An applied vision of integrated parametric design as a sustainable design (Student experiment)

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Abstract:

Parametric design is one of the most important design methodologies that provides designers with flexibility and creativity, regardless of the complexity of the design. With technological advancements, designers have been able to execute numerous complex organic designs through parametric design. Given the current global trend that supports sustainability and sustainable design, influenced by climate change issues and the importance of mitigating them for human survival, it has become necessary for designers to seek design solutions that align with the current global concept. Integrating parametric design with sustainability is one of the key approaches that must be followed.

This research is based on a collaborative study between the department of interior design and furniture, and the department product design, aiming to utilize parametric design to find alternative and unconventional solutions to design and implementation problems within the framework of sustainability. This was achieved through practical application experiments conducted in the courses of Structural Analysis and Form Technology in the Product Design Department, as well as Administrative Facilities and Presentation methods and techniques courses in the Interior Design and Furniture Department. These experiments were based on the concept of sustainable parametric design.

The research highlights the importance of parametric design and its capabilities in enhancing the creative aspect of sustainable design to support the issue of climate change and its mitigation. The use of modern applications and parametric techniques in design helps achieve sustainability by providing sustainable materials, utilizing clean energy, and reducing waste. New applications have been developed in the field of parametric design, emphasizing the role of both product design and interior design and furniture departments in promoting the concept of sustainability through parametric design and utilizing it to preserve the environment and reduce current environmental damage. Therefore, we recommend increasing scientific practical design experiments that support environmental issues and address current climate change challenges.

Keywords:

Sustainability, Product design, Interior design and Furniture

الملخص:

التصميم البارامتري أحد أهم طرق التصميم، والذي يعطي للمصمم المساحة في التصميم والابداع مهما كانت درجة تعقيدة ومع التقدم التكنولوجي استطاع المصمم تنفيذ العديد من التصميمات العضوية المعقدة من خلال التصميم البارامتري.
نظرا للأتجاه العالمي الحالي الذي يدعم فكرة الاستدامة والتصميم المستدام متأثرا بقضية التغيرات المناخية وأهمية الحد منها من أجل بقاء الانسان. كان لزاما علي المصمم ان يسعي للحلول التصميمية لمحاولة التلائم مع المفهوم العالمي الحالي وكان دمج التصميم البارامتري مع الاستدامة أحد أهم الطرق التي يجب إتباعها.

البحث قائم علي دراسة مشتركة بين قسمي التصميم الداخلي و الاثاث وتصميم المنتجات للإستفادة من التصميم البارامتري في ايجاد بدائل وحلول غير تقليدية لمشاكل التصميم والتنفيذ في اطار الاستدامة من خلال إجراء تجارب تطبيقية عملية في مقرر تحليل بنائي وتقنية شكل بقسم تصميم المنتجات، ومقرري منشأت إدارية،و مقرر أساليب و تقنيات إخراج بقسم التصميم الداخلي و الأثاث،و كانت التجارب قائمة علي مفهوم التصميم البارامتري المستدام. توضح أهمية التصميم البارامتري وإمكانياته في تعزيز الجانب الابداعي في التصميم المستدام لدعم قضية التغيرات المناخية و الحد منها. فاستخدام التطبيقات الحديثة والتقنيات البارامترية في التصميم يساعد علي تحقيق الاستدامة والاستفادة منها في توفير الخامات المستخدمة،و إستخدام الطاقات النظيفة،و تقليل الهادر الناتج.

تم التوصل الي تطبيقات جديدة في مجال التصميم البارامتري، والتأكيد علي دور كلا من قسمي تصميم المنتجات والتصميم الداخلي والأثاث في تعزيز مفهوم الاستدامة من خلال التصميم البارامتري والاستفادة منه في الحفاظ علي البيئة وتقليل الاضرار البيئية الحالية؛و لذلك نوصي بزيادة التجارب العلمية التطبيقية التصميمية الخاصة بدعم القضية البيئية والحد من التغيرات المناخية الحالية.

الكلمات المفتاحية :

الإستدامة – التغير المناخي – التصميم الداخلي و الأثاث – تصميم المنتجات

Introduction:

Parametric design is one of the most important design methods, which gives the designer space in design and creativity, regardless of the degree of complexity. With technological progress, the designer has been able to implement many complex organic designs through parametric design.

But with the current climate changes that threaten humans, the designer must seek solutions through design. Emphasizing the importance of applying sustainability standards.

Research problem:

The problem of the research is to show the importance of parametric design in the fields of product design and furniture design and how to benefit from it to produce many typical ideas and alternatives, within the framework of sustainability.

Research objective:

-Finding unconventional alternatives and solutions to design and implementation problems.

-Conducting an applied experiment that demonstrates the importance of parametric design and its potential in enhancing the creative aspect of design.

-Demonstrating the outcomes of both specializations in design by means of Structural analysis and form technique in the Administrative Structures course (2), the Production Methods course in the Furniture Interior Design Department, and the Structural Analysis and Form Technology course in the Product Design Department.

Research Importance:
Highlighting the importance of parametric applications and techniques in interior design and contemporary product design in light of sustainability.

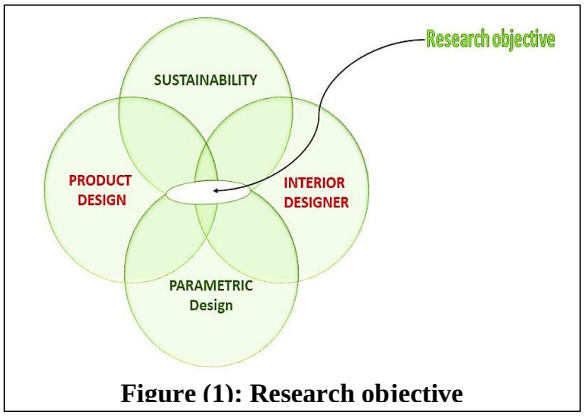


Figure (1): Research objective

Research hypotheses:
Preparing and studying sustainable parametric designs through a student experience in the Interior and Furniture Design Department and the Product Design Department.

search limits:
Time limits: The second semester - for 14 weeks, one lecture per week
Spatial boundaries: Faculty of Applied Arts - 6th of October University
Research Methodology: Due to the nature of the research and its objectives, the researchers relied on the descriptive, analytical and experimental method.
Study plan: It consists of eight successive stages shown as follows:

