and cons as follows:

I. Pros:

- The adoption of parametric design in interior furniture achieves flexibility and streamlining. Also, it fulfills a good and perfect aesthetic, functional and innovative value.
- The parametric design saves and reduces the time and effort required in the traditional design process.
- Achieves softness and quality during the design process stages, and this becomes evident when modifying a specific part of the design, which is automatically applied to the rest of the design.
- In line with the principle of sustainability through the principle of recycling building materials.
- Succeeded in designing many activities (i.e., exterior, and interior design and furniture) with flexibility, innovation, and creativity.
- Ease of implementation and manufacturing due to the use of repetitive units (prototype).
- The possibility of adding the fourth dimension (movement) by controlling the composition and formation of the interior furniture.

II. Cons:

- Parametric design in interior furniture needs a high skill in using designing software (e.g., Generative Components, Rhinoceros, Digital Project, BIM Revit, Dynamo, DS Max3, Inventor, Marionette, Maya Modular).
- High implementation cost due to the development and use of automated cutting technology and robots in manufacturing.
- Some specialists see it as boring, repetitive, and unusual compared to the traditional interior design.
- Compatible with modern designs, while it slightly compatible with ancient and popular legacies.
- Heavy reliance on computer software in design weakens the designer's ability to innovate manually.

8.2. Part Two (Measurement):

At this stage, we measure the extent of application and fulfillment of parametric design criteria and indices in modern digital parametric furniture. The same previously proposed sample of architects and designers is used. These indicators are extracted from previous studies in this field. CROPLEY (2011) By looking at example pictures of parametric interior furniture (see Fig. 18):



Fig.18 Examples of parametric digital interior furniture [49].

Parametric Design Indices:

1. Aesthetics Index.
2. Elegance Index.
3. Originality Index.
4. Innovation Index.
5. Functional Index.

Part Two Results:

The participants in the proposed sample evaluated the parametric furniture according to the previous indices, and their opinions are requested to be limited between (very good - good - acceptable - unacceptable) for each index separately, and the results are as follow:

1- Aesthetics index: a branch of philosophy dealing with the nature of beauty, art, and taste and with the creation and appreciation of beauty, it is clear from the proposed sample, (see Graph. No.8):

- That 18% decides that the level of aesthetics in parametric furniture is very good.
- while 47% decides that the level is good.
- 22% decides that the level is acceptable.
- and 13% decided that the level is unacceptable.



Graph. No. (8): Percentages of Aesthetics index results. Source: researcher.

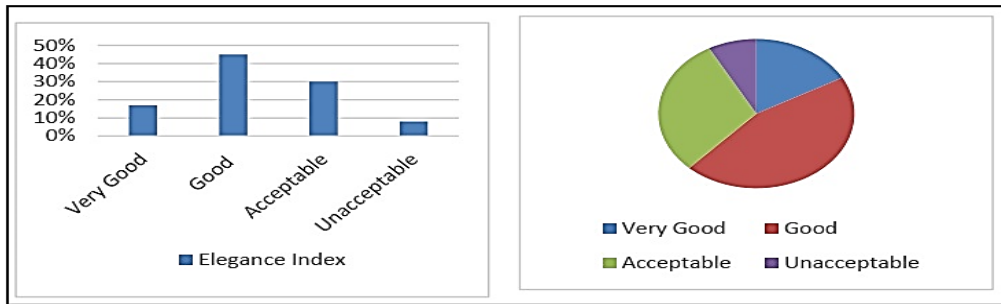
Statistical analysis has been done for collecting data from the participant responses: for the Aesthetics index scale as shown in Table (2): mean of the answers was 2.5 median=2, std. deviation=1.75, variance=1.65

TABLE 2: STATISTICAL TABLE ANALYSIS FOR ANSWERS OF THE SURVEY ABOUT AESTHETICS INDEX SCALE, SOURCE: RESEARCHER USING SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Aesthetics	1	38	8	7	20	16	2.5	2	1.75	1.65

1. Elegance Index: It indicates the richness of taste in design or decoration, the results show that (see Graph. No.9):

- 17% finds the level of elegance in parametric furniture is very good.
- while 45% finds the level is good.
- 30% finds the level is acceptable.
- and 8% finds the level is unacceptable.



