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Nurturing Biophilic Design and Nature-Inspired Design in Furniture Design Projects

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Abstract

Nature provides a plethora of inspiration for designers and artists towards the generation of ideas in a design process. The biophilic design focuses more on the need of human beings to associate with nature in the built environment. The main concern of this study is to focus on natural inspiration, analogy and the application of natural materials rather than the application of bio-inspired approaches towards the bionic, biomimetic or biomimicry. This paper also provides enhance deliberation towards the nature-inspired design projects with the attributes on the indirect experience of nature in biophilic design elements. To validate the nature-inspired design projects with biophilic design elements, the attributes were cross-referenced and tabulated. Apparently, the use of natural materials, colours, and shapes, forms and natural geometries in the designs produced have a relation to biophilic designs. Furthermore, the knowledge and understanding of the respondents towards biophilic design and its relation to nature-inspired design were also analysed and deliberated. Moreover, it is hoping that more furniture designs can be produced in the future by utilising more locally source natural materials as these materials can be expanded and have potential to be used whilst also could help to generate local community income.

Keywords: *biophilic design, nature inspired design, furniture design, design project, inspiration*

1. Introduction

Nature has always been an important resource as it supplies the abundance of inspiration towards the generation of ideas in a design process. It has always been one source of inspiration for designers to create new designs or products. There is much to be learned from natural forms and shapes, colours, functions, materials, and systems. Sayuti (2016) stated seven reasons why humans need to be close to nature or other living organisms: First, *the benefits of nature to human beings*: nature provides food, water, shelter,

new materials, etcetera. Second, *to experience and explore nature* because this world provides: a) visual experiences b) physical experiences, and c) sense and emotional experiences. Third, *nature affects people's emotions, behaviours and health*: several studies have been undertaken about human preferences towards nature and how nature affects us in daily life, in positive or negative ways, depending on how we experience it (Mehrabian and Russell, 1974; Ulrich, 1981; Balling and Falk, 1982; Kaplan, 1995; Williams, 1996; Frumkin, 2003; Heerwagen, 2009; Simaika and Samways, 2010; and Capaldi, et al., 2014). Fourth, *nature inspires people*: in studies, artworks, designs, work, and environment (Benyus, 1997; Orr, 2002; Thorpe, 2007; Helms, et al., 2009; Heerwagen, 2003; Montana-Hoyos, 2010; Gruber, et al., 2011; and Gray and Birrell, 2014). Fifth, *interaction with living organisms other than human*: animals and plants, which are part of nature, have proven to be a companion for humans. Animals have been associated with humans and have been living together since long ago. Studies by Baun, et al. (1984); Walsh (2009a); and Walsh (2009b) suggested that physical contact with animals creates bonding and produces relaxation effects, and physical and mental health benefits. A study which involved children, by Nagengast, et al. (1997), discussed that having pets helped in the physiological arousal and behavioural distress in children. A study of the influences on the social-emotional and cognitive development of children, by Endenburg and van Lith (2011), showed that personal affiliation with animals brings benefits in therapy sessions with patients in hospitals (Odendaal, 2000; Hoffman, et al., 2009; and O'haire, 2010). Sixth, *changes in lifestyle*: human nowadays live in urban environments that have limited spaces for natural elements, which has created a stressful lifestyle, pollution, and environmental issues. Seventh, as a result, this has encouraged consciousness in point 6 which has *triggered awareness on sustainability and the importance to preserve nature* (Flannery, 2005; Heerwagen, 2006; Beatley, 2011; and Kellert, 2012). Environmental preservation is a huge issue, and more people nowadays are participating and working together to find solutions and address this matter. Design genres, namely, biomimicry, biomorphic, bionic, eco-design, and sustainable designs are some parts of the connotation involving nature, not only as inspiration but also adapting the functionality of nature to solve design problems and provide benefits.

