Biomimicry comparison studies before and during Covid-19 pandemic in product design innovation.

Dina Lestari
Product Design Study Program, Universitas Agung Podomoro
Email: dina.lestari@podomorouniversity.ac.id

Abstract. Technological advances bring changes and impacts in many aspects of human life, and it is also affecting product design innovation learning system, one of the examples is the students' dependence on the internet in finding references to their design ideas. In this research, students are introduced to an environmental observation-based learning method known as biomimicry to create innovative product designs. Respondents in this research were students of the product design study program at the Universitas Agung Podomoro Jakarta which were divided into 2 groups as a comparison. The observation process was carried out before and during the Covid-19 pandemic in different locations and objects. The method used in this research is a participatory qualitative method with a comparative and correlational approach. The purpose of this research is to study and evaluate product design innovative learning systems by observing comparative biomimicry before and during the Covid-19 pandemic. The conclusion is that after comparing biomimicry observations to students before and during the Covid-19 pandemic occurred, it turns out that there are significant differences in skills, conceptual, and creativity aspects resulting from the learning process in two different groups of students.

Keywords: Comparative Studies, Biomimicry, Covid-19, Innovation, Product Design

1. Introduction
There is nothing new under the sun, an old phrase that reflects human behavior. One obvious example can be seen from the practice of Observe, Imitate, and Modify (OIM) in the product design process. In modern times like today, technology by means of the internet of things helps designers to collect references for their designs. The Internet of Things (IoT) paradigm promises to make “things” as mention by Buyya and Dastjerdi[1] in the book entitled “Internet of Things: Principles and Paradigms” which said that it can open the doors to new innovations that will build the novel type of interactions among things and humans [1]. Aside from these advantages there also bias problems that often occur from this practice include the rampant cases of plagiarism and the decline in the exploratory abilities of designers in finding original visual ideas. To create innovative designs, one way to explore ideas is to make in-depth observations. The object of observation is not only from the
internet but can be obtained from nature. Nature is a source of unlimited inspiration, so the process of exploration of nature can encourage innovation from the observation process.

Several innovative products that play roles in human life take inspiration from nature, some examples are discussed in the book entitled “Innovation Inspired by Nature” written by Janine M Benyus, she introduced a nature-based observation known as Biomimicry or often referred to as biomimetics. In observing biomimicry, objects that are used as material for observation are all aspects that have natural elements, can be from the form, how it works, the mechanism system, the ecosystem, and other natural elements that can be imitated to be used as inspiration for innovation to meet and address human needs [2]. Thus biomimicry is the technique of copying nature. Kannarath in his book “Mimicking Nature: A solution for Sustainable Development” said that the term biomimicry or biomimetics is derived from Greek words bios, meaning life, and mimesis, meaning to imitate [3].

In this research, students as respondents were introduced to an environmental observation-based learning method known as biomimicry. Students are given encouragement to make innovative designs by conducting a process of environmental observation as inspiration for innovative product designs. Respondents in this research were students of the product design study program at the Universitas Agung Podomoro Jakarta which were divided into 2 groups.

The observation process was carried out before and during the Covid-19 pandemic. The observation process before the pandemic occurred at the Jakarta Aquarium Neo Soho Mall with marine biota objects by group I, as a comparison, when the Covid-19 pandemic occurred, the observation process was carried out in the vicinity of each residence with the object of observation of land biota by group II. The method used in this research is a participatory qualitative method with a comparative and correlational approach. The purpose of this research is to study and evaluate product design innovation learning systems by observing comparison of biomimicry learning methods before and during the Covid-19 pandemic.

2. Biomimicry in product design

Through biomimicry observational studies, humans can make technological designs. One example of technological development taking inspiration from nature can be seen in the design of the Japanese shinkansen fast train by Eiji Nakatsu. Eiji Nakatsu is the head of the Shinkansen rail project who also works as a bird watcher. He studied the anatomy and behavior of birds to develop shinkansen technology. Nakatsu designed the front end of the train to model the beak of kingfishers and penguins, taking inspiration from nature, a researcher named Lakhtakia wrote in his book “Engineered Biomimicry” that the train design to be almost identical in shape to the kingfisher’s beak, providing a carefully matched pressure/impedance match between air and water [4]. With this visual form, the train produced is not only reduced in sound so that it is quieter, but also uses 15% less electricity, even the train is also able to run 10% faster [5]. The shinkansen train is only a small example of the application of biomimicry of land biota to technology, there are still many other land biotas that can be taken as inspiration to create and develop other innovative products.