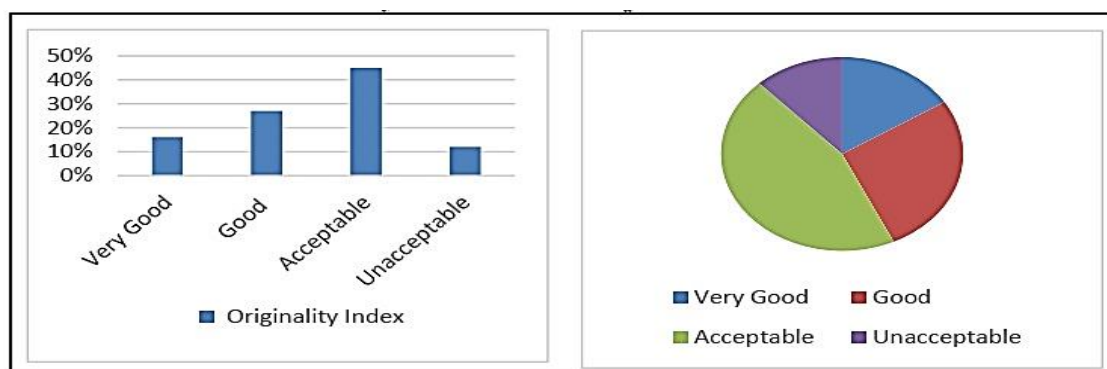
Graph. No. (9): Percentages of elegance index results. Source: researcher.

Statistical analysis has been done for collecting data from the participant responses: for the Elegance index scale as shown in Table (3): mean of the answers was 2.49, median=1.99, std. deviation=1.70, variance=1.65

TABLE 3: STATISTICAL TABLE ANALYSIS FOR ANSWERS OF THE SURVEY ABOUT ELEGANCE INDEX SCALE, SOURCE: RESEARCHER USING SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Elegance	1	35	4	6	18	14	2.49	1.99	1.70	1.65

2. Originality Index: It indicates the quality or state of being original, freshness of aspect, design, or style, the power of independent thought or constructive imagination, the proposed sample shows that (see Graph. No.10):
 - 16% decides that the level of originality in the parametric furniture is very good.
 - while 27% decides that the level is good.
 - 45% decides that the level is acceptable.
 - and 12% decides that the level is unacceptable.



Graph. No. (10): Percentages of Originality index results, Source: researcher.

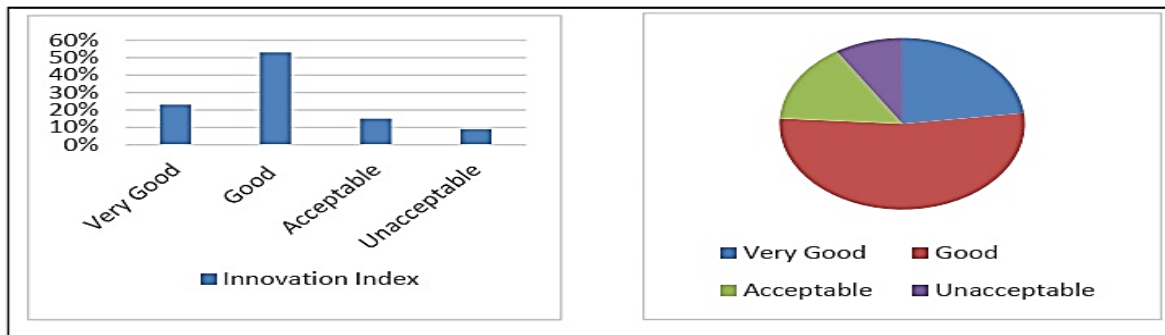
Statistical analysis has been done for collecting data from the participant responses: for the Originality index scale as shown in Table (4): mean of the answers was 2.25, median=1.78, std. deviation=1.70, variance=1.05

TABLE (4): STATISTICAL TABLE ANALYSIS FOR ANSWERS OF THE SURVEY ABOUT ORIGINALITY INDEX SCALE, SOURCE: RESEARCHER USING SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Originality Index	1	37	2	5	12	8	2.25	1.78	1.70	1.05

3. Innovation Index: It indicates a new idea, method, or device, or the introduction of something new, it is clear from the proposed sample that (see Graph. No. 11):

- 23% finds that the level of innovation in parametric furniture is very good
- while 53% finds that the level is good.
- 15% finds that the level is acceptable.
- and 9% finds that the level is unacceptable.