As this design project involving the use of a locally source materials, the students should already have noted the importance of being aware on the environmental issues arise. In this study, the students (the main respondents) were required to create furniture designs that incorporated the natural materials available in the local area for their third- semester project. The proposed natural materials are normally used by the local crafters to produce craft products. However, some of the materials needed to be studied further or go through several processes before they could be used as the main materials in the furniture making. These materials, such as screwpine leaves, palm leaves, coconut fibre, coconut shells, banana trunks, and egg shells, are seen to have potential to be further developed in order to be used in furniture making with a combination of other materials. Moreover, bamboo and rattan were also chosen as they are abundant and widely used locally, and it was hoped that more sophisticated designs could be produced out of these materials. In the Malaysian furniture design scene, wood and timber are the mainly used materials in low -tech or hi-tech furniture industries (Ng and Thiruchelvam,2012) and also in Indonesia (Puspita, Sachari, and Sriwarno, 2016). This paper is structured to discuss on the usages of natural and local materials towards the production of furniture design in furniture studies, which also might can be proposed to be used widely in the other design projects in the future and to validate the relation of biophilic design elements and attributes.

This paper will explain, in brief, about the biophilic design and nature-inspired furniture designs. Following up on the design projects, the results on the knowledge and understanding of the relation of biophilic design and bio-inspired design in the furniture

design study will be discussed further. The findings on the biophilic design attributes with the furniture design projects are also cross-referenced and tabulated for this study.

2. Literature Review

Biophilic Design

Biophilic design, which was developed from biophilia (Wilson, 1984), incorporates the positive benefits of natural elements in the built environment (Kellert, et al., 2008. Therefore, biophilia can be defined as the needs of a human being towards the association with nature, natural elements, and natural processes. Kellert, et al. (2008, page 7 - 15) have divided the biophilic design into six design elements (can be seen in Table 1 below), which are (1) *Environmental features*, which involve colour, water, air, sunlight, plants, animals, natural materials, views and vistas, facade greening, geology and landscape, habitats and ecosystems, and fire in nature; (2) *Natural shapes and forms* in man-made designs that include the natural traits, motifs, forms or structures; (3) *Natural patterns and processes* which comprise the integration of natural elements and cycles that are compatible to be adapted to the built environment; (4) *Light and space*, involving the function of lights and spaces in outdoor and indoor built environments; (5) *Place-based relationship*, as the merging of ecology into culture; and finally, (6) *Evolved human- nature relationships*, where there are affiliations between human beings with nature, and how nature has influenced them. The biophilic design elements (1) and (2) can be seen to have a relevant connotation to this study, which can be further applied as the basis of incorporating the biophilic design in tangible products (mainly in industrial designs).

Based on the biophilic design elements in Table 1 below, this study has adopted the attributes of environmental features and natural shapes and forms. Although the characteristics of biophilic design were developed for architectural, landscape, and built environments, the relevant elements for both are seen to be compatible, and the criterion is shown by the furniture designs inspired by nature in this study or any other existing furniture designs. The features in furniture designs inspired by nature can be seen on the usages of natural materials; colour; botanical motifs; animal print motifs; spiral, oval, and tubular forms; and the latest are the application of furniture designs with living organisms. Furthermore, the biophilic design principles of environmental features (number 1) and natural shapes and forms (number 2) as explained earlier, are related to biomimicry, and other bio-inspired genres, such as, bionics, biomimetics, and biomorphism.

