Appreciative of the Biomimicry Design Process for Revolutionary Furniture Development

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Abstract. The significance of biomimicry as a design methodology is discussed in this paper within the context of industrial design planning and design. For this research, the researcher has taken measures to validate the ontology of designers towards the "Biomimicry Design Process" (BDP) in order to discuss imitating nature to design sense. In the context of this study, biomimicry is the primary approach in assessing the designer's understanding of the design process from conceptual idea to visualised product. The strategies of (BDP) activities were applied to furniture design in order to bring a "Concept To Reality" (CTR). The various interpretations of transformation of idea development in (BDP) in furniture design have been discussed in both qualitative and quantitative research. Data has been gathered and analysed implicitly and explicitly from a designer's thought process to represent the main empirical data of previous studies. In this study, a stage of (BDP) was used: (1) Appreciation, (2) Emotion, (3) Transformation, and (4) Maximisation of Ideas.

Keywords: Appreciative, Biomimicry Design Process, Conceptual to Reality.

1 Introduction

Biomimicry is a study in which nature serves as a mentor. Many studies have applied biomimicry as the primary approach to spark ideas, including architecture, engineering, designers, and many others. However, understanding the subject matter through science-thinking of the existing surroundings is key for idea generation in this field. The biomimicry approach is an empirical implementation, where researchers analyse a problem based on nature's principles of model, mentor and measuring, whilst the implementation of design thinking processes is carried out through the emulation of form, processes and the ecosystem (Othmani, 2018). The approach to biomimicry on nature and organisms will be improved scientifically, either naturally or artificially. The aspect must be comprehensive and logical. A product design exists as a result of imagination (Omar 2015).

The combination of industrial design and the ontological approach was seen in this study as a human necessity to solve the problem in the development of furniture design. Designers can research potential biomimicry solutions in their work without an in-depth scientific understanding or collaboration with a biologist or ecologist if they can observe organisms or ecosystems or have access to available biological research. In this study, the arrangement of the

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thinking process is critical to explaining the (BDP) among designers. According to Watson (2003), biological knowledge, which almost doubled, led designers to have the tools and the ability to imitate nature through an understanding of nature methodology. This study intends to provide some perspectives on (BDP) based on the following structure: (1) Introduction, (2) Biomimicry Design Process (BDP), (3) The transformation of (BDP) to develop (CTR), (4) discussion, and (5) conclusion. As a result, the goal of this research is to uncover the method of (BDP) and demonstrate how it contributes to the appearance of furniture design.

2 Biomimicry Design Process (BDP)

According to Wanieck (2021), biomimicry is the interdisciplinary collaboration of various scientific disciplines and fields of innovation with the goal of solving practical problems with biological models. Biomimicry research and its applications are numerous, and the community includes people from a variety of disciplines, ranging from biologists and engineers to designers. In the process of biomimicry thinking, the implementation of biomimicry-based design involves two associated issues; which are, understanding the ecosystem to ensure environmental development, and simultaneously mimicking the complex interactions between living organisms in ecosystems. This is an easy example for creating built environments that can integrate into the habitats of other species in a reciprocal manner (Zari 2015). Biomimicry brings insights into design strategies that have been proven successful through several stages of process, which was identified to have specific features in the planning arrangements in a process, to social and ecological systems. The conception of new ideas in the design process was successfully demonstrated by combining the characteristics of nature and its benefits; for example, durability, as a feature in a design (Helmrich 2020).

2.1 The Stage of (BDP) from (CTR)

In the context of design management, this study focuses on how designers produce from (CTR) in (BDP). For this research, we are exploring various aspects of the level or stages of design thinking and biomimicry implemented through previous research. The design thinking process, according to Brown et.al (2010), involves three categories of sequence: inspiration, ideation, and implementation. The process of generating, developing, and testing ideas is referred to as ideation, while the process of reflecting on inspiration allows or encourage opportunity to provide solutions for problems. These implementations can promote a better approach to the design process. There are four elements that focus on humanistic, listening, designing, and delivering in its thinking process (Suprobo 2014).

