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Method of Sustainable Product Development through Nature-Inspired Form

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Abstract

Throughout the initial days of documented history, human beings' designed' things by looking at nature. In our days, the use of nature in design has become more systematic and detailed. Although as old as humanity itself, use of nature especially in the field of design, still offers novelty and often brings success in solving problems in a sustainable way. Nature has always been a source of inspiration for humankind. Since early years people used to observe and study nature in order to find answers and solutions to several of their daily problems. The practice of imitating the models, systems, and elements of nature in order to solve problems of our daily life is called Bio-mimicry or Biometric. The purpose of this study is to explain how nature can be a source of inspiration for designing and developing a product, and by selecting suitable materials and production techniques, create a new functional product.

Keywords: Nature-inspired Form, Bio mimicry, Sustainability, Design, Materials, Abstract Form.

Introduction

Designers often draw inspiration from a wide range of sources, including similar designs, art, nature, and everyday objects, which are essential for design thinking and idea generation. These analogies help designers achieve high levels of creativity, expression, and emotional impact in their design solutions. The inspiration from a natural system, also referred to as bio-inspiration, is now becoming a widespread practice in design in spite of the limited number of patented products which can be considered fully inspired to nature, the incorporation of biological concepts and functions in design objects is increasingly common (Vincent 2009). Bio-inspiration is not to be intended as a formal imitation of the natural geometry, aimed at mimicking functions and morphology of natural structures, which has been more precisely termed as bio-morph-ism and has been a paradigm in modernist art (Mann 1990). In contrast, bio inspiration would rather imply transferring to the culture of design new qualities and strategies inspired to nature, via an abstraction process.

Biologically inspired design has been particularly effective as a form of analogical thinking. Using nature in design is not born in present-day; human beings looked at nature to refer what they had made since they had relationship to artificial things. However the techniques that people use to mimic nature had changed due to the developments in technology in our day. It became more systematic and detailed. There are many ways to use nature in design; analogy is one of them. It issued frequently to bring nature and design together. Further, there are many ways to use Natural analogies. It takes different names in different fields. It appears as Bio-mimicry, Bio-inspiration, etc. although all of these terms express nearly the same meaning copied, adapted or converted from nature defined the difference between Bio-mimicry and Bio-mimetic clearly. Bio-mimicry literally means the imitation of life, the word coming from a combination of the Greek roots bios (life) and mimikos (imitation). It is however not a clearly defined term, with several synonyms being used, including biometric, bionics, biognosis and biological creativity engineering. There are also disciplines bordering on bio-mimicry that use similar names, for example biomechanics and biophysics. In defining bio-mimicry, this paper follows Kennedy's definition (Kennedy, 2004, p.):

Bio-mimicry ... refers to studying nature's most successful developments and then imitating these designs and processes to solve human problems. It can be thought of as 'innovation inspired by nature'.

They claimed that, besides having the same meaning Bio-mimicry is a process; Bio-mimetic is the study field. Bio-mimicry is frequently preferred in design as a term, while Bio-mimetic is used mostly in engineering. The fields where natural analogy issued are not limited to design and engineering. Social sciences like Economy, Psychology, Culture, etc. Use nature as a guide to explain a process. That is why this research is built on Natural Analogy as a more inclusive heading, and Bio-mimicry is specific to design. Much of the literature regarding bio-mimicry uses the terms 'design' and 'designer' as umbrella-terms to cover all kinds of activities where something is created and individuals are involved in the creative process. It could be for example signify making a new drug

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based on active ingredients found in nature. **Kennedy (2004) states that** 'biomimetics is currently being used to explore a variety of design projects, including ... robots based on animal models', thus using the word 'design' when referring to mechatronics and cybernetics.
All of these fields share a common dialect in their own way, which leads to the concept of Sustainability. The use of natural analogy has significantly increased in various fields, but it is not in high demand for industrial design. It is observed that industrial product design students are not enthusiastic about using natural analogy in their studio projects. While the modernist approach to education keeps students away from figurative applications, the use of nature is often practiced as a direct translation of the formal qualities of the natural model to an imaginary project.

This paper describes the positioning of a research project aiming to explore 'nature-inspired design strategies' in the field of sustainable product development.