1. Environmental features	2. Natural shapes and forms	3. Natural patterns and processes
Colour	Botanical motifs	Sensory variability
Water	Tree and columnar supports	Information richness
Air	Animal (mainly vertebrate) motifs	Age, change, and the patina of time
Sunlight	Shells and spirals	Growth and efflorescence
Plants	Egg, oval and tubular forms	Central focal point
Animals	Arches, vaults, domes	Patterned wholes
Natural materials	Shapes resisting straight lines and right	Bounded spaces
Views and vistas	angles	Transitional spaces
Facade greening	Simulation of natural features	Linked series and chains Integration of parts
Geology and landscape	Biomorphy	to wholes
Habitats and ecosystems	Geomorphology	Complementary contrasts
Fire	Biomimicry	Dynamic balance and tension
		Fractals
		Hierarchically organized ratios and scales
4. Light and Space	**5. Place-based relationships**	**6. Evolved human-nature relationships**
Natural light Filtered and diffused	Geographic connection to place	Prospect and refuge
light	Historic connection to place	Order and complexity
Light and shadow	Ecological connection to place	Curiosity and enticement
Reflected light	Cultural connection to place	Change and metamorphosis Security and
Light pools	Indigenous materials	protection
Warm light	Landscape orientation	Mastery and control
Light as shape and form	Landscape features that define building form	Affection and attachment Attraction and
Spaciousness	Landscape ecology Integration of culture	beauty Exploration and discovery
Spatial variability	and ecology	Information and cognition
Space as shape and form Spatial	Spirit of place	Fear and awe
harmony	Avoiding placelessness	Reverence and spirituality
Inside-outside spaces		

Table 1: Biophilic Design Elements according to Keller et. al. (2008).

The Biophilic Design Experiences and Attributes

Kellert and Calabrese (2015) have developed the biophilic design experiences and attributes which can be seen in Table 2 below. The relations of these attributes towards these design projects can be seen indirectly with the usages of natural and locally sourced materials. The attributes can support the findings from this study as they show that nature inspired designs can have the connection with biophilic designs based on the indirect experience of the natural attributes as highlighted in the blue box. The attributes include images of nature, natural materials, natural colours, naturalistic shapes and forms, evoking nature, information richness, natural geometries, and finally, biomimicry. Furthermore, this study could also propose the used of integrated framework model for Biophilic Industrial Design as developed by Wolfs (2014). Wolfs looked into biophilic industrial design (as defined in his study) examples and categorised the examples into (1) *Bio-Collaboration*: Indoors Air Purification, (2) *Bio-Collaboration*: Sustainable Energy Production, (3) *Bio-manufacture*: Materials and Processes, (4) *Bio-Systems*: Interdependent Home Appliances. He did a product analysis using the biophilic attributes by tabulating and cross-referencing them with product designs.

Experiences and Attributes of Biophilic Design

DIRECT EXPERIENCE OF NATURE	INDIRECT EXPERIENCE OF NATURE	EXPERIENCE OF SPACE AND PLACE
• Light • Air • Water • Plants • Animals • Weather • Natural landscapes and ecosystems • Fire	• Images of Nature • Natural Materials • Natural colours • Simulating natural light and air • Naturalistic shapes and forms • Evoking nature • Information richness • Age, change and patina of time • Natural geometries • Biomimicry	• Prospect and refuge • Organised complexity • Integration of parts to wholes • Transitional spaces • Mobility and wayfinding • Cultural and ecological attachment to place

Table 2: The experiences and attributes of Biophilic Design by Kellert and Calabrese (2015)

Nature-Inspired Design

Creating or developing ideas is part of the design process. Gabriel-Petit (2010) stated that design is the creative process that considers the needs of the customer whilst trying to meet their own needs and create business opportunities, which also means adapting the right technologies and productions present and other relevant factors. Whilst biophilia involves the reactions and the tendencies of human beings towards nature, most nature- inspired design approaches adapt or mimic the natural elements and incorporate them into the designs or technologies to solve problems (Benyus, 1997; Thorpe, 2007; Montana- Hoyos, 2010; and Gruber, 2011). Massimo et al. (2017) proposed bio-inspired as: (1) Nature as inspiration where designs are inspired by a systematic ecological or natural process, and (2) Nature as a design constraint; nature is very resourceful, and lots can be learned or applied from it. It can be said that, it is quite a common process for designers to produce designs taken from nature in the development of ideas phase.