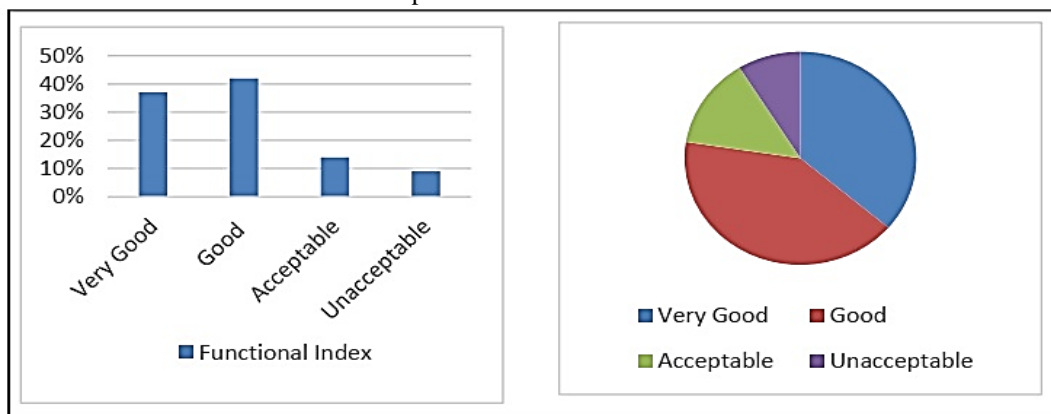


Graph. No. (11): Percentages of Innovation index results, Source: researcher.

Statistical analysis has been done for collecting data from the participant responses:

4. Functional Index: Refers to what is designed to be practical and useful rather than attractive, The results show that (see Graph. No.12):

- 37% decides that the functional level in parametric furniture is very good.
- while 42% decides that the level is good.
- 14% decides that the level is acceptable.
- and 9 % decides that the level is unacceptable.



Graph. No. (12): Percentages of functional index results, Source: researcher.

Statistical analysis has been done for collecting data from the participant responses: for the Functional index scale as shown in Table (6): mean of the answers was 2.66, median=2.2, std. deviation=1.70, variance=1.05

TABLE (6): STATISTICAL TABLE ANALYSIS FOR ANSWERS OF THE SURVEY ABOUT FUNCTIONAL INDEX SCALE, SOURCE: RESEARCHER USING SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Functional	1	37	2	4	11	16	2.66	2.2	1.70	1.05

Part Two (Reliability Statistics):

a. Reliability Statistics has been done for collecting data from the participant responses: for the Part Two (Measurement) as shown in Table (7): Cronbach's Alpha of the answers was 0.855.

TABLE (7): A. RELIABILITY STATISTICS OF PART TWO, SOURCE: RESEARCHER USING SPSS.

Reliability Statistics	
Cronbach's Alpha	N of Items
.855	5

8.3. 8-3-Part Three (Comparison)

At this stage, we compare between the innovation and creativity levels in some proposed examples of traditional and parametric furniture (e.g. chairs and tables) in furniture interior design, using the previous proposed sample. It is requested to limit their opinions between (very creative - creative - normal - uncreative - very uncreative) for each type of furniture separately.

Part Three Results:

1- Chairs:

I. Parametric chairs (see Fig. 19):

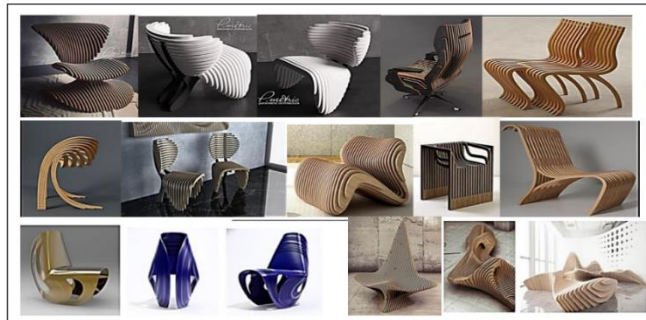
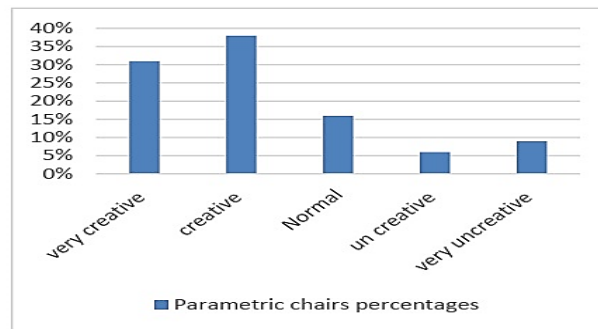


Fig.19: Digital parametric chairs, Source: [50]

It is clear from the proposed sample that (see Graph.No.13):

- 31% decides that the level of creativity and innovation in parametric chairs is very creative.
- while 38% decides that the level is creative.
- 16% decides that the level is normal.
- 6% decides that the level is uncreative.
- and 9% decides that the level is very uncreative.