Objective:

The aim of this study is to demonstrate a methodology that illustrates how nature can serve as a source of inspiration for the design and development of a product and furthermore, by selecting appropriate materials and production methods, result in a working product with a new form.The validation of the efficiency of this methodology is the design and development of a product with the aid of Solid Works 3D CAD system that follows the bio-mimicry philosophy and the analysis of the process adopted for material selection and production method to minimize the environmental impact and make the final product as sustainable and environmentally friendly as possible. The result of this study is a pizza cutter that mimics the form of a seahorse.

Methodology of Form development Process:

To develop the ability and attitude and understand the process required to transform product ideas from nature to mental state of imagination to tangential and real through sketches, 3D sketches, rendering in to 3 dimensional. Aesthetically awareness and sensitive perceptions is most essential for form generation in expressible and communicable manners.

Table 1 Methodology of Form development Process:

Form Integrity and aesthetics	Survey, study and select **natural elements**
Understanding Visual Language	Visualize and derive the design with sketches in **abstract manner**.
Convergence of nature Form in abstract manner	**Analyze the nature** based on form and attributes. Example - abstraction, growth,forces, complexity, natural form, geometries, proportions, principals, uniqueness, optimum, gradual etc.
Form and Communication	Make alternate concepts in sketches; try quick models in **3D** for refinements. **1:1 model** ensuring design solution.

Survey, study and select Natural Objects.

1.1 Table 1 Survey natural object with it's attribute examples

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Survey natural object				
Characteristics:A**ttribute study**	**Mantis** ● Large eyes shape ● Triangular Face ● Texture ● Long	**Cabbage** ● Texture ● Oval Shape ● Colour ● Smooth, Curvy Leaves	**Honey Comb** ● Less in weight ● High in Strength ● Hexagonal Shape ● Brown ● Space	**Seahorse** ● Long ● Slender ● Ability to change colour ● Scales on the body ● Grasping ability ● Cuts water to move in water

2. The process of finalizing the object idea and for the project

2.1. What is Abstraction Form:

Abstract Drawing does not aim to represent observed reality; rather, it utilizes forms, colors, textures, and shapes to create compositions unrelated to the physical world. By employing non-representational techniques, it allows designers to experiment with the fundamental elements of visual language . Abstract drawing can range from slightly altered reality to entirely non-objective pieces devoid of recognizable shapes. These forms may be completely non-representational or created by simplifying, distorting, or exaggerating real-world objects to emphasize certain characteristics or meanings. The expressive potential of visual components is often explored in abstract forms, enabling free interpretation and a focus on fundamental qualities rather than precise reproducti**o**n.

2.2. Why Abstract Sketching?

- **Form of Exploration**: Abstract sketches allow you to break free from traditional constraints, enabling you to experiment with forms and ideas.
- I**dentify the Essence**: Abstract sketches help you capture the overall feeling or movement of a design, which can then be refined into a more detailed plan.
- **Explore Creativity**: In order to develop an innovative concept, you need to open your mind to new directions and unexpected solutions.
- **Deliver of Ideas**: By focusing on design depth, abstract drawings can deliver complex ideas more effectively.

2.3 How to Begin?

- Begin with a concept: Focus on the core idea/emotion; be it the most rudimentary notion (abstract thought like "motion" or some intricate notion "harmony in chaos").
- Start with Basic Shapes and Lines: When you are conveying your thoughts, begin with the most fundamental shapes and lines. Instead of obsessing over everything coming out just right, try to think about the way pieces slot together and yet converse across them.
- Look at Different Angles: Change your angle, experiment with other mediums or focus on a part. By doing so you can see your design through a range of different lenses and potentially come up with new ideas
- Design: test by altering the measurement and scale of the completely different parts in your design. Look at how it and alters the layout of a little work.
- Utilize Texture and Contrast: Incorporate shading, intersecting, or different materials to develop a sense of texture and contrast that will expand the depth of abstract compositions.

Draw Abstract Form Original photo Seashores

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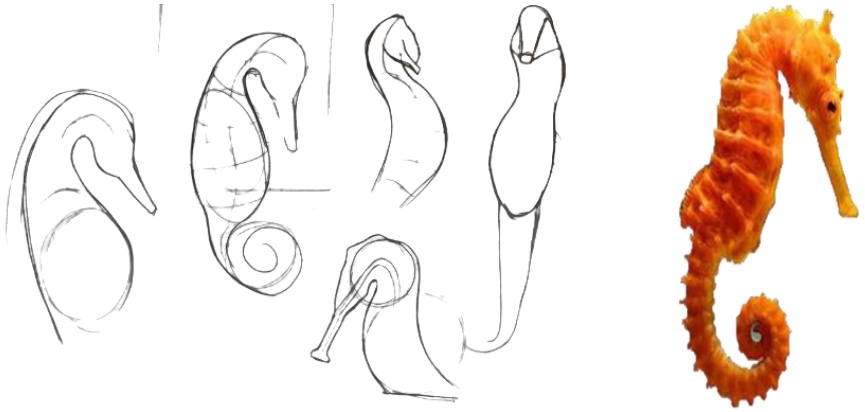