In the design phase, there are three levels of development: (1) The initial stage when we question the image elements' orientation; (1) the middle stage when we must consider the kind of image element format; and (3) the final stage in which we take decisions leading to a detailed image picture that we have so far developed (SZ Abidin 2008). According to Benyus (2007), we imitate what all well-adapted species are able to achieve at deep biomimicry level. The first level of biomimicry involves imitating the natural form, which means imitating organisms for their morphological attributes such as their visual form, their components, their materials or their appearance, which means copying an organism's design. The second level of biomimicry involves mimicking natural processes, which is to reproduce a biological entity's appearance or

actions and processes within the environment. The third level of biomimicry is to mimic natural ecosystems (Pawlyn 2011). A firm understanding of all the biomimicry levels and the reason why they need to be incorporated into design will provide us with information or knowledge about biomimicry in its true nature (Othmani 2018). As a result, this research has been carried out in the field of education, with the goal of studying its applications for educators and design students. In this study, the justification in understanding the thinking model and level of (BDP) to create an idea from (CTR) is aimed at observing the relationship between the gap in methodology and data collection before and after understanding (BDP).

2.2 The process of (BDP)

Understanding the existing conceptual framework is the first step in defining a conceptual framework. The purpose of understanding the existing conceptual framework aims to focus on strategic (BDP). Based on the conceptual framework diagram below, the researcher has determined the appropriate domain for the research based on the issues that have been highlighted in the study.

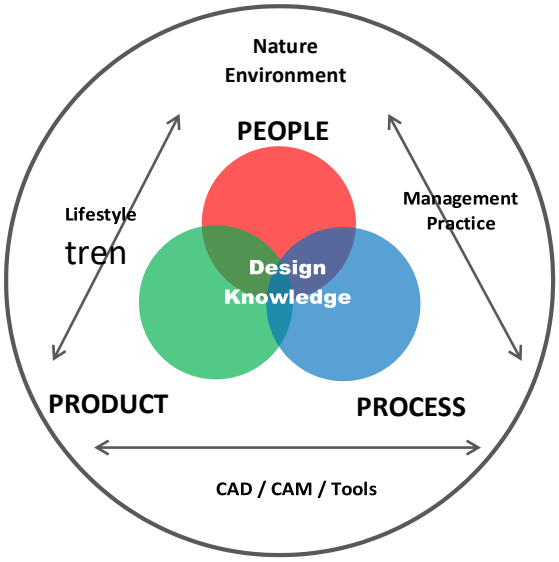


Figure 3.2: Conceptual framework sourced by Rahman KAA (2016)

In the solution space, Design Knowledge includes knowledge that can be used to solve related problems. However, producing in a specific project can be elaborately intricate. Indication of the significance of problems, the designed solution, proof of evaluation, and acceptable improvement on how well solutions solves problems, appeases scholars of their main conundrum (Brocke, 2020). As a result, design knowledge is about the means-to-end relationship between problem and solution spaces and can be represented in a variety of ways, including designed artefacts, design principles, and design theories. According to Omar (2015), there are three main focuses in this conceptual framework which are humans, processes, and products. In the first domain, the combination of human and process functions focuses on management practices, whereas the function on the use of software, machines, and equipment

is a combination of products and processes, and finally, the combination of products and human produces a range of lifestyle preferences.

The overall combination of these domains is the result, according to Rahman KAA (2016), of the natural environment created by God of which we benefit from. In this study, theories of understanding are focused on the first factor in the search for a new conceptual framework, which is the combination of human and process that serves as a management practice of design thinking. Building a conceptual framework, according to Jabareen (2009), is a theoretical process that employs grounded theory methods that are not based on evidence but focuses on data and phenomena. In addition, it is the result of resources generated by theory upon theory in a variety of disciplines that become empirical data used to analyse the conceptual framework. Based on the description it is clear that the conceptual framework plays a role in a particular study. The determination of its functions is based on the understanding of theories in various fields. While in terms of needs, it is based on the needs and heuristic understanding of a field. To determine the model framework (BDP) several methods have been taken, including the phase of understanding the appropriateness of keywords and the construction of a conceptual framework on the attributes of the biomimicry approach. The overall combination of the phases of this study has responded to the Gap for the study i.e., formation (BDP). We created a biomimicry thinking model tool to aid in the design process based on our methodology. According to Omar (2017), to produce design from (CTR), the method to develop in (BDP) has four sequences: appreciation, emotion, transformation, and idea maximisation.