Graph.No.13: Parametric chairs percentages, Source: researcher.

Statistical analysis has been done for collecting data from the participant responses: for the Parametric chairs as shown in Table (8): mean of the answers was 2.65, median=2.44, std. deviation=1.77, variance=1.44

Table (8): statistical table analysis for answers of the survey about parametric chair, Source: researcher using SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Parametric chairs	1	35	2	9	25	20	2.65	2.44	1.77	1.44

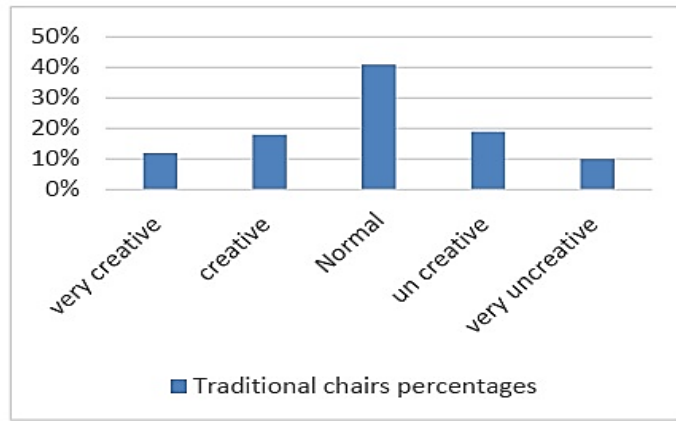
II. Traditional chairs (see Fig.20):



Fig.20: Traditional chairs, Source: [51]

The results show that (see Graph.No.14):

- 12% finds that the level of creativity and innovation in traditional chairs is very creative.
- while 18% finds that the level is creative.
- 41% finds that the level is normal.
- 19% finds that the level is uncreative.
- and 10% finds that the level is very uncreative.



Graph.No.14: Traditional chairs percentages, Source: researcher.

Statistical analysis has been done for collecting data from the participant responses: for the Traditional chairs as shown in Table (9): mean of the answers was 2.5, median=2, std. deviation=1.75, variance=1.65

TABLE (9): A STATISTICAL TABLE ANALYSIS FOR ANSWERS OF THE SURVEY ABOUT GEOMETRIC MODEL BASED CHAIR, SOURCE: RESEARCHER USING SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Traditional chairs	1	38	8	7	20	16	2.5	2	1.75	1.65

2- Tables:

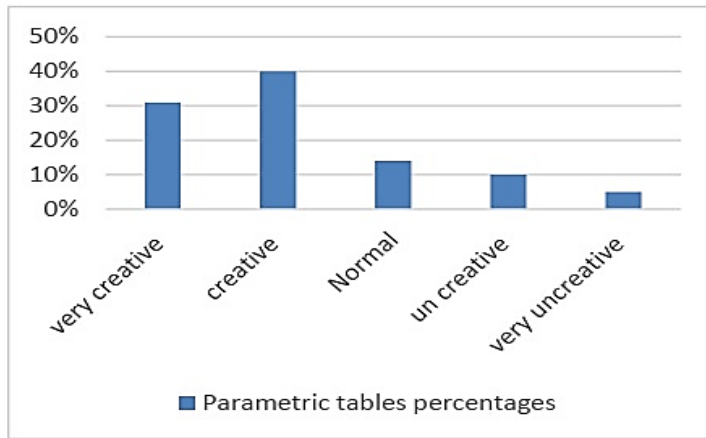
I. Parametric tables (see Fig. 21):



Fig.21: Parametric tables [52].

Through the proposed sample we find that (see Graph.No.15):

- 31% decides that the level of creativity and innovation in parametric tables is very creative.
- while 40% decides that the level is creative.
- 14% decides that the level is normal.
- 10% decides that the level is uncreative.
- and 5% decides that the level is very uncreative.