In the history of design, Art Nouveau, a design movement that used nature as the main source of inspiration. Industrial designers and architects develop new designs and to explore new materials which were inspired by nature. In Europe, Art Nouveau or Jugendstil, started in the early 1890s to 1910. During this movement, artists and designers believed that artworks should be inspired by nature (Hinchman, 2009). The furniture designs from this period were highly ornamented and used materials such as glass and metal. More recently, the increasing awareness towards conserving nature has encouraged the emergence of new genres in design that are nature-related, such as sustainable designs, eco-designs, green designs, and biomimicry, among others. These contemporary design

movements have aimed to alleviate the problems caused by human beings due to the over usage of natural resources and materials. Generally, many examples of furniture designs inspired by nature can be seen to be related to green design (Eco-design or environmentally friendly design) or sustainable design (which encompasses social, environmental, and economic aspects of design); however, this research has focused more on the relation of biophilic design and nature inspired design.

3. Methodology

The Nature-inspired Furniture Design Projects

Inspiration is the process of being mentally stimulated to do or feel something, especially to do something creative (oxforddictionaries.com, 2018). Gonçalves, et al. (2014) and Chan, et al. (2015) explained inspiration, which was taken from design samples such as art pieces, pictures, and other diverse forms of life, is a process of an idea searching for where it can be performed by engaging in an active or passive design process. In this context of the study, the students used natural elements as their main sources of inspirations, and the designs were also produced with natural materials which could be found locally.

The nine (9) scaled-furniture designs selected for the questionnaire survey are shown in Table 3 below:

		
A. Stool, Material: banana trunk, recycled wood, resin & coconut fibre	***B. Lounge Chair*** *Material: Screw pine leaves & recycled wood*	***C. Coffee Table****, Material: Rattan & acrylic*
		
D. Stool, Material: Rattan, coconut fibre & recycled wood	***E. Rocking Chair,*** *Material: Bamboo & Ceramic*	***F. Chair,*** *Material: Mixed natural materials (coconut shell, flowers, leaves etc), steel & resin*
		
G. Bench, Material: Nipa Leaves, resin & recycled wood	***H. Stool****, Material: Rattan & resin*	***I. Stool,*** *Material: Resin, ceramic & eggshells*

Table 3: Furniture design projects

Table 3 above shows the various usages of natural materials which was also the main concerns in the brief of their projects. The students were required to choose natural

materials which are normally used to produce simple craft products. The materials, as seen in the table above, were screwpine leaves, palm leaves, coconut fibre, coconut shells, banana trunks, egg shells, bamboo, and rattan. They had experimented with those materials with other industrious materials or chemicals such as resin, ceramic, steel, and recycled wood in order to supplement the usage of the natural materials (as some of the materials were quite fragile and could not be used alone) in the design as required in the design phase.

The Questionnaire Surveys

Initially, around 21 responses were received for this study. The respondents were the students of the BA Hons Industrial Design semester 05 and semester 03 (17 respondents) and 4 Industrial Design lecturers. This study was executed using a qualitative approach. Table 4 below shows the breakdown of the respondents considered in this study.

Questionnaire survey	Respondents
Students A – Designers (Semester 05)	9
Students B (Semester 03)	8
Lecturers	4

Table 4: The breakdown information of data gathered from the questionnaire survey respondents.

There were two types of questionnaires designed for this study. The first questionnaire was designed specifically for the furniture design students, where the questions were more on their designs (inspirations, material usages, errors or problems in the design process, suggestions to improve). Questions on the understanding or knowledge of nature inspired and biophilic designs were also asked at the end of the questionnaire. The second set of questionnaires asked about the respondents' opinions on the furniture designs that were produced by Students A (Designers). Questions on the biophilic design and its relation towards the nature inspired design and the students' projects were also asked in order to fathom the knowledge of the respondents towards those topics. The questionnaires used an open-ended format.

4. The Results and Findings

The Summary of Furniture Design Project

Table 5 below shows the summary of the answers received from the Student A (Designers) group. The answers were categorised according to the 12 questions. The furniture design which was produced by each student was a semester project and had been assessed. The questions that they had to answer were more towards their projects and their experiences whilst producing the designs. It was important for the students to share the feedback in order for them to solve the issues arising, which could help to improve their designs for the upcoming projects. The nine (9) students had provided answers depending on the designs, materials, and design requirements as stated in Table 5 below.