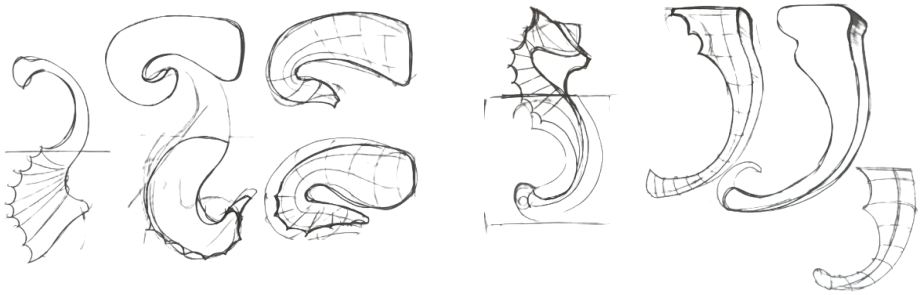
Fig no: 2.1(Drawing by Bhavya Dandwala Institute of Design, Nirma University)

3. Ideations/Explorations:

3.1 Concept Development:

- **Brainstorming:** Begin by generating a variety of ideas. These could be abstract forms, functional objects, or purely aesthetic designs.
- **Inspiration:** Look for inspiration in nature, architecture, or everyday objects. Consider how these forms can be translated into clay using coils.
- **Sketching:** Start with rough sketches to explore different shapes, patterns, and combinations. This is a reform stage where you can experiment with different ideas without worrying about the final outcome.

Ideation : 1 **Ideation : 2**



Ideation : 3 **Ideation : 4**

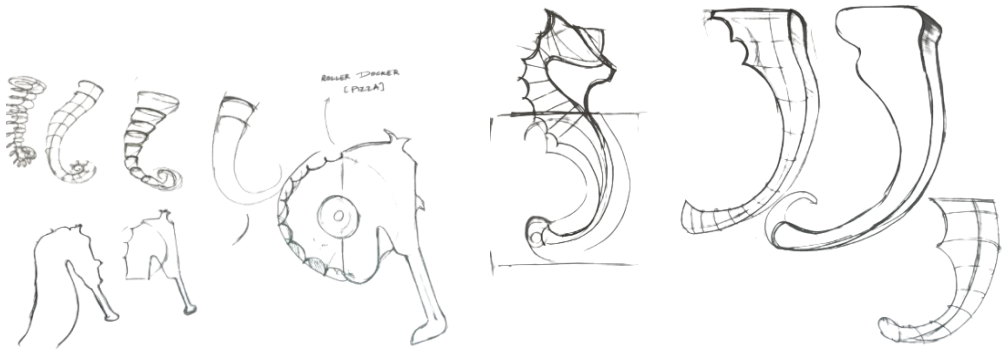


Fig no: 3.1(Drawing by Bhavya Dandwala Institute of Design, Nirma University)

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4. Final Ideation for product : Form and Communication Make alternate concepts in sketches; try quick models in **3D** for refinements. **1:1 model** ensuring design solution.

4.1 Design Refinement:

- **Detailing:** Once you have a few promising concepts, start refining them. Add details like textures, patterns, and any functional elements like handles or openings.
- **Functional vs. Aesthetic Balance:** Decide whether the design will prioritize functionality (e.g., a bowl, vase, or sculpture) or be purely decorative. This decision will influence the final form and the way the coils are used.
- **Final Sketches/Renderings:** Create more detailed sketches or digital renderings of the selected design. Focus on proportion, balance, and how the coils contribute to the overall aesthetic.