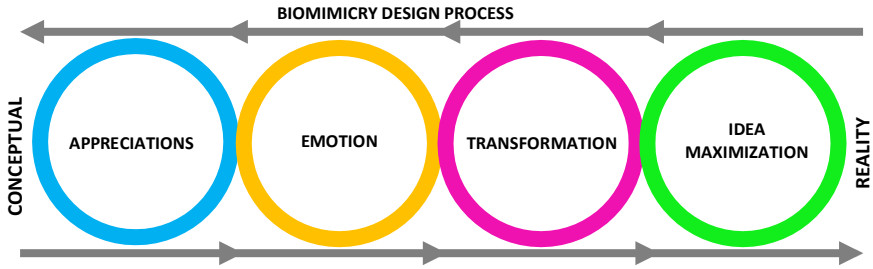


Figure 7: Biomimicry Design Process According WNF Omar 2015

The element biomimicry through this research was aimed to trigger the thinking process in (BDP). In practice, the element of (BDP) in this study targeting the innovation requires collaboration in term of ideation, implementation, and value of creation. Collaborative process in this area of research was produce a very complex creation and interpretation to the (CTR). Research found the element of (BDP) was a key of idea generation and the creativeness to create the appropriate method in area of study. This research used 3 main methods to justify the element biomimicry design process which are (1) Literature Review (2) KJ method (3) Data analysis (SPSS). According to Nikou 2019, the nature of idea generation in new product development is challenging, competing, risky, and requires an interdisciplinary approach. However (BDP) in this study was strategized to produce the sources, techniques, and metric of ideation, while for idea generations in (BDP) could be described the compassions the metaphors of in translating the emulation in biomimicry efficiently.

Description Element of (BDP)
Appreciation in the (BDP) was classified into three categories: appreciation of form analysis, appreciation of aesthetic analysis, and appreciation of function analysis. In- depth appreciation also encourages designers to translate the design into more effective and appealing ways rather than simply imitating the chosen study material.
Emotions are seen in several areas, including the interaction with natural objects by understanding their needs, in the context of the research (BDP). Emotions in the (BDP) also considers the aspect of giving a function to the design during the development process of the idea.
According to our research, **transformation** was defined in several significant ways. First, in terms of the exterior, through the process of transformation, it must be something significant and appropriate with the subject matter that has been indicated for testing. Second, in terms of shape, it should be explicit and reliable, and third, it should be transformable. For creative innovation, nature objects must be transformed to look specific or generalise in terms of form and shape based on external and internal changes.
The final process of (BDP) at this stage was idea **maximisation.** Any design process in the context of this research, even if it is based on a variety of ideas, must have a limit when the outcomes are achieved.

Table 1: the elements of (BDP)

2 The transformation of (BDP) to develop (CTR)

This research necessitates paying close attention to every step of the process, as each serves a specific purpose in the design of a seater for this study. It began with several phases in which industrial design students were involved and we choose degree level students as participant. The definition of the subject matters was the first step in gathering data for this study. Five subject matters were chosen to put the designers to the test. They were hibiscus, tarantulas, a human hand skeleton, a beehive, and water splashing. The subject matters for this study were chosen because they represent five elements of nature: flora, fauna, human body part, habitat, and atmosphere. They were chosen for the ease of imagination they should provide the designers, as well as the ease with which they can be found in the designers' daily surroundings or environment.

Figure 8: Nature-Inspired Subject Matter

The design process is being implemented for this study. Each group of three designers must choose one of the identified subject matters from among the five groups of designers. Designers must conduct in-depth examinations of specific and entire parts of the object. They were given one week to complete this task. Following a week of research and adhering to the (BDP) rules, the designer must express imagination in the form of their own emotion in order to transform the design. The empathy process arose from their group discussion; the respondents held a brainstorming session to maximise the design. The respondents' or designers' maximisation of

ideas is created using Computer Aided Industrial Design (CAID) and 3Dimensional (3D) software known as Rhinoceros. This task takes three weeks for the designer to understand the subject matter before implementing (CTR).