Respondents/ questions	Student 1 (Design A)	Student 2 (Design B)	Student 3 (Design C)	Student 4 (Design D)	Student 5 (Design E)	Student 6 (Design F)	Student 7 (Design G)	Student 8 (Design H)	Student 9 (Design I)
Q1: Project description	**Lovato**: designing a stool for a condominium using natural materials.	**Lounge chair**: Designing a seater/ lounge.	**Alekhabebi Coffee Table**: designing a coffee table using natural material for the condominium living room.	**360 S stool**: this semester, I did a furniture project that was a stool for a condominium; this stool was designed with a combination of rattan and coconut fibre.	**Rocking chair**: I designed a rocking chair using bamboo and ceramic	**NOVA**: Lounge chair for a condominium. Designing a lounge chair with natural materials.	**Delobbs**: Waiting chair for a condominium lobby.	**Stool** made from rattan and epoxy resin.	**STD Stool**: A stool with a combination of eggshells, epoxy resin, resin, and ceramics.
Q2: Reason for designing	Because I wanted to explore new materials; epoxy resin with natural material.	According to the given theme.	Because not many coffee tables using natural materials can be found.	I designed it because there are not many designs for the condominium using natural materials.	No answer.	From my subject matter (pong pong fruit).	To replace an existing design with new designs.	To experiment with the new material of epoxy resin.	I wanted to make an innovation with the mixture of natural materials and other materials.
Q3: Inspiration	I got the ideas from a snail.	- Internet - Nature	My inspiration was from avocado, boat and canoe shapes.	I got the inspiration from the bud of the guava and a woman wearing a *kebaya*.	A deer horn tree.	From my observation, research, and many other things.	Vanilla orchid.	From web research.	I got my inspiration during my study field trip to the Craft Centre, Kedah.
Q4: Materials	Epoxy resin, banana trunk, and wood.	Mengkuang (Screwpine).	Rattan and glass.	Rattan, coconut fibre, cushion, sponge, and wood.	Bamboo.	Epoxy resin mixed with coconut shells.	Epoxy resin, nipa leaves, and recycled wood.	Rattan and epoxy resin.	Eggshells, epoxy resin, resin and ceramics.
Q5: Design/ experimentation process	I think that epoxy resin was beautiful as it looked like glass.	The process was good, but it was too much to handle at the same time.	Rattan was the best material from the natural materials to be used as the structure,	I learned the coconut fibre making process and learned to weave and which part of the furniture was the best to apply the weave.	I experimented on the jointing of the bamboo and how to apply ceramic into the design.	New material used (epoxy resin). This material has the potential to be used in furniture design,	The materials used were suitable for users and the environment.	The material was complicated to use. I needed more time to study it.	It was a very hard process for me as I'm a beginner to these materials.
Q6: Errors/ problems in the design	I had a problem to apply the epoxy resin because the banana trunk had lots of water in it.	Materials handling: The preservatives did not transfer into the material.	The problem during the prototyping production was to join the small parts of the rattan.	Yes, the weaving part of my stool. I had to learn and find out the best technique to produce a good weave.	Bamboo jointing.	The structure maybe not stable.	Yes, I found a problem, which was that it was too heavy.	The epoxy resin did not dry completely.	Yes, my epoxy resin with egg shells is still wet until now.
Q7: Learned	I learned new techniques on how to use the epoxy resin and combine it with natural materials.	- Weaving technique - Colour preservation in screwpine leaves.	I learned how to bend rattan and make research on the jointing techniques.	I learned about the type of materials that I used, such as coconut fibre, and explored whether it was suitable to be applied with other natural materials.	I learned about the combination of different materials and a suitable bamboo jointing.	New experiment on new material.	Experimentation on new materials.	Learned on how to use the epoxy resin.	There are lots of new materials that can be developed in furniture design.
Q8: Redesign	I want to make my stool more suitable for users.	Make it more proper than a crafty look.	I want to combine it with other materials.	I will make my own furniture design based on the materials and will make it well known.	Design more comfortable furniture.	Yes, I want to use more new materials.	Yes, I will. I want to expand it and I want to bring my design forward.	I will study more on how to use the epoxy resin.	Using the right process and learn the details and specifications of the materials.
Q9: Improvement	No.	Jointing.	Need more time to explore the selected materials.	No.	Improve on the bamboo jointing.	Maybe not.	Try using a material that is environmentally friendly.	Need more time to study the materials and reduce the scale because the materials are expensive.	Using fewer materials.