Graph.No.15: Parametric tables percentages, Source: researcher.

Statistical analysis has been done for collecting data from the participant responses: for the Parametric tables as shown in Table (10): mean of the answers was 2.75, median=1.8, std. deviation=1.44, variance=1.10

TABLE (10): A STATISTICAL TABLE ANALYSIS FOR ANSWERS OF THE SURVEY ABOUT PARAMETRIC TABLES, SOURCE: RESEARCHER USING SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Parametric tables	1	29	8	7	20	2	2.75	1.8	1.44	1.10

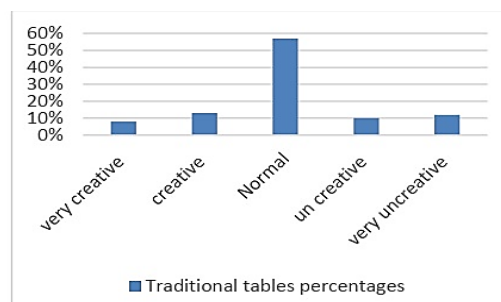
II. Traditional tables (see Fig. 22):



Fig 22: Traditional tables [53].

It is clear that (see Graph.No.16):

- 8% finds that the level of creativity and innovation in traditional tables is very creative.
- while 13% finds that the level is creative.
- 57% finds that the level is normal.
- 10% finds that the level is not uncreative.
- and 12% finds that the level is very uncreative.



Graph.No.16: Traditional tables percentages, Source: researcher.

Statistical analysis has been done for collecting data from the participant responses: for the Traditional tables as shown in Table (11): mean of the answers was 2.05, median=1.98, std. deviation=1.75, variance=1.65

TABLE (11): A STATISTICAL TABLE ANALYSIS FOR ANSWERS OF THE SURVEY ABOUT TRADITIONAL TABLES, SOURCE: RESEARCHER USING SPSS.

Row	Range		Last Frequent		Most Frequent		Mean	Midian	Standard Deviation	Variance
	From	To	frequency	Value	Frequency	Value				
Traditional tables	1	39	4	4	2	18	2.05	1.98	1.75	1.65

Part Three (Reliability Statistics):

Reliability Statistics has been done for collecting data from the participant responses for the Part Three (Comparison) as shown in Table (12): Cronbach's Alpha of the answers was 0.891

TABLE (12): A. RELIABILITY STATISTICS OF PART THREE, SOURCE: RESEARCHER USING SPSS.

Reliability Statistics	
Cronbach's Alpha	N of Items
.891	4

9. LIMITATIONS OF THE STUDY:

This paper is concentrating on parametric design tools and their effects on increasing the creativity level of furniture designers in the conceptual stage furniture design process.

10. CONCLUSIONS

- We conclude that parametric design tools for interior furniture actually help designers to make important creative and original designs. This is because they are more than just traditional engineering design tools. In this paper, we focus on the tools, criteria and indicators of parametric interior design furniture and their effects on increasing levels of creativity.
- Parametric design tools are basically defined as the generation of a computational design concept that provides more options than the human mind can cover while making decisions in the conceptual design process. Thus, generating new ideas and creativity are issues that most furniture designers find difficulties with because it requires imagination and a high level of creativity.
- methodology consists of three stages. In the first stage, questionnaire and a survey on the main concepts, familiarity, and applications of parametric design in furniture and interior design is done. Then, the stage of measuring the success and extent of fulfillment of parametric design characteristics criteria and indices in the modern parametric furniture. Finally, comparing the levels of creativity in some proposed types of traditional and parametric furniture (i.e., chairs and tables) in furniture interior design. A survey was prepared and distributed to 40 architects who had experience in furniture design to rate the creativity level of each furniture, the participants were 27 males and 13 females.
- We can see that from the preliminary results of a first-part analysis, we found that 29% of the sample have a very good impression of the parametric architecture, 40% have a good impression, 20% have an acceptable impression, and 11% have an unacceptable impression.

Reliability Statistics has been done for collecting data from the participant responses for the Part One (Survey), Cronbach's Alpha of the answers was 0.808 It is good acceptable rate for testing the validity and reliability of the Survey questionnaire.