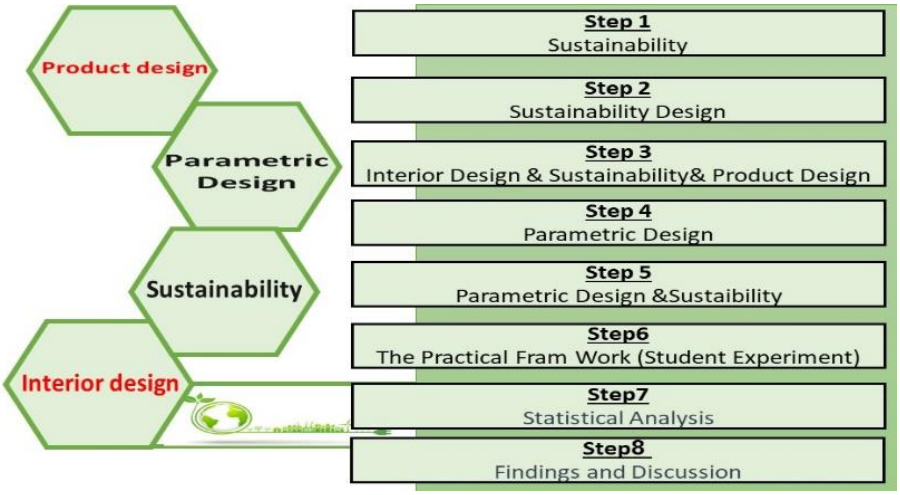


Figure (2): A diagram of the research stages

Educational Needs for Teaching by the Two Specializations at the Faculty of Applied Arts:

1. Comprehensive Vision:

- Develop a curriculum development plan by enhancing teaching methods and utilizing modern techniques.
- Present various learning approaches, including lectures, best practices, and critical thinking.

- Foster collaboration between instructors in both specializations.
- Share knowledge by participating in research groups and presenting findings through presentations.

2. Specialization Needs:

- Coordinate among instructors to establish teaching strategies.
- Provide the necessary laboratories and equipment at the college, such as Laser Cut machines, 3D printing facilities, and CNC machines.

3. Educational Outcomes:

- Achieve innovation and creativity in design among the students, enabling them to create non-conventional and diverse forms in the fields of interior design and product design.
- Develop an educational output for project evaluation.
- Measure the success of the educational process through statistical analysis.
- Collect and analyze data to contribute to the continuous improvement of education and teaching at the Faculty of Applied Art

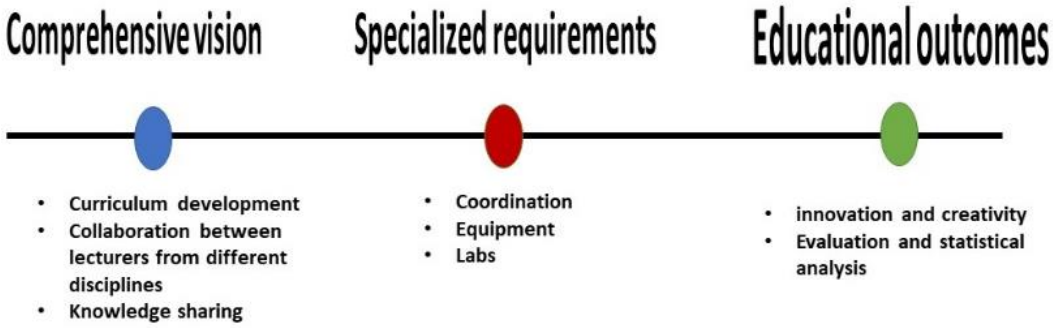


Figure (3) A schematic diagram illustrating the organization of the relationship between the key points of teaching management in the two specialties".

Firstly: Sustainability

The concept of sustainability dates back to the early 1970s, derived from the Latin word "sustinere," which means "to hold up." The term sustainability has multiple interpretations depending on its context of use, and it can be defined as follows:

"Figure (4): Sustainability"

1. **Environmental Sustainability:** This concept primarily pertains to the environment and signifies the continuity of life based on natural resources.
2. **Sustainable Development:** It refers to a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
3. **Sustainability in Design and Place:** This perspective emphasizes the integration of natural systems with human patterns to ensure the continuity and uniqueness of place-making.

Sustainability in essence means engaging in activities that benefit someone in the future. It revolves around three interconnected areas: Environmental Sustainability, Social Sustainability, and Economic Sustainability. Achieving sustainability in these areas allows us to lead a truly sustainable life. **Figure (4)**

Sustainability goes beyond the traditional concept of green living. Therefore, we all have endless opportunities to make a real and lasting difference in our lives.

Sustainability and sustainable development focus on balancing the assessment of needs, our need for technological and economic use, and the need to protect the environments in which we live. Sustainability is not only about the environment; it is also about the health of communities and ensuring that people do not suffer due to environmental regulations. It involves assessing the long-term impacts of human actions and asking questions about how to improve the situation. To achieve sustainability, it requires reducing resource and energy consumption.

Secondly: Sustainability Design

The philosophy of environmentally sustainable design is a philosophy that encompasses the design of material things, the environment, and services to conform to the principles of environmental sustainability. It is a philosophy that seeks to maximize the quality of life while minimizing damage to the natural environment. (**figure5)** Sustainable design is the kind of design that seeks to reduce negative environmental, social, and economic impacts by considering sustainability (environmental preservation) throughout all stages of the design process and the final product execution, as well as after the product's assumed life has ended. This includes using environmentally friendly materials, clean energy sources, reducing material use, and facilitating recyclability at the end of a product's life.

"Figure (5): Sustainable Design"

Sustainable design is achieved by following several important principles during the design process, including:

- Minimizing energy and water consumption throughout the product's lifecycle, from manufacturing to use and disposal.
- Reducing emissions of greenhouse gases that contribute to climate change and harm the environment.
- Utilizing new and renewable energy sources.
- Limiting resource consumption through waste-free manufacturing and a focus on recyclable materials.

Examples of sustainable design:

1. A designed seat for proper body relaxation executed using parametric design and constructed using wooden slats to minimize material usage and promote environmental sustainability. **(Figure 6)**

Figure (6): a seat executed using structural analysis method.

2. The KAGURA system, created by Chaozhi Lin, consists of three main parts: a food waste container, a tall light structure, and three clay pots. The food waste container transforms organic food leftovers into compost used for fertilizing indoor plant pots. The slim and attractive light fixture is positioned directly above the KAGURA garden pots, providing the mini garden with nourishing light energy. The self-sustaining indoor gardening system is compact and suitable for any kitchen or living space**. (Figure 7)**

Figure (7): KAGURA system.