Table 5: The summary of design projects

As seen in Table 5 above, the students had designed a variety of furniture, such as stools, chairs, lounge chairs, and a coffee table. Most of the designs were inspired by nature (plants or animals) which were found in the local environment, and others were from the internet search or existing designs. As the students were required to use natural materials in this project, each of them was assigned different types of materials. However, some of the materials could not be used alone as they required support from more sturdy materials. For example, after a series of experimentations (in the design process), screwpine leaves could only be used with a wood-based material because the leaves couldn't hold a heavyweight unless there was a layer of fabric or cloth incorporated in the design. The screwpine leaves were weaved and wrapped around the lounge chair, and as a result, the material made the design look a bit crafty and traditional. However, it has a lot of potential to be further developed to be more contemporary. Another example is a stool that was made of a banana trunk (Lovato), banana trunks consist of lots of water, and so it took lots of time to dry. The banana trunk might collapse due to the moisture and also, it has a foam-like structure that could not hold heavyweights. The student had experimented with it using a resin. The epoxy resin was used to strengthen the form, to hold and preserve the shape, and to show the cross-cut view of the trunk layers which is very interesting. Other than that, a stool that used eggshells as the main material also used epoxy resin where the eggshells were incorporated into the epoxy mixture before it was hardened in the mould. The student also combined the eggshells in a ceramic mixture which was designed for the top layer of the stool. It was an interesting process, and it required lots of patience as his stool had not thoroughly dried before the assessment day, and the eggshells tended to float to the top of the stool. It was clear that the epoxy and the eggshells needed to be applied layer by layer in order for it to have a spreading effect of the eggshells from the top to bottom of the stool. Overall, the designs that the students had created for this project were very interesting and each of them managed to explore new materials which had never been used before.

The indirect experience of nature attributes with furniture design projects

Apparently, the use of natural materials, colours, and shapes, forms and natural geometries in the designs produced by the students have a relation to biophilic designs when the attributes are used to clarify them. The main concern in this study is more on the attempt to focus on natural inspiration, analogy and the application of natural materials rather that the application of bio-inspired approaches towards the bionic, biomimetic or biomimicry. Table 6 below shows the relation of the bio-inspired design projects (9 furniture design projects) with the attributes by Kellert and Calabrese (2015), which focused on the indirect experience of nature in design. These attributes can be used to validate more design projects in the future by tabulating and cross-referencing them with the other furniture or product designs.