In actual fact, this biomimicry research method has been around for a long time. However, in the past time, the “biomimicry” term has not been used. One of the historical figures who used this method to make product innovation is Leonardo Da Vinci. Leonardo da Vinci is well known as an artist and innovator, he created lots of innovative works by taking inspiration from nature for example his tank design as shown in figure 1 was inspired by turtle shells anatomy. Da Vinci's works were later featured in “Da Vinci biography book” written by Walter Isaacson, it is explained in the book, that after leaving Florence in 1499 Leonardo was recruited by Cesare Borgia in Venice as a military engineer [6]. Some of his designs were later developed and used to this day, his military vehicle design was the result of innovation taking inspiration from nature (biomimicry).
Da Vinci was also considered a genius who had a visionary mindset that was far more advanced than other people who had grown up in his time. The experience of the Da Vinci design process is discussed in a book by Michael J. Gelb entitled "how to think like Leonardo Da Vinci". According to him, in order to become a genius innovator like Leonardo, we can train it by imitating his way of thinking [7].

Gardner, an American educator, in his article entitled "Using Biomimicry to Engage Students in a Design-Based Learning Activity" explained that a good way to educate students is by giving examples of how natural objects can actually inspire technology [8]. Da Vinci and Nakatsu are among the many innovators who have succeeded in creating technology by taking nature as inspiration, this makes them perfect as examples of biomimicry learning models.

3. Biomimicry observation
The focus of this research is a comparative study of marine biota objects and land biota objects before and during the Covid-19 pandemic, this research was carried out by analyzing causal indicators or triggers for the emergence of certain phenomena. In this research, nature is a source of inspiration for the development of innovation learning in the Product Design Study Program. A comparative study was conducted by comparing learning outcomes in 2 groups of students. Group I students conducted a process of observing marine life together at the Jakarta Aquarium Neo Soho Mall before the Covid-19 pandemic. While group II conducted the process of observing land biota from their respective places of residence when the Covid-19 Pandemic occurred.

3.1. Before pandemic covid-19
In this research, the first sample to be studied was a group of students of the 3rd batch of Product Design Study Program at the University of Podomoro, totaling 21 people as shown in figure 2. The 21 people participated in observing marine life as inspiration for making innovative product designs. The research activity was carried out on November 5, 2019 and taking place at the Jakarta Aquarium Podomoro City.

This observation site is a giant aquarium with more than 600 species of marine and terrestrial animals, but the objects studied in this sample are focused on marine life. In this study, respondents were asked to observe and collect data from the marine sample to be analyzed using descriptive analysis techniques, the points to be analyzed include:

1. Identification of the object of observation
2. Conceptual identification
3. Product Design Ideas
Tabel 1. Research observation sheet for marinebiota biomimicry. sample 1of 21

| Marine Biota Biomimicry Observation Sheet |
|------------------------------------------|
| Name: S.M.H.                             |
| NIM: 23100101019                          |
| Day/Date: November 2019                  |
| Observation Location: Jakarta Aquarium   |
| Object of Observation: Black Diamond Stingray |

**PRODUCT IDEAS:**
A product designed in the form of a map, this map moves in waves automatically using a source of electrical energy. When the energy runs out it can be recharged again, then it can be removed from the sand to be washed. The stick itself is height adjustable.

**CONCEPTUAL:**
This product is an autonomous map which is designed inspired by the way the male black diamond stingray moves. Namely by moving using the fins on the chest by shaking it.

From 21 samples of the observation sheet, the interesting fact is that most of the students from this group ended up designing a household product as shown in tabel 1. The indication could happened because this group of the participant is students from the 4th semester which focused on human-centered design as shown in podomoro university product design program curriculum map in figure 3.

After conducting observations at the Jakarta aquarium, students continue their practical activities at the madison studio workshop building on November 12, 2019 as shown in figure 3. They explore clay modeling materials to visualize the aesthetical form of marine biota in 3-dimensional shape. There are findings in this practical activity, it seems that the results of the clay modeling between one participant with another look similar. As mentioned by Kadavy in his book “Design for Hackers” said that visual design, as the name implies, is mostly associated with things that you see, such as the arrangement of design elements, the look of typography, or the choice of colors, but these things are all affected by some pretty concrete things [9]. In this case, visual design ideas unconsciously arouse through practical experience from working with a group at the studio in resulting similar visual ideas.