Thirdly :Interior Design& Sustainability& Product Design:

Drawing conclusions on the specific parameters of sustainable parametric design between interior design and product design:

Parametric design enhances sustainability in architecture in general and interior design in particular. This type of design can achieve numerous environmental, economic, and social benefits, as illustrated in Table (1):

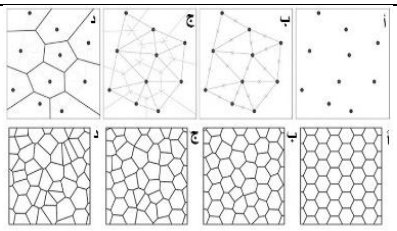
Sustainability	Application in Parametric Design
1. Reduced Use of Harmful Materials for the Environment.	Parametric designs can use alternative and sustainable materials in construction and interior design, such as sustainable wood, plant fibres, and other biodegradable materials.
2. Energy Efficiency	Precise lighting and ventilation system design can improve energy consumption efficiency and environmental compatibility.
3. Waste Control and Cost Reduction	Parametric designs can achieve efficiency and waste control in water, energy, and other materials in interior design, reducing costs and resources required for building and furniture maintenance.
4. Emission Reduction	Parametric designs can reduce harmful emissions to the environment and minimize the negative impact on public health.

5. Waste Management	Furniture and furnishings should be designed for future recycling and reuse, and waste should be managed properly and sustainably.
6. Modern Technologies	Modern technologies like 3D printing and computer-aided design can be used in parametric design to enhance efficiency, precision, and sustainability.
7. Aesthetic and Functional Values	Parametric design should achieve aesthetic, well-being, and functional values, perfectly meeting the users' needs.

Table (1): Drawing conclusions on the specific parameters of sustainable parametric design between interior design and product design.

Fourth: Parametric Design

There are several meanings for the term parametric design, including "boundary design," "design modeling," "standardized design," or "variable design." It can also be defined as "variable design." Parametric design represents a rebellion against old guidelines. Patrick Schumacher, who was a partner at Zaha Hadid Architects at the time, coined the term "parametric."



"Figure (8): the parametric design process as a method for connecting dimensions and geometric variables"

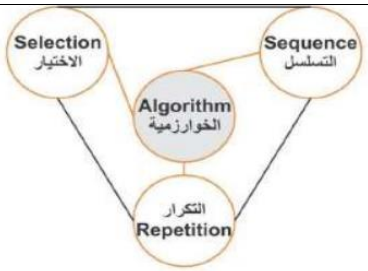
Parametric design is a system built on algorithmic calculations, typically a well-defined series of instructions processed by computer software in a sequence of mathematical and logical steps, visually simulating the desired design.

Most computer-aided design (CAD) programs today use a design concept called "Parametrics," which is defined as a method for linking geometric dimensions and variables in a way that allows continuous changes in shapes. This study aims to shed light on one of the modern theories that impact advanced environmental designs, which, in turn, affect interior design and product design both aesthetically and functionally. It illustrates ways to develop the design process to align with the future dimensions of parametric theory as a design method that enables continuous changes in shapes while

maintaining non-symmetrical, harmonious, and infinite connections, as shown in **(figure 8).**

Algorithms Designing:

Algorithms Designing is a sequence of ideas aimed at helping to understand a problem and present possible solutions. It also serves as a means to identify new problems. It can be defined as the compilation of various types of information through a system to meet the designer's needs and provide the output in a geometric form.



"Figure (9): the triple structures of the algorithm"

Parametric Forms and Shapes Generation

The advancement of information technology has greatly facilitated the shaping and configuration for designers, providing them with a wide range of ideas that were not available before. When using computer-aided design and computer-aided manufacturing (CAD/CAM) software, as well as 3D modeling software like 3D Max, designers can break away from conventional geometric shapes such as cylinders, pyramids, cubes, prisms, and spheres, as shown in Figure (10). These shapes were used in ancient Egyptian civilizations, for example, even before the advent of digital technology in design. These shapes have transformed into[3] dynamic, kinetic forms , as shown in Figure (11)

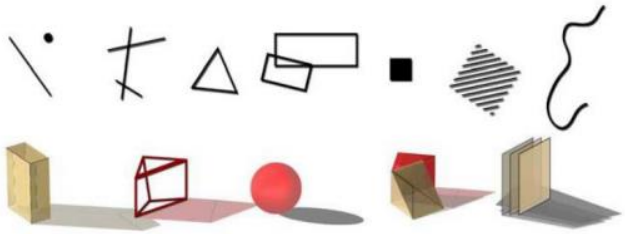


Figure (10): illustrates some of the typical geometric shapes that were used in design before parametric design.

Sources of inspiration for digital parametric shapes and designs can be categorized into:

1. Shapes inspired by nature, such as living organisms, plants, and more.
2. Shapes and patterns preserved in digital programs, such as traditional Islamic patterns and other motifs.
3. Shapes inspired by geometric solids that can be generated using digital software, especially 3D modeling software like 3D Max, Solid Works, and Rhino Script.[5]

[4]

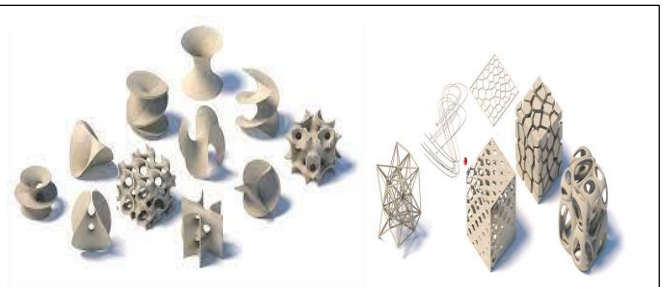


Figure (11): illustrates some of the non-standard shapes that can be created using digital modeling with a computer.

The Importance of Parametric Design in Interior and Product Design:

- Applying the principles of parametric design in the early stages, all the way to the actual construction, changes the nature and sequence of traditional design processes.
- Parametric design offers an infinite number of different possibilities.
- Quantitative production using computer-aided manufacturing processes reduces industrial production costs.
- Elements are interconnected, forming an infinite set of adjustable possibilities that align with the client's needs.
- Complex designs can be executed, with the ability to calculate pressures, hardness, elongation rates, material weights, and loads, among other factors.[6]) (

Examples of Parametric Design:

1. Objectile Project: Objectile calculates designs of curved and variable shapes and produces them using digital manufacturing mechanisms through the Topcad program. This allows for quantitative production of items such as furniture and interior partitions. These designs are characterized by their versatility and adjustability to meet the client's needs before production.

Figure (12): shows images of "Objectile" products.

2. **Interior Design of the Benetton Tower (Tehran, Iran):** Designed by the architect Aquili Alberg in 2009, the interior design of the Benetton Tower showcases the impact of diverse geometric spaces in its facades. Some spaces were treated as architectural openings, while others became flat surfaces, influencing the overall spatial configuration. Parametric design played a significant role in reshaping both the internal and external aspects of the design.[7]

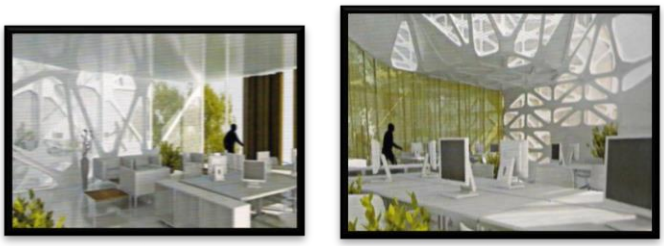


Figure (13): shows the interior design of the Benetton Tower building (Tehran, Iran).