The Indirect Experience of Nature Attributes by Kellert and Calabrese (2015)	The Design Projects (Please refer to Table 3 for the students' project)		
Images of nature The image and representation of nature in the built environment—plants, animals, landscapes, water, geological features	None of the designs used images of nature.		
Natural materials Prominent natural building and decorative materials include wood, stone, wool, cotton, and leather, used in a wide array of products, furnishings, fabrics, and other interior and exterior designs.	Design A Design D Design G	Design B Design E Design H	Design C Design F Design I
Natural colours • The effective biophilic application of colour should generally favour muted "earth" tones characteristic of soil, rock, and plants. • Appealing environmental forms as flowers, sunsets and sun ups, rainbows, and certain plants and animals.	Design A Design D Design G	Design B Design E Design H	Design C Design F Design I
Simulating natural light and air Artificial light can be designed to mimic the spectral and dynamic qualities of natural light. Processed air can also simulate qualities of natural ventilation through variations in airflow, temperature, humidity and barometric pressure.	None related to this attribute		
Naturalistic of shapes and forms These naturalistic forms can be extraordinarily diverse from the leaf-like patterns found on columns, the shapes of plants on building facades, to animal facsimiles woven into fabrics and coverings.	Design A Design D Design G	Design B Design E Design H	Design C Design F Design I
Evoking nature The satisfying experience of nature can also be revealed through imaginative and fantastic depictions. These representations may not literally occur in nature, but still draw from design principles prominently encountered in the natural world.	Design A Design D Design G	Design B Design E Design H	Design C Design F Design I
Information richness The diversity and variability of the natural world is so pronounced, it has been described as the most information-rich environment people will ever encounter. Whether natural or built, people tend to respond positively to information-rich and diverse environments that present a wealth of options and opportunities, so long as the complexity is experienced in a coherent and legible way.	Design B	Design C	Design D
Age, change, and the patina of time • Nature is always changing and in flux, life especially reflecting the dynamic forces of growth and aging. • Change and a patina of time can be achieved through such design strategies as naturally aging materials, weathering, a sense of the passage of time, and in other ways.	Design A Design D Design H	Design B Design E	Design C Design G
Natural geometries Natural geometries refer to mathematical properties commonly encountered in nature. These include hierarchically organized scales, sinuous rather than rigid artificial geometries, self-repeating but varying patterns, and more.	Design A Design D Design G	Design B Design E Design H	Design C Design F Design I
Biomimicry Biomimicry refers to forms and functions found in nature, especially among other species, whose properties have been adopted or suggest solutions to human needs and problems.	None of the designs focus on biomimicry		

Table 6: The matrix documented the attributes of the indirect experience of nature with the students' projects

Respondents knowledge on biophilic design and nature - inspired design

The questionnaire was designed to retrieve information on the understanding or knowledge of the respondents on bio-inspired and biophilic designs. Two (2) questions on the knowledge of biophilic design and bio-inspired design were asked at the beginning of the questionnaire. The comparison of the answers represented in the table shows the responses by the students from group A and B as in Table 7 below. Also, the answers from the design lecturers have been listed in Table 8.

	Biophilic Design			Bio-Inspired (Nature-Inspired) design	
	Student A	**Student B**		**Student A**	**Student B**
Student 1	No	No	**Student 1**	No	No
Student 2	I heard it from my lecturer	No	**Student 2**	I don't know	No
Student 3	Biophilic design is a combination of nature	No	**Student 3**	No	No
Student 4	No	No	**Student 4**	No	No
Student 5	No	No	**Student 5**	No	No
Student 6	No	No	**Student 6**	No	No
Student 7	No, I've never heard this before	No	**Student 7**	No	No
Student 8	Never heard of it before	No	**Student 8**	No	No
Student 9	Yes, biophilic design is a combination of nature in furniture design		**Student 9**	No	
Percentage	66.7%	100%		100%	100%

Table 7: Knowledge on biophilic design and nature inspired design by Student A and B

Table 7 shows the answers gathered from questions on the knowledge about Biophilic design and bio-inspired design. More than half of the students (66.7%, 6 students) did not know about biophilic design, and 100% did not know about bio-inspired design. A hundred per cent (100%) of the students from Group B did not know what biophilic and bio-inspired designs were.

Respondents/ Questions	Biophilic design	Bio-inspired design (nature- inspired) design
Lecturer 1	Biophilic design focuses on bringing nature closer to the user through design. Thus, the design must relate to nature, both flora and fauna.	The design is inspired by nature. The design does not use real nature in the design, but only the influence from nature.
Lecturer 2	How humans interact with nature and natural processes through design.	Study of organism structure, mechanisms or biology parts to create an innovative design solution.
Lecturer 3	To integrate nature with design.	To include nature in design. Part of the design is inspired/ influenced by the characteristics from nature.
Lecturer 4	A design based on nature.	A design using natural materials.
Percentage	100%	100%

Table 8: Knowledge on biophilic design and bio-inspired design by the design lecturers

The design lecturers provided the answers as shown in Table 8 above. One hundred percent (100%) of them understood what biophilic design and bio-inspired design were. However, the answers were various. For biophilic design, the answers by most respondents are including connection, interaction and integration of nature in design, while for bio-inspired design, nature is adapted in design through the inspirations, structures, mechanisms or characteristics.