- From the analysis results of the second Part The survey is prepared and distributed to the proposed study sample (40 professionals) of architects, designers and specialists to assess the extent to which the parametric design criteria and indices are met. The maximum percentages for each index separately are as follows:
 - In the Aesthetics index, the highest percentage is 47% (good), mean of the answers was 2.5 median=2, std. deviation=1.75, variance=1.65

- In the Elegance Index, the highest percentage is 45% (good), mean of the answers was 2.49, median=1.99, std. deviation=1.70, variance=1.65
- In the Originality index, the highest percentage is 45% (acceptable), mean of the answers was 2.25, median=1.78, std. deviation=1.70, variance=1.05
- In the Innovation index, the highest percentage is 53% (good), mean of the answers was 2.5, median=2, std. deviation=1.75, variance=1.65
- In the Functional index, the highest percentage is 43% (good), mean of the answers was 2.66, median=2.2, std. deviation=1.70, variance=1.05

Reliability Statistics has been done for collecting data from the participant responses for the Part Two (Measurement), Cronbach's Alpha of the answers was 0.855 It is a very good acceptable rate for testing the validity and reliability of the Measurement questionnaire.

- While in the Third part the survey is prepared to compare the levels of innovation and creativity in some proposed examples of traditional and parametric furniture (e.g., chairs and tables) in furniture interior design, the highest percentages are as follows:

I. Chairs:

- For parametric chairs, the highest percentage is 38% (creative), mean of the answers was 2.65, median=2.44, std. deviation=1.77, variance=1.44
- For traditional chairs, the highest percentage is 41% (normal), mean of the answers was 2.5, median=2, std. deviation=1.75, variance=1.65

II. Tables:

- For the parametric tables, the highest percentage is 40% (creative), mean of the answers was 2.75, median=1.8, std. deviation=1.44, variance=1.10
- For traditional tables, the highest percentage is 57% (normal), mean of the answers was 2.05, median=1.98, std. deviation=1.75, variance=1.65

Reliability Statistics has been done for collecting data from the participant responses for the Part Three (Comparison), Cronbach's Alpha of the answers was 0.891 It is a very good acceptable rate for testing the validity and reliability of the comparison questionnaire.

- we can conclude that parametric design tools indeed helps designers to do creative designs more than geometric based design tools ,the main highlight of furniture in interior design in parametric digital architecture, for the most part, is The lack of realism is to a very great degree, and we always find a clear increase in interactivity, vitality and vitality. The furniture is in harmony with the surrounding environment. While we conclude that the least parametric characteristic of digital furniture is the imitation of nature or the tendency to everything that is traditional, as well as often inclined to everything exotic and unusual.

11. RECOMMENDATIONS

1. The research suggests applying the applied research study on a larger scale on all the parametric interior design elements, not just some types of furniture, and examining the psychological impact of that on the user behavior.
2. The need to increase the cultural and scientific awareness among designers on such new concepts in design through new parametric design computer software.
3. The inevitability and necessity of taking advantage of pros derived from the parametric design questionnaire and avoiding the cons that were reached through the research study.
4. The necessity of applying and including parametric design systems within the academic curricula in specialized colleges (e.g., engineering and applied arts) so that students can keep pace with the requirements of the modern market in the field of parametric interior design.

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12. APPENDIX:

A questionnaire form (see Fig.23) is prepared on the parametric design concept and its applications in furniture and interior design. It is applied to a sample (40 professionals) Participants were 27 males and 13 females of architects and specialists in this field, to know their theoretical background, information, awareness, impressions and influence on parametric design concepts:

1- Did you know about the existence of the term (parametric architecture) or (digital architecture) before?			
Yes	No	Not sure	
2- What level of informational background do you have about digital architecture and parametric design?			
I have good information	I have simple information	I have no information about that	
3- By looking at some examples of parametric design in the following pictures, what is your impression of this type of design?			
			
Very good	Good	Acceptable	Unacceptable
4- By looking at some examples of parametric design in the following pictures, can you, as a specialist, adopt the concept of digital parametric design and use it, whether in architectural design or interior design?			
			
Yes	No	The possibility of this can be known after studying this architectural trend and its mechanisms.	
5- By looking at some examples of parametric design in the following pictures, do you find that digital parametric design has added more aesthetic and functional values to furniture than traditional design?			
			
Yes	No	To some extent	
6- From the above, in your point of view, what are the pros and cons of the parametric design?			
Pros:-----		Cons:-----	
7- Through the information available in the questionnaire, has information been added about the parametric design concept?			
Yes	No	To some extent	

Fig.23: Questionnaire form, source: the researcher.