Fifth: Sustainability and Parametric Design

Parametric design is inherently sustainable as it can lead to structures that are more environmentally friendly by reducing waste and energy consumption during construction. Reusability and recycling are fundamental principles of sustainability. An integrated design where every element is a crucial part of the larger whole is vital for the success of sustainable design.

For example, Egyptian engineer "Hanaa Dahy" designed an invention that integrates natural fibers (rice straw) with other materials to serve modern technology while preserving the environment by disposing of rice straw waste. Another example is the experimental BOXEL pavilion designed and built by students from the Department of Architecture at the University of Applied Sciences in Detmold. It consists of over 2,000 boxes organized along the free-form structure. The "Parametric Lamp" chairs, designed by Vincent Callebaut Architectures, are made from natural fibers derived from agricultural waste. They are 3D-printed to create comfortable, complex geometries with smooth lines, significantly reducing energy consumption and materials used.

These examples demonstrate how parametric design can contribute to sustainability by minimizing waste and promoting the use of eco-friendly materials.[8][9]

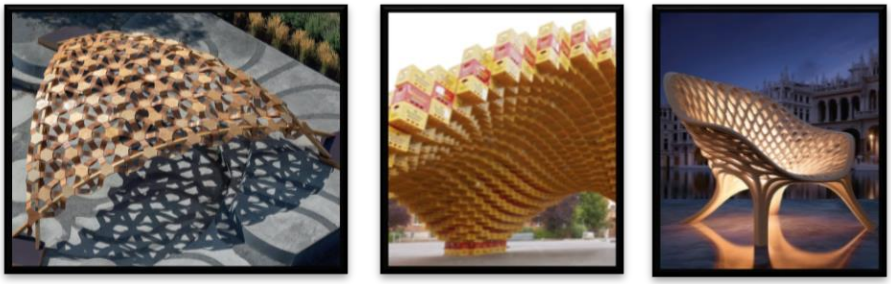


Figure (14): On the right, a pavilion designed by the Egyptian engineer "Hanaa Dahy" made from natural fibers (rice straw). In the middle, a picture of the BOXEL pavilion. On the left, the "Parametric Lamp" chairs designed by Vincent Callebaut Architectures.
https://parametric-architecture.com/vincent-callebaut-architectures-parametric-lampchairs-showcasing-the-potential-of-agro-waste/

Sixth: The Practical Framework (Student Experiment)

The current research methodology (descriptive-experimental) enables the realization of research hypotheses by applying a set of research experiment steps in a number of practical sessions with students according to a timeline during the second semester. These steps were conducted as follows:

1. Parametric Design and its Applications in Interior Design and Furniture - Applied Experiment.

An applied experiment was conducted in two courses, "Design of Administrative Facilities (2)" for third-year students and "Introduction to Design Methods" for first-year students in the Interior Design and Furniture Department, Faculty of Applied Arts, 6th of October University. Sustainability concepts were integrated into the course outcomes through student guidance and the reinforcement of parametric analysis and design methods, highlighting their importance in achieving environmental sustainability.

The course was divided into several stages:

- **Descriptive stage 1**: Introducing parametric design to students and the importance of using it for sustainability.
- **Descriptive stage 2**: Each student conducted scientific research to study and analyze the requirements of their specific project, including examining similar case studies and working closely with the instructors to determine the optimal project analysis.
- **Experimental stages 3 to 7**: These stages focused on the design process.
  - **Stage 3**: Initial sketching and comparing various design options.
  - **Stage 4**: Introduction to modern digital design software for parametric modeling, such as 3Ds Max, Photoshop, SketchUp, Blender, and AI software, and students were asked to apply these tools to confirm their understanding.
  - **Stage 5**: Implementing the final design concept through 3D digital simulations on modern digital simulation software to visualize the interior spaces of the project.
  - **Stage 6**: Preparing the execution drawings for the project.
  - **Stage 7**: Creating a prototype model of the design concept to experience the mass and void.

Sample: The sample consisted of randomly selected students enrolled in the course.

project (1)

Etisalat Company is a parametric design based on inspiration from the water waves in the sea, as well as the color petal inspired by nature. It relied on the intersection of the lines of the sea waves with the circular line to create the formation of the company's horizontal landscape. Accordingly, the open, semi-open and closed interior spaces were divided and distributed. Horizontal and vertical green spaces, which work to connect the interior with the exterior, replenish natural air, and also act as sound insulation.

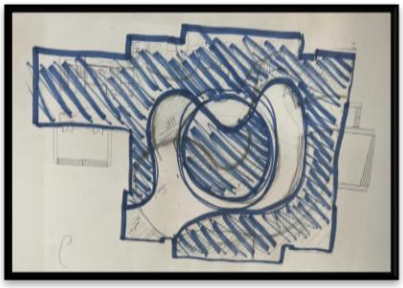


Figure (15): Initial sketches of the design idea for the horizontal projection.

Responding to the formation of flooring in the ceiling with a skylight to help provide good natural lighting, which increases the production of employees within the company and also works to save electrical energy, as in the figure (17).

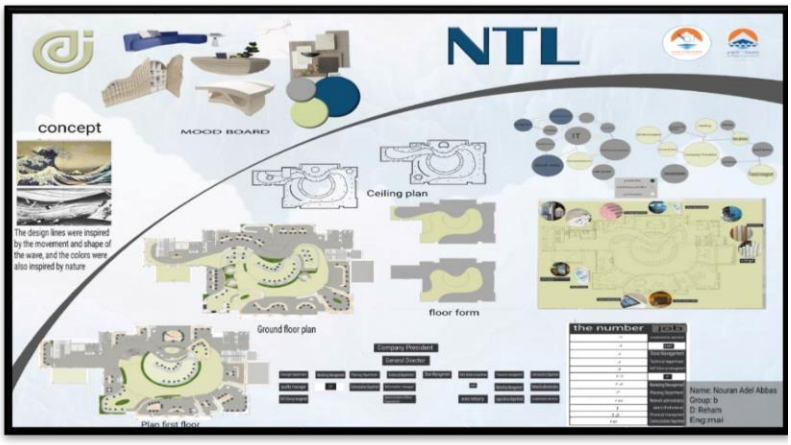


Figure (16): The final plan panel for the idea. The final design of the horizontal project includes the form panels, furniture, ceiling, and plank, explaining the technologies used..