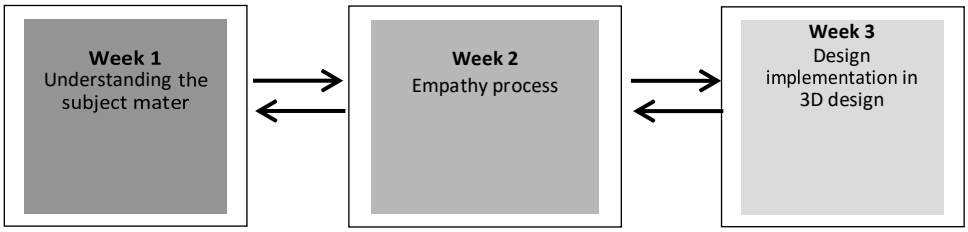


Figure 9: Weekly Progress For Data collection

The flow of progress in data collection is depicted in the figure below, in which respondents should progress from the appreciation stage to the design maximisation stage. Students must understand the entire environment and ecosystem of a subject matter in week one in order to trigger their ideation to create the task. During Week 2, designers must share their design ideas in order to create the design, and by Week 3, their design should be complete. In week three, 15 respondents must present their ideas in 3D format. We evaluated the research from conceptual ideas to design processes in our study in the way of data analysis, using Likert scale measurements of 1 to 5 for a particular attribute. The conceptual idea comes from the subject matter, sketching, and brainstorming, whereas the real design is created with the assistance of a 3D software. During validation of the data by 30 respondents, the semantic differential scale was analysed to determine the key attribute for furniture designing using the biomimicry approach.

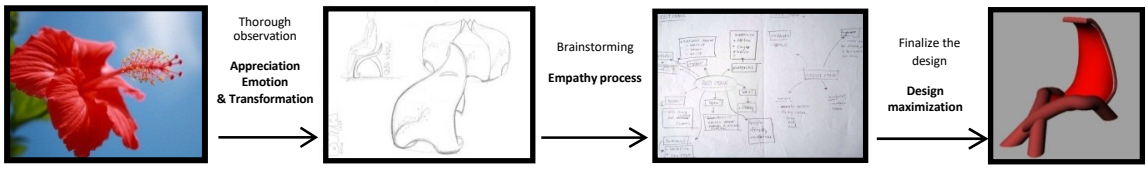


Figure 10: Implementation Progress

3.1 Data Collection

The primary goal of this research is to define the attribute through the design process. The data gathering was done in two major phases: first via the development of ideas and second through the validation of ideas. Students of industrial design respond to the methodology of action research used for this research. In each implementation, each model of thought has its own strength. The action research has been evaluating the students' ability to design seats in accordance with the (BDP). Action Research is an empirical process of which the design and construction is to take place in connection with the resolution of a collective problem in which collaborative and participatory involvement of researchers and participants as well as representatives of the situation studied (Dresch 2015). Combining the process in action research could result in good communication with impact on guiding a study phase and study

achievement; additionally, action research could trigger the orientation to knowledge creation that arises in a context of practice and necessitates researchers working with practitioners (Huang 2010).

Figure 11: Design Thinking Phase

An informed eye can immediately "read" the concept that explores new visual forms, but not necessarily as easily understood by readers of conventional literary forms. The knowledge of semantics, at least in the form of an implied understanding based on practical spatial experience, is a requisite for decoding the implied function expressed in an object's form (Swann, C. 2002). The expansion of ideas in this research focusses on the 4 design processes that involved the maximisation of appreciation, emotion and transformation. This research presents the brainstorm method to determine design development as indicated in the research methodology. In this research, the importance of brainstorming is to highlight keywords before and after design. Table 1 shows an example. Keywords from the brainstorming session will be omitted to recognise the importance of their differences in the measurement of the subject matter before and after the understanding. The researcher has planted contrasting words in the semantic deferential scale method to distinguish between the effects of before and after the design process.

The Likert scale from 1 to 5 as weightage was set to measure the difference in design and understanding on the given subject matter for the validation of the research. The purpose of the semantic differential scale between designer and consumer research was to determine the value of design between subjects via telephone conversation. The distinguishing feature of this research is that it focuses on the expansion of ideas through the designer's sketching; that is, visual evaluation. All empirical social science research is built on the concept of measurement. These could include information systems as well as disciplines such as marketing and psychology. The Likert Scale is calculated by assigning a weightage to each point on the scale and calculating an average score for each individual item. In terms of rules, it must go from negative to positive. Items are counted from 1 to 5, and their scores are used to evaluate the overall analysis of the study. It is important to note that the idea expansion evaluation consists of four steps. They are subjects provided in the form of images or visual objects from nature that will be transformed into 3D objects. When survey participants are asked to rank their agreement with survey items on a scale of Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, and Strongly Agree, Likert scales are generated. Some authors include scales

with other attitude categories. Other opposites on semantic differential scales include Not Interesting to Interesting.