Figure 3. Curriculum map of podomoro university product design program

Figure 4. Group I, marine biota clay modeling practice
3.2. During Covid-19 pandemic

After conducting observations at the Jakarta aquarium with participants from 3rd batch students. An extended observation as a comparison then planned to be done with 29 participants from group II which is 2nd semesters students from batch 4. At first, it was planned to be carried out at the Ragunan Zoo. Unexpectedly when the activity was going to take place the COVID-19 outbreak began to appear. This pandemic made many changes in plans which later turned out to be giving interesting findings. We decide to change our learning methods by using blended learning. According to the book entitled “Blended Learning in Higher Education”, it defined as “the organic integration of thoughtfully selected and complementary face-to-face and online approaches” Blended learning is the inspiration of much of the innovation, both pedagogically and technologically, in higher education. By innovation, we mean significantly rethinking and redesigning approaches to teaching and learning that fully engage learners [10]. Some physical activity then replaces with an online course, introductory theory, and practice regarding biomimicry and its application in the field of product design innovation decided to be carried out online. The object of this observation is terrestrial biota which includes animals, insects, plants, and ecosystems. The observation location was carried out around their own house by implementing health protocols to avoid exposure.

In this study, respondents were asked to observe and collect data from the land biota object that they trying to analyze, the points to be analyzed include:

1. Identification of the object of observation
2. Conceptual identification
3. Product Design Ideas

Tabel 2 down below shows the terrestrial observation sheet filled form sample.

**Table 2. Research observation sheet for biomimicry terrestrial biota, sample 1 of 29**

| IDENTIFICATION: | PRODUCT IDEAS: | CONCEPTUAL: |
|-----------------|----------------|-------------|
| Plants (Pandanus fragrans) | Name: Pandanus Fragrans<br>Latin name: Pandanus amaryllifolius |  |
| One type of the Pandanus family, several other species from the same family are commercial pandanus, white pandanus, pagoda, pandanus, and pandanus, archimedes pandanus, Pandanus pandanus etc. Several species are used as ornamental plants, some species are eaten by birds, etc. This plant however is characterized by kidney shape leaves (such as palm leaves or grass) with jagged edges. The roots are large and have supporting roots that support the plant. The pandanus fruit is arranged in a round arrangement like a donut. The size of this fruit varies, from 2 cm to 5 meters, even in Papua there are lots of pandanus up to 12 meters in height. | Name: Pandanus<br>Size: 5x3 x 5 cm for the pot, 25 cm long for each stick (Red).<br>Makes: Ceramic for the pot, paper cord or bamboo for the stick (Red).<br>Product function: Essential oil diffuser (aromatherapy for the room). |  |
| Generally, pandanus plants can grow well in coastal habitats as well as in tropical and sub-tropical areas, one of which is the Indonesian and Polynesia Micronesia region and the Pacific area. Most pandanus plants can reproduce directly using seeds, but artificial cultivation can be done by doing pandanus stem cuttings which aim to propagate pandanus vegetatively. |  |

From 29 samples of the observation sheet, the interesting fact is that most of the students from this group ended up designing a decorative product. The indication could happen because this group of the participant is students from the 2nd semester which focused on entrepreneurship and creative design, as shown in figure 3.
At first, we were planning to hold a clay modeling class but we canceled it due to covid 19 lockdown, we change the activity and give instruction for students to explore and create their own materials from home by using kitchen materials via an online course, and the result is unexpectedly surprising. They succeed in creating land biota models out of kitchen materials. Each one of their work is unique as shown in figure 5. The ideas of innovative products also vary, And for the reference data, they get benefits from many online libraries and open access journals during the COVID-19 pandemic.

4. Conclusions
The conclusion obtained from this research is that it turns out that learning product design innovation using the biomimicry method has a significant difference when it is given before the pandemic and during the COVID 19 pandemic. The situation during the pandemic turned out to limit many facilities and access for students to work but provided space and time for students to carry out observations independently. Products created from independent observation during the pandemic produced original and creative visual ideas, opposites from products created by students that work in the classrooms before the pandemic which had many similar designs between students. This research still focuses on basic visual aspects and planned to be further developed through multidisciplinary collaborations in the future.

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