Figure (17) On the right: The painting includes internal sectors and perspective shots. On the left: Perspective shots of the project

The partition design follows parametric design with free flexible formation inspired by the nature of waves, using modern technological methods in design using the 3D Max program, while achieving sustainability standards by combining transparency to achieve a visual connection with the external environment and wood slices to reduce the materials used in addition to being an environmentally friendly material. As shown in Figure (18).

Figure (18) A perspective shot of the barracks in the reception area, and on the left are the projections of the furniture piece.

Project (2):

A telecommunications company, where the basic design idea of the project was based on the parametric design inspired by sand dunes in the desert, starting with the design of the formation of the plan, offset by the ceilings and walls, which helped in achieving flow and flexibility, as in Figure (19).

Figure (19): Right: The final plan for the idea. The final design for the horizontal project includes the form panels, furniture, ceiling, lighting, the company's functional structure, and the Babel Digram. Left:

A multi-functional parametric design that combines its function as a partition and a seating area in the waiting area, with a parametric design inspired by sand dunes, based on the combination of environmentally friendly wood slats as a saving on the material used and the green wall system as part of the formation for an environmental purpose by renewing the air, sound insulation, and connection with nature. As in Figure (21).

Figure (20) Sustainable parametric chair maquette made of SL wood slices.

Figure (21) on the right: a perspective of the partition and on the left: the geometric projections of the furniture piece

Project (3):

Bank project: The student followed the geometric design method inspired by logo lines by merging the lines of the square, then making a rotational movement for the square with the diagonal lines, arriving at a dynamic design in dividing the spaces, creating open spaces horizontally and vertically, and integrating the interior with the exterior through horizontal and vertical green spaces, and openings. The ceiling has an open geometric design with the presence of a mezzanine to provide good ventilation and natural lighting within the internal spaces, and to exploit the division of multi-purpose halls with a moving partition design with a parametric geometric design characterized by light weight, ease of movement and transparency through smart glass for visual expansion and access to natural lighting. Better in spaces, with the possibility of changing the transparency of the glass to opaque to achieve privacy, as in Figure (22).

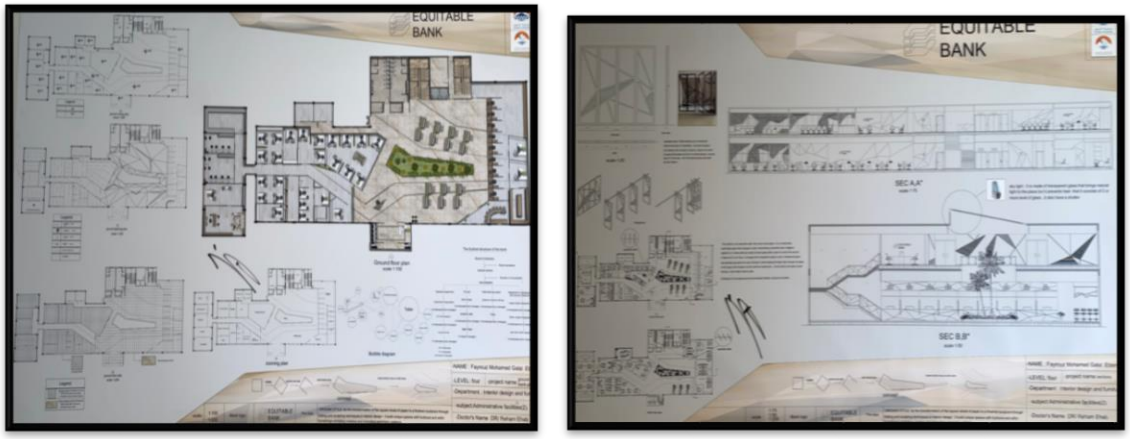


Figure (22): Right: Horizontal projection panel for the project, and left: Panel that includes on the right a longitudinal section and a cross section explaining the exploitation of the mezzanine area by creating green spaces and Skylight, and on the left the design of the mobile partition and signing its locations on the plan.

By making fixed internal vertical shades from slats that carry the same refracted geometric design lines to provide indirect natural lighting and thus control the intensity of lighting without disturbing the appearance of the external destinations in the tribal and western destinations, which works to increase the concentration of employees and thus increase production capacity .

Figure (23) Perspective shots of the bank showing the different treatments of the walls and panoramic window openings without disturbing the form of the artistic painting of the external landscape.

Project (4):

Designing a bank with a parametric design with broken lines is sustainable by combining the bindings and green walls, and in the double height area, the student was keen to create a double height area and Skylight to penetrate the natural lighting from the skylight and penetrate the internal spaces of the company to a greater extent, as in Figure (24). The design of Foldable furniture that is easy to move and lightweight for multiple mobile uses, as shown in Figure (25).

Figure (24): On the right: a panel of the horizontal projections of the project, and on the left: a panel that includes the longitudinal and transverse vertical sectors and two enlarged sectors in one of the departments.

Figure (25) plate includes drawings of the furniture piece and interior views.

Project (5):

Design for a bank with refracted parametric lines inspired by the bank's logo and achieving sustainability by connecting with the natural environment. Improving air quality and interior lighting through the elements (waterfall - planting - water - architectural openings (vertical and horizontal in the ceiling) - mezzanine), which reduces It eliminates the need to use artificial lighting and improves the working environment inside the building, which achieves increased energy efficiency and reduced electricity consumption. Optimizing design and manufacturing processes By using parametric design methods, material and waste can be reduced.

Figure (26) On the right: The ground floor plank, on the left: The first floor plank.

Figure (27) panel of colored sectors in the entrance area, the teller, the manager, and customer service.

Figure(28) Perspective shots panel

For the reception area, a panel of wood slices was made to give an optical illusion that suggests depth and movement. A student experiment using modern technological means of artificial

intelligence programs by applying the Mid Journey application to reach different ideas for sustainable geometric design in different administrative spaces, as in Figure (29)..

Figure (29) Perspective shots using the AI program on the Mid Journey application in the initial stages of design.

A multi-use piece of furniture that can be folded and unfolded to enlarge and reduce and make better use of the company's internal spaces, especially in multi-purpose spaces. The student began by folding the paper and coming up with several results and functions:

In the vertical position: it acts as a separator between the spaces. They are strips that can be made of environmentally friendly materials such as wood or lightweight cardboard. These strips achieve privacy in the semi-open work spaces, which works to penetrate indirect natural lighting from them, which saves energy while achieving visual connectivity. Between the spaces and the external nature, it helps increase the productive efficiency of employees within the company, as shown in the figure (30)

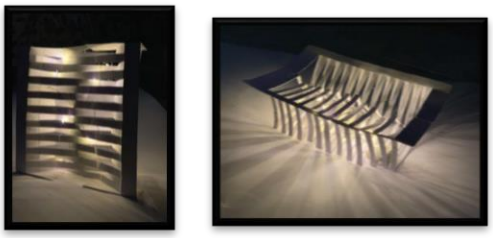


Figure (30) simulating the design idea by making a miniature prototype of a piece of furniture using cardboard, thus being able to reach more than one result and more than one design treatment, explaining the development of the design idea between the vertical position and the horizontal position.