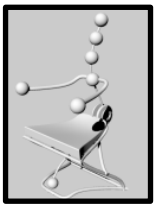
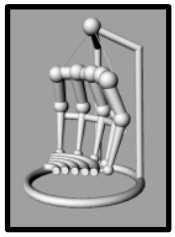
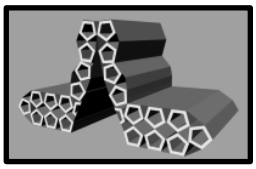
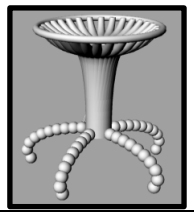
Subject matter	Likert scale for semantic deferential scale.					Design
Before	1	2	3	4	5	After
	Ineffective			Effective		
	Dull			Interesting		
	Low qualitiy			High quality		
	Not stylish			Stylish		
	Not practical			Practical		
	Conservative			Innovative		
	Not resembles			Resembles		
	Not creative			Creative		
	Weak			Strong		
	Ordinary			Unique		
	Inexperience			Experience		
	Not understand			Understand		
	Unskilled			Skillful		
	Not comfortable			Comfortable		
	Not harmony			Harmony		
	Difficult			Easy		
	Not logic			Logic		
	Disorderly			Arranged		
	Unsuccesful			Successful		
	Classic			Contemporary		

Table 2: Design with Important Attributes

3.2 Analysis of data

The following step is to examine the differences in the semantic differential scale based on the average score of 30 respondents. Design students from the industrial design department were chosen as respondents. In contrast to random public selection, the respondents were chosen based on their understanding of design and familiarity with the variable design process.

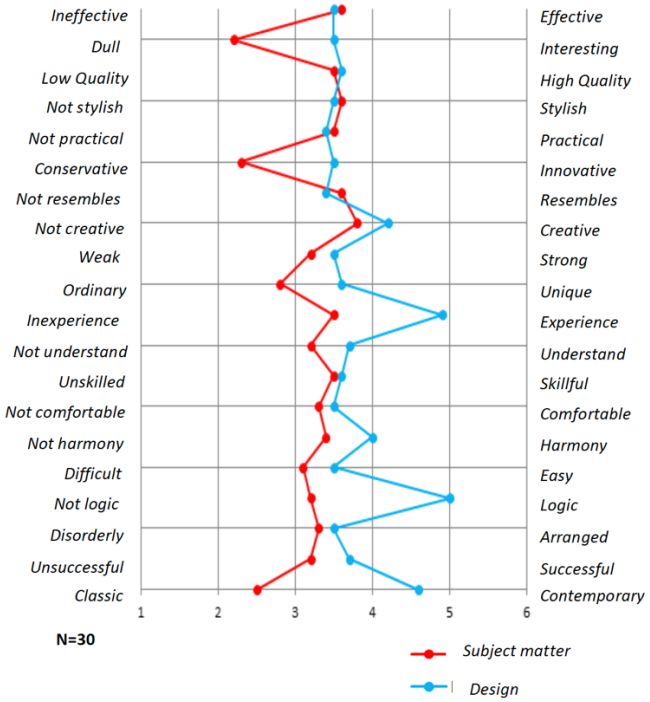


Figure 12: Plot Semantic Differentials Scale

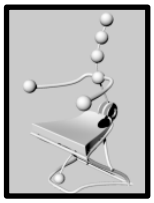
The attribute ‘Not Resemble' has the highest plot for subject matter with an average score of 3.8, followed by ‘Not Effective' with an average score of 3.6 shared with attribute ‘Not Stylish'. The three attributes with the highest average score of 3.5 are 'Low Quality,' 'Not Practical,' and 'Inexperience.' The thought evolution that the designer goes through after the evaluation phases is the importance of a high score that should be observed. This factor can be seen in the designer's preference for before and after transformation of ideas. The next step is to observe an inclination toward the lowest possible score in the implementation of a conceptual idea. At 2.2, the lowest score focuses on the attribute 'Dull.' The attribute 'Conservative' has the second lowest score of 2.3. The third lowest score is on attribute 'Classic,' with a minimum of 2.5, and the final lowest score is on attribute 'Standard,' with a minimum of 2.8. The attribute ‘Logic' has the highest average score of 5.0, while the attribute ‘Not Logic' has the lowest average score of 3.2 for three-dimensional ideas. The second highest score is 4.9 for attribute ‘Experience,' compared to 3.5 for conceptual sketch using attribute ‘Inexperience.' The third highest average score demonstrated a change in thinking and emotional attributes ‘Contemporary' with an average score of 4.6 compared to conceptual sketching at 2.5 to understanding of attributes