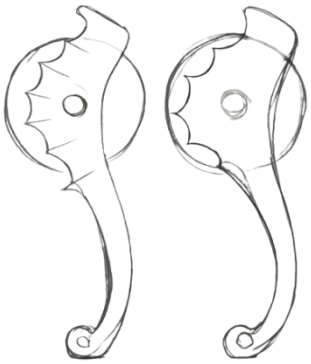

Fig no: 4.1.1 (Final IdeationDrawing by Bhavya Dandwala Institute of Design, Nirma University)

5. Form and Communication Make alternate concepts in sketches; try quick models in **3D** for refinements. **1:1 model** ensuring design solution.

5.1. Material Exploration:

- **High density Thermocol sheet and MDF Board Exploration:** Experiment with different types of clay to see which one best suits your design. Consider factors like flexibility, drying time, and how well the clay holds the coil shapes.
- **Color and Finish:** Think about the final look. Will the clay be glazed, painted, or left natural? How will these choices affect the overall design?

Fig no: 5.1. (quick models 1:1 scale model with High density Thermocol sheet **by Bhavya Dandwala Institute of Design, Nirma University)**

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6.QUICK MODEL Prototype Creation:

- **Building a Prototype:** Create a prototype of your design using the selected materials with technical aspect. This allows you to explore the design in real life, see how it holds up structurally, and make any necessary adjustments.
- **Iteration:** Based on the prototype, make any necessary changes to improve the design. This might involve adjusting the materials thickness, changing the shape, or adding/removing details.

6.1 3D MODEL (Solidworks)

Fig no: 6.1 by Bhavya Dandwala Institute of Design, Nirma University)

7. Technical Drawing For manufacturing processes:

From the very early days, man realized that if he had to construct any structure or machine correctly and methodically, he must first record his ideas before starting construction work. These recorded ideas become more vivid and forceful if they are shown on paper in form of a drawing of the structure or machine. Such a drawing will be of very great help to the man who looks after the construction of this structure or machine.

Indeed, "technical drawing is the language of engineering". Without the good knowledge of drawing, an engineer is nowhere and he could not have constructed the various magnificent structures or intricate machines. Evidently, any one connected in any way, with engineering construction must understand this language of engineers. Technical drawing is, therefore, indispensable today and shall continue to be so as long as engineering and technology continue to be of in the activities of man.

By means of drawing, the shape, size, finish, colour and construction of any object (no matter how complex) can be described accurately and clearly. The engineer should develop his skill, in two phases of technical drawing; first, he must be able to draw clearly and rapidly, the freehand technical sketches; secondly, he must be proficient in drawing to scale the instrumental drawing. The purpose of the present volume is to give the basic principles of the instrumental drawing only.Bhatt (n.d.)

Technical drawing, often referred to as engineering or mechanical drawing, is a fundamental tool for transforming conceptual ideas into functional prototypes. It provides the precise visual representation of an object, including dimensions, materials, assembly instructions, and s, enabling engineers, designers, and fabricators to communicate effectively.Technical drawings are an essential part of the process of developing a working prototype. They translate abstract ideas into detailed instructions that guide the fabrication and assembly of the product. By following the principles of technical drawing, designers can ensure that their prototypes are not only functional but also manufacturer and replaceable.

7.1 Key Elements of Technical Drawing for Prototyping

AUXILIARY VIEWS

When a surface of an object is not parallel to one of the three principal views, an auxiliary view may be used to obtain the true size of the surface. An auxiliary view is usually only a partial view showing the desired features. An auxiliary view should be positioned close to the principal view so that both views can be read together. A centre line represents the axis of symmetry. Projectors are usually drawn at 90 degrees to the inclined surface. Measurements from one view are projected across to the auxiliary view. Auxiliary views may be projected from

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any of the three principle views. A primary auxiliary view is projected onto a plane that is perpendicular to one of the principal planes of projection and is inclined to the other two. A secondary auxiliary view is projected from a primary auxiliary view into a plane that is inclined to all three principal projection planes. Generally, auxiliary views are used to show the true shape or true angle of features that appear distorted in the regular views. Basically, auxiliary views have the following four uses:

- True length of line
- Point view of line
- Edge view of plane
- True size of plane

To draw an auxiliary view of a curved surface a number of random points on the curve in one of the principle views must be taken. These data points can then be projected into the auxiliary view. Sometimes it is required to draw an auxiliary view first from one principal view before being able to obtain another complete principle view. Auxiliary views are also used to find the lines of intersection of surfaces. (Berhanu & Deberie, 2003)