As for the horizontal position: it works as a meeting table made of wooden strips to save on material. It is foldable to enlarge and reduce the work surface, as shown in the figure.

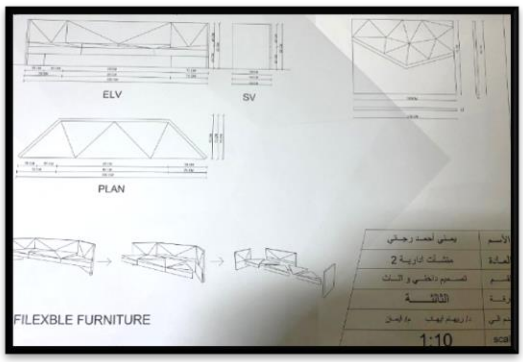


Figure (31) panel of the piece of furniture for seating in the waiting area.

Design flexible furniture in the reception area that can be dismantled and assembled with the possibility of converting it to this function. It can be assembled as a sofa for sitting in the waiting area of the bank or assembled vertically as a separator between the different administrative spaces, as in the figure (31).

2. parametric design and its applications in product design

The practical application was conducted in the course of Structural Analysis and Shape Technology in the second year of the Product Design Department at the Faculty of Applied Arts, 6th of October University. The concept of sustainability was applied to the outputs of the course by guiding the students and emphasizing the importance of structural analysis, geometric design, and their role in environmental sustainability through the reduction of materials used. The course was divided into several stages, which are:

First stage, the student is introduced to the concept of parametric design and geometric design, as well as their importance in achieving sustainability.

Second stage, the student works on simple and abstract applications of parametric and geometric design, focusing on how these designs can help conserve materials. One such application involves designing a different cube while maintaining geometric and parametric principles through subtraction and addition, while also ensuring balance and achieving the desired aesthetic form. Figure (32)

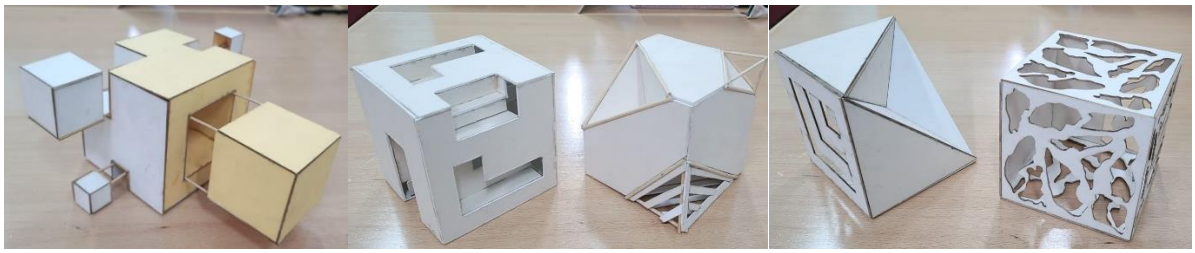


Figure (32) cupics designed by Geometric& parametric designs

Third stage, the student is introduced to software programs that assist in analyzing products using parametric shapes, such as the Slicer program. The student is then requested to apply the program to confirm their proficiency in using it and to assess their understanding of the software's capabilities.

Fourth stage, each student selects their final project. They study and analyze their respective projects with their instructors to achieve the optimal analysis and initial implementation. The project idea is based on studying and analyzing existing pergolas for reconstruction using the principles of structural analysis, parametric design, and geometric design.

This approach aims to provide efficient use of building materials and conserve industrial energy by replacing it with natural lighting through the study of open pergola designs, in line with sustainability principles. Figures (33_41)

Project 1

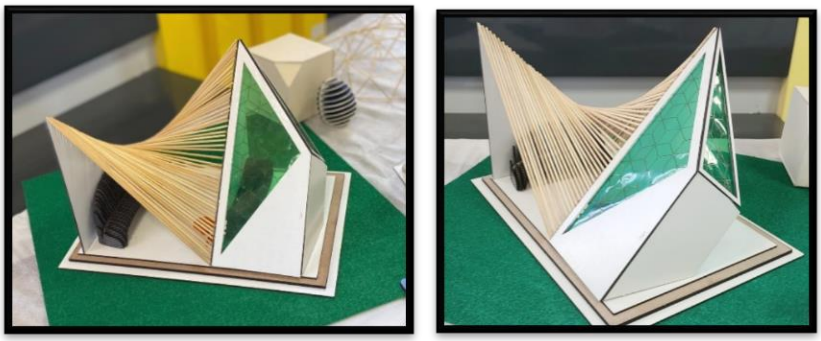


Figure (33): Design of a pergola using the Geometric design & parametric design technique. The student analysed the design well and reconstructed it, taking into account all the building proportions, ventilation areas, internal movement paths, and entry and exit openings. With a simplified design for the interior furniture used in the same style with the pergola design, it was built using the Parametric technique.

Project 2

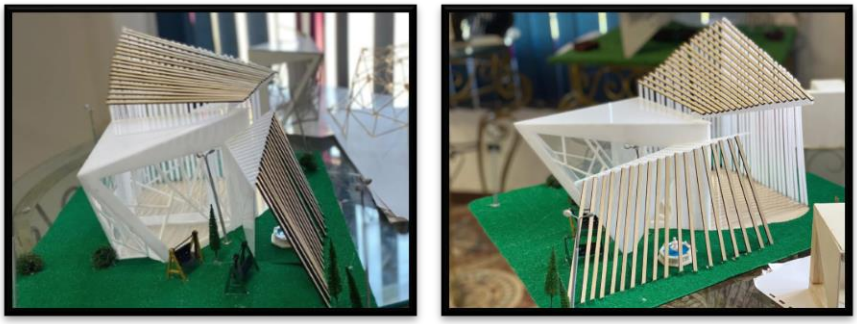


Figure (34): Design of a pergola using the Geometric design & parametric design technique. The student analysed the design well and reconstructed it, taking into account all the structural proportions, ventilation areas, internal movement paths, and entry and exit openings.