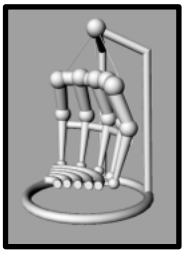
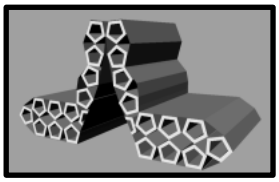
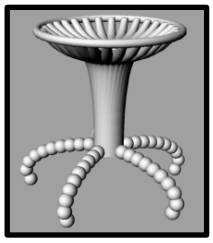
‘Classic' in design creating with the biomimicry approach. The difference between the attributes ‘Conservative' and ‘Innovative' is 2.5 to 3.5.

This situation indicates that the designer is inclined to think creatively when creating a design. In the context of research, innovative thinking refers to the designer demonstrating a positive transformation of their designs from ideas to reality. At this stage, it is apparent that the designers have considered the opinions and suggestions in order to properly harmonise their design with estimations of positioning and dimensions to their creations. The attribute ‘Dull' is the next to be measured in design thinking when creating using the biomimicry approach. There is an interesting difference in the scores of 2.1 on ‘Dull' and 3.6 on ‘Interesting.' The creation of beauty is an important aspect in the way a designer thinks because humans are drawn to beauty. This study emphasises the importance of creating beauty based on emotions, and beauty based on emotions will be based on the difference in experience and skill level. Changes to the subject matter and final ideas generated, on the other hand, were based on activities carried out solely for the purpose of strategizing and understanding the implementation of this research in creating a design process using the biomimicry approach.

3 Design Result

In this study, an educational intervention was used to assist students in solving creative problems and thinking in a systematic manner. Through seamless integration into current methods, the implementation of (BDP) tends to renew and review our own education. The design-based learning uses related scientific knowledge and skills and is practical and reflective, according to Stevens (2019). It allows students to internalise in a variety of learning styles. The practical and reflective principles are used in such a way that students can internalise in order to allow a variety of styles of learning based on three different processes: recognition through reminiscence, determine applicability and application of recalled material. This research's design finding was the result of 3 weeks of design progress. The results show that the respondent developed their own interpretation of the subject that was assigned to them. Our study indicated 5 designs from the collection of data to follow their conception through the final design. According to the findings of this study's 30 respondents, each designer has a unique perspective on the chosen subject matter. To demonstrate effectiveness in the emulation process, some designers are more likely to take only a portion of the appearance, while others are more likely to mimic the entire design. The table below contains an analysis of the interpretation of each design obtained.

Before	After	Design Interpretation
		**Design 1** Observing the carpel, which consists of the stigma, sylye and ovary. A massage chair has been designed by the designer. The filament and anther were repurposed as massage rollers.

		**Design 2** In this design, the tarantula was turned belly-up to create a soft, comfortable seat for this furniture. In selecting the upholstery material, the designer made a concerted effort to research the velvety texture of the tarantula abdomen.
		**Design 3** The designer created a hanging seat after researching the strength of the human hand.
		**Design 4** The designer has created a fashion forward furniture with a modern seat design derived from the beehive structure. Because the design employs only one material, i tis anticipated that the production of this furniture will save on upholstery costs.
		**Design 5** As a subject of study, a seat design based on water splashing was created. This furniture is suitable for daily use because it is comfortable and functional.