Sectional view

Interior features of an object can be described with the use of hidden lines. This can be become confusing however. The use of sectional views simplifies the representation of internal features. In a sectional view we imagine the object is cut by a plane to reveal the interior features. Longitudinal sections cut the object lengthwise. Cross section cuts the object crosswise. A full section cuts the object in half. Section lines represent where the surface was cut. The cutting plane must also be described in another view. A half section cuts the object in a quarter. A half sectional view shows the interior and exterior of the object. The cutting plane can be offset to show desired features. A broken section (Partial section) can also be used to give greater description of an object. Revolved and removed sections are used to eliminate the need of a separate view. Line technique is important: contrast, spacing, inclination.(Berhanu & Deberie, 2003)

Dimensioning

A detailed drawing must indicate not just the shape, but the size of the object. Additional information such as surface finish, welding techniques, material lists and tolerances may also be included. Dimensioning includes both size and location dimensions. Dimensions should be placed outside the object for clarity. Try not to repeat dimensions on drawings. Extension lines must be light and do not start in contact with the outline of the object. Arrow heads are also usually three times the length compared with the width.

The following are a few basic rules that summarize what might well be a list of hundreds of very specific rules that apply to dimensioning. Review the list carefully. Make each of these items a part of your dimensioning practices. (Berhanu & Deberie, 2003)

1	Each dimension should be clearly shown and stated so that it can be interpreted in only one way.
2	Dimensions should be placed in the view where the best shape and true form are shown
3	Place a dimension between views, especially if it applies to both views and will improve clarity.
4	Do not assume that a part is symmetrical. Dimension both sides of symmetrically shaped part or use the centre line symbol or note to avoid confusion.
5	Spacing between dimensions should be consistent within a drawing
6	Line up dimensions horizontally or vertically where possible.
7	Avoid crossing dimension lines or leaders where possible.
8	Cylinders should be dimensioned in their rectangular view.
9	When using chain dimensioning don't complete the chain. Instead dimension all but one part of the chain and do an overall dimension
10	Dimension circles by their diameter and arcs by their radius.
11	Use dimensioning symbols where appropriate.

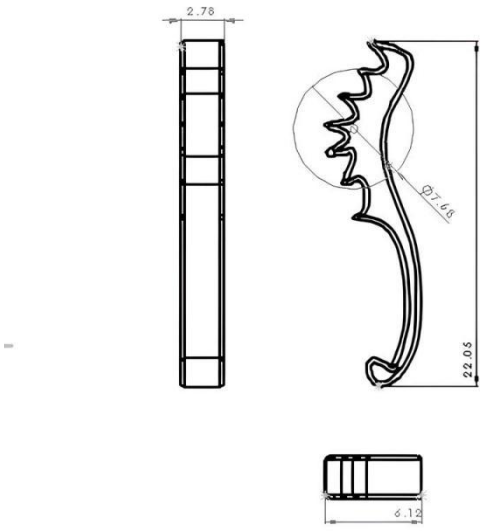

Fig no: 7

7. Final Design:

- **Finalize the Design:** With all the adjustments made, create the final version of your design. Pay close attention to the craftsmanship, ensuring that the MDF wood are smooth, well-connected, and that the overall form is stable.
- **Presentation:** Document the process with photos, sketches, and notes. This will be helpful for explaining your design choices and the evolution of your idea

7. Final Design by Bhavya Dandwala Institute of Design, Nirma University)

Conclusion:

Since ancient times, designers have drawn inspiration from emulating nature, which is the technique of replicating nature's models, systems, and elements to address common problems. This research investigates how nature may be utilized to inspire product design and development, as well as the selection of appropriate materials and manufacturing procedures. While natural analogy has gained acceptance in a variety of fields, it is not often used in industrial design. This research project seeks to explore nature-inspired design techniques in sustainable product

creation by analyzing sustainable design strategies, identifying existing methodologies and tools, and offering product examples.

The research presented here presents an approach for developing and designing products that takes inspiration from nature. To minimize the the impact on the environment, the technique makes use of the solid work 3D CAD software and the bio-mimicry principle. The finished item is a pizza cutter designed to have the shape of a seahorse. The procedure include observing, examining, and choosing natural materials as well as deciphering visual language to analyse the qualities of nature. Abstract drawing promotes creativity, expresses autonomy in expression, and conveys difficult concepts in an understandable way.It may also be utilized to explore new concepts and ideas as well as to provide original solutions to problems. Furthermore, abstract drawing may be utilized to simplify difficult topics using visual aids.

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