Project 3

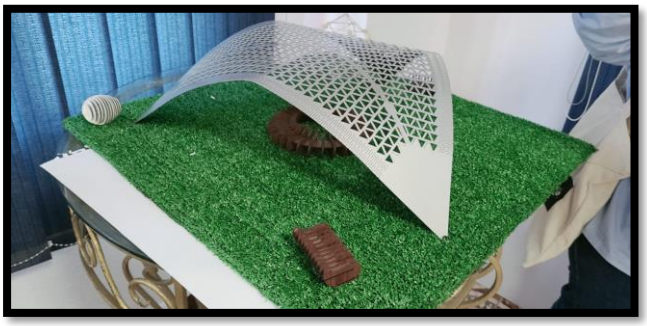


Figure (35): Design for a pergola. Engineering design technique. The student analysed the good design of the structure, taking into account all the structural proportions of progression, internal movement paths, entry and exit permits, and providing the opportunity to benefit from the maximum of the natural. With simplified design of interior furniture used and construction of parametric technology.

Project 4

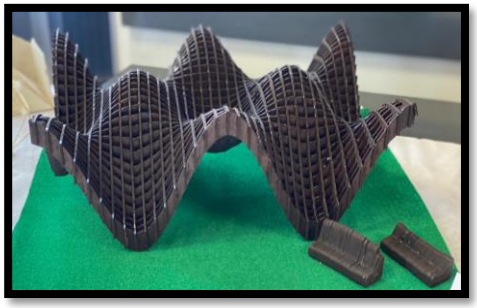


Figure (36): Design for organic shape pergolas using the parametric design technique. The student analysed the design well and reconstructed it, taking into account all the structural proportions, ventilation areas, internal movement paths, and entry and exit openings. With a simplified design for the interior furniture used in the same style with the pergola design, it was built using Parametric technology.

Project 5

Figure (37): Design of a pergola using the Geometric design technique. The student analysed the design well and reconstructed it, taking into account all the structural proportions, ventilation areas, internal movement paths, and entry and exit openings.

Project 6

Figure (38): Design of a pergola using the Geometric design & parametric design technique. The student analysed the design well and reconstructed it, taking into account all the structural proportions, ventilation areas, internal movement paths, and entry and exit openings. With a simplified design for the interior furniture. it was built using Parametric technology.

Project 7

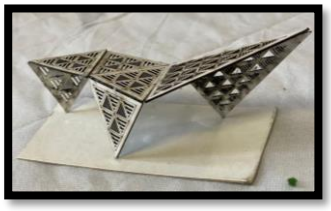


Figure (39): Design of a pergola using the Geometric design & parametric design technique. The student analysed the design well and reconstructed it, taking into account all the structural proportions, ventilation areas, internal movement paths, and entry and exit openings.

Project 8

Figure (40): Design of a pergola using the Geometric design & parametric design technique. The student analysed the design well and reconstructed it, taking into account all the structural proportions, ventilation areas, internal movement paths, and entry and exit openings.

Project 9

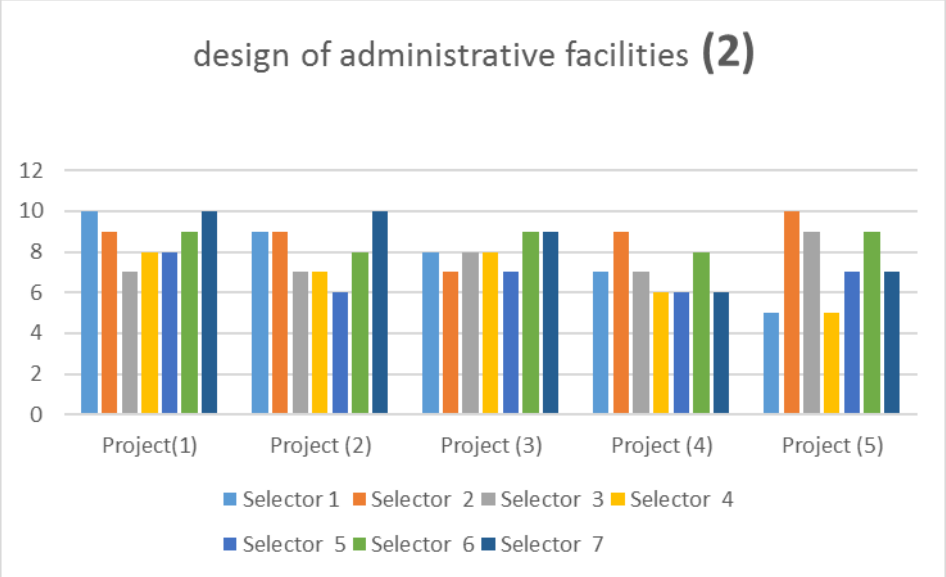
Figure (41): Design of a pergola using the Geometric design & parametric design technique. The student analysed the design well and reconstructed it, taking into account all the structural proportions, ventilation areas, internal movement paths, and entry and exit openings.

Seventh: Statistical Analysis

The achievements of sustainable parametric design specifications were measured in the previously mentioned designs, and a percentage was reached for each design to ensure that the desired results were achieved. Shown in the following tables:

Interior design department									
sustainable parametric design determinants									Design
Percentage	Total ٧٠	7 New Technology ١٠	6 Realizing aesthetic and functional values 10	5 waste management ١٠	4 Reducing harmful emissions. ١٠	3 Waste control and cost reduction ١٠	2 Energy efficiency ١٠	1 Reducing the use of environmentally harmful materials 10	
design of administrative facilities(2)									
٪٩٧	62	١٠	٩	٨	٨	٧	٩	١٠	project (١)
٪٨٠	٥٦	١٠	٨	٦	٧	٧	٩	٩	project (٢)
٪٨٠	٥٦	٩	٩	٧	٨	٨	٧	٨	project (٣)
٪٧٠	٤٩	٦	٨	٦	٦	٧	٩	٧	project (٤)
٪٧٤	٥٢	٧	٩	٧	٥	٩	١٠	٥	project)5(