Nurturing the Biophilic Design and Bio-Inspired Design on the future design projects

At the end of the questionnaire, a question specifically on the opinions of the respondents towards future furniture design projects which are inspired by nature was asked. The answers from the Group A and B students were compared and depicted in Table 9 below. Answers from the design lecturers can also be seen, in Table 10.

View on furniture design inspired by nature on future projects			
	Student A		**Student B**
Student 1	I think the usages of natural materials in furniture design can make the furniture more unique.	**Student 1**	I like the used of rattan with resin in design
Student 2	I'm okay with any furniture made from natural material as long as it looks firm and durable to sit on.	**Student 2**	I'm interested in rattan and resin.
Student 3	Furniture design inspired by nature is an interesting project, but we must select the suitable materials and doing the experiment.	**Student 3**	Nature is something that is attractive, so if the furniture using a natural influence, it would be good and attractive.
Student 4	I'm impressed because the materials used are not widely known.	**Student 4**	If the furniture using a nature as influence it would be attractive.
Student 5	Aesthetic	**Student 5**	Nature give us inspiration and make us feel relax. I think it would be a good design.
Student 6	From me, it is one new idea with the use of natural materials.	**Student 6**	No answer
Student 7	it's looking fresh and suitable with environment and human	**Student 7**	Nature is good to inspire designs.
Student 8	It makes the furniture more unique and makes the user feels close to nature.	**Student 8**	It is good for the inspirations as some natural shape can be applied on the furniture design.
Student 9	Furniture design inspired by nature is interesting when applied with new materials		

Table 9: Views on furniture design projects which are inspired by nature by Students A and B

Table 9 shows the answers from the student's group A on their opinions towards furniture design inspired by nature. Furniture design which is inspired by nature in their opinions can be interesting and unique with the combination of natural materials and the newly explored materials, such as resin. Seven (7) out of 8 students from group B agreed that nature is the best form of influence in furniture design and thought that the usages of natural materials can make the designs more attractive.

Respondents/ Questions	**View on Furniture Design Inspired by Nature on Future Projects**
Lecturer 1	It is possible to enhance or extend this project, but the designers should focus on the state of the product. Avoid solid state of material.
Lecturer 2	Yes, and we need more emphasis on the practical aspects of furniture design and also the manufacturing process
Lecturer 3	Good for environmental awareness
Lecturer 4	Good to provide other materials option for material manufacturing process.
Percentage	100%

Table 10: Views on furniture design inspired design by nature by the lecturers

The design lecturers provided the answers as shown in Table 10 above. A hundred percent (100%) of them agreed that a project on furniture design inspired by nature is a good topic which can be explored further. This topic can be a way to identify and experiment on the practicality of the natural materials as alternatives in the manufacturing process, whilst it also helps to encourage environmental awareness. Overall, this project would provide a positive impact on incorporating natural elements in furniture designs.

Biophilic design and nature- inspired design project

A question on the connection of biophilic design with nature inspired design was asked. This question was asked after the images of the furniture design projects were presented (as in Table 3), and a brief explanation on biophilic design and nature inspired design were included in the questionnaire. The students (Group B) and the lecturers were asked on the relation of Biophilic Design towards the students' projects by the Group A (designers) students. Table 11 below shows the answers by both respondents.

Connection of Biophilic Design and Nature Inspired Design Projects			
Students (Group B)		**Lecturers**	
Student 1	Using the natural materials	**Lecturer 1**	For the design, Yes. Especially for the