4 Discussion

There is a clear relationship between a wide range of keywords and transformation features in (BDP). As a result of the transformation from (CTR) study, features that represent certain

form elements of a subject matter can be developed based on related keywords in brainstorming sessions and from Plot Semantic Differentials analysis. In relation to seat or chair design, strong relationships can be found between certain form elements and chair perceptions based on selected subject matter. Popular perceptions, as measured by the semantic differential scale, range from Dull to Interesting; it was discovered that the (BDP) are effective in driving respondents from the understanding process to the design creation process. However, there are other attributes which have been shown to be effective (BDP) in this study, such as Conservative to Innovative which is apparent in (BPD) to (CTR). This attribute empowers the designers with the efficacy in terms of biomimicry-based design production. Significant changes from inexperience to experience can also be identified with the process of the subject matter understanding "before and after" as well as in the implementation of the process design. The biomimicry-based design process appears to provide designers with new, easily understood experiences. However, this research has altered designers' perceptions of how an illogical idea can be translated into a logical development idea in terms of the formation of interesting ideas. Imitation from nature typically leads to the designer expressing ideas in the form of classics, but the findings of this study shift the trend toward more contemporary and up-to-date design. The overall attributes before and after understanding of biomimicry chosen for analysis in this study are based on detailed studies in the development of furniture design. In the context of this study, the designers essentially changed their interpretations after understanding (BDP).

The element of understanding and appreciation is the first thing that needs to be emphasised in the process of internal appreciation (BDP), where the designer must understand the subject matter or object of nature of choice in (BDP) implicitly and explicitly. This is a requirement for making a product's form or function mimic the object under study. Researchers argue that designers or practitioners (BDP) such as architects, engineers, and others should take the initiative to thoroughly and extensively study the study material for effective design delivery. The Beijing Olympic Stadium, which was built in 2008, is mentioned in the issue of appreciation in (BDP) as an example of some innovations that have been successful in terms of appearance and function by using inspiration based on nature. The designer of the Beijing Olympic stadium has successfully conveyed the meaning of imitation of a subject matter, which is bird's nests, in terms of design and appearance explicitly, even implicitly the imitation of the structure of the bird's nest has proven to be a solid structure that is capable in accommodating more than 100,000 spectators at a time. In determining the transformation of ideas in (BDP), appreciation is also associated to emotions and communication. It is seen in terms of how a design is managed and given limitations to successfully and effectively place the mimic shape in showcasing the look and function of the design built.

According to Cheong (2014), the superficial level of biomimicry design corresponds to the attributes of biological subject matter associated with the causal or time- based relations between the functions of biological entities. However, (BDP) must refer to how understanding must be prioritised while going through the process (CTR), that is, understanding and interpretation while going through transformation (BDP). According to this study, understanding in transformation is the value from the designer's analysis to realise the idea that gives meaning to biomimicry, which refers to bio mean life and mimesis mean imitation or mimic. Aside from that, in the (BDP) role, (CTR) is a critical process in maximising ideas. A creative approach will be used to determine the aesthetic and functional value of biomimicry designs. What has been accomplished in this study is a method or procedure that demonstrates design thinking in order to obtain concepts in the formation of biomimicry-based ideas. The

findings of this study show that an individual who wants to understand (BDP) is not necessarily someone who understands it scientifically, that is, biologically, chemically, or physically; it can be exhibited artistically, in fact, it is exhibited through aesthetics.

However, scientific understanding is also required in determining the function of a design, as demonstrated by Gilles Martin, a nature photographer who conducted a two-year study on dragonflies and came to the conclusion that dragonflies have a very complex mechanism. Biologically, the dragonfly's colour can change to a dark red that emulates metal. While it has an unusual movement in terms of physics, it can stop abruptly at any speed or direction when moving to take the opposite direction of flight. It is clear that the combination of internal design thinking (BDR) must be balanced in terms of aesthetics and function to determine the success of development (CTR), in this case (BDP). However, the planning (BDP) for (CTR) varies depending on the designer's skill level, such as design students versus professional designers. For design students, maximisation of ideas is limited to the needs and tools available, whereas for professional designers, it is dependent on technology and user needs.

5 Conclusion

In conclusion, this study has provided an overview of planning and strategy in designing, which is critical to ensuring the contribution to new knowledge. The appreciation process in this design process can be seen as focusing on deep appreciation in recognising the study material from the selected nature in (BDP). Despite the fact that important factors have been explained in a series of observations based on this study, it was discovered that designing in (BDP) provides the opportunity to understand a subject matter in "real-time" as opposed to observing an image and watch a video as a guide in understanding for transformation (CTR) in (BDP). This entire research phase is also crucial in ensuring designers have precise guidelines in the design process.

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