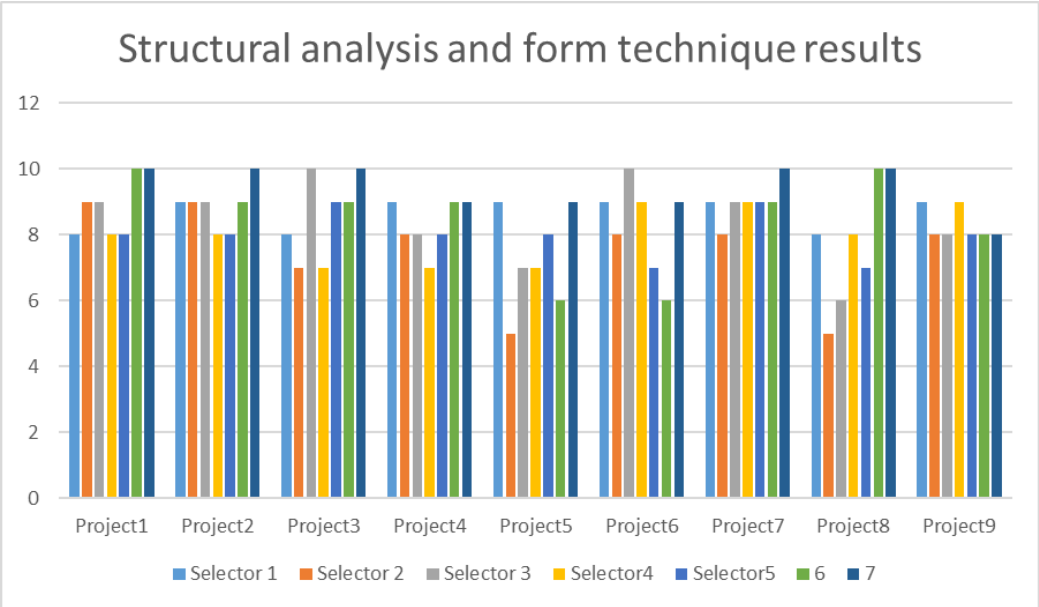
Table (2) this measures the extent to which the parametric design determinants are achieved in the previously mentioned Interior design department's designs, and it allows for the calculation of a percentage for each design



Through the percentage resulting from measuring the project outcomes with the determinants of sustainable parametric design, the success of the applied experiment was confirmed.

Product design department									
sustainable parametric design determinants									Design
Percentage	Total ٧٠	7 New Technology ١٠	6 Realizing aesthetic and functional values ١٠	5 waste management ١٠	4 Reducing harmful emissions. ١٠	3 Waste control and cost reduction ١٠	2 Energy efficiency ١٠	1 Reducing the use of environmentally harmful materials 10	
Structural analysis and form technique									
٪٨٨	٦٢	١٠	١٠	٨	٨	٩	٩	٨	project (١)
٪٨٨	٦٢	١٠	٩	٨	٨	٩	٩	٩	project (٢)
٪٨٦	٦٠	١٠	٩	٩	٧	١٠	٧	٨	project (٣)
٪٨٣	٥٨	٩	٩	٨	٧	٨	٨	٩	project (٤)
٪٧٢	٥١	٩	٦	٨	٧	٧	٥	٩	project (5)
٪٨٣	٥٨	٩	٦	٧	٩	١٠	٨	٩	project (6)
٪٩٠	٦٣	١٠	٩	٩	٩	٩	٨	٩	project (7)
٪٧٧	٥٤	١٠	١٠	٧	٨	٦	٥	٨	project (8)
83%	58	8	8	8	9	8	8	9	project (9)

Table(3) this measures the extent to which the parametric design determinants are achieved in the previously mentioned product design department's designs, and it allows for the calculation of a percentage for each design.



Through the percentage resulting from measuring the projects outcomes with the determinants of sustainable parametric design, the success of the applied experiment was confirmed.

Findings and discussion :Eight

The idea of the research began with an attempt to find the common factors between the product design department and the interior design and furniture department, as well as the importance of collaboration between the two departments, which emphasizes the role and importance of each department. This was done in the course of structural analysis and form regulation, as well as the course of designing administrative facilities, and working on linking the goals of the material in both departments with the requirements of sustainability and emphasizing its importance within the framework of parametric design and geometric design. Work was carried out through these requirements and a plan was developed for the material in both departments.

Product Design Department /aims to introduce students to the concept of parametric design and geometric design, as well as the importance of using these approaches to achieve sustainability. Students will also work on simple and abstract applications of parametric and geometric design, focusing on how these approaches can help optimize material usage. Students will be introduced to software programs that assist in analyzing products with parametric shapes, such as the Slicer program. They will be asked to apply their knowledge using the software to confirm their understanding and proficiency.
Furthermore, students will have the opportunity to select a final project. Each student will study and analyze their own project with the guidance of their instructors, aiming to achieve the most optimal analysis for the project.

The project idea revolves around studying and analyzing existing pergolas for the purpose of reconstruction. This will be done through the process of structural analysis and re-regulation using parametric design and geometric design methodologies. The aim is to optimize the use of construction materials and conserve industrial energy by replacing it with natural lighting through the study of open pergola designs, all while considering the principles of sustainability.

the Interior Furniture Design Department focuses on introducing students to the concept of parametric design, geometric design, and their importance in achieving sustainability. Each student conducts scientific research to study and analyze the requirements of their specific project. They also examine similar case studies with the guidance of their instructors to reach the optimal analysis for their project. They then create initial sketches and compare them to determine the best design solutions. Furthermore, students are introduced to modern digital software for easily applying parametric shapes. They are asked to apply their knowledge using the software to confirm their understanding and proficiency. Finally, students proceed to execute their final design idea, bringing it to life through the implementation phase.

The two researchers relied on statistical analysis of the data to verify the validity of their research hypotheses. This approach allowed them to assess the accuracy and reliability of their assumptions.

The Results:

1- Development and enhancement of teaching methods, creative thinking, and exchange of knowledge and diverse experiences among lecturers and between them through interdisciplinary collaboration.
2- Parametric and geometric design enhances the creative abilities of the student designer, allowing them to create unconventional and diverse forms in the fields of interior design and product design.
3- Parametric design can be a powerful tool for designers to improve building sustainability and reduce its environmental impact. Data and information derived from parametric design can be used to make design decisions that effectively consider environmental factors and user needs.
4- Emphasizing the importance of form analysis and its reintegration for the designer, as well as the importance of applying sustainability standards.
5- Applying sustainability standards in geometric and parametric design in line with aesthetic values.
6- Applying sustainability standards in the study of administrative facility design in the interior design and furniture department, as well as in the material analysis and form technology in the product design department, to achieve practical results
7- The emergence of new forms and methods that enrich the aesthetic artistic values in interior design and product design.

Recommendations:

1. The importance of incorporating the principles of parametric design into the curriculum of interior design and furniture design within the Department of Interior Design and Furniture at the College of Applied Arts is highlighted.
2. It is necessary to focus on digital parametric programs and their applications in design courses as a design tool that can be relied upon in the educational system of the Department of Interior Design and Furniture and the Department of Products at the College of Applied Arts as an applied methodology to enhance the skills and awareness of the student designer.

3. It is essential to take advantage of new developments in programming and stay updated with design-related advancements that contribute to the integration between parametric design and sustainability.
4. Teaching and having scientific data about digital technology programs in the field of interior design and product design, which operate according to the algorithmic system and parametric design, is necessary. Keeping up with the latest developments in these programs is important for their significance in generating innovative ideas and designs that surpass imagination. However, designers should also be cautious to consider the functional aspect alongside the aesthetic aspect in their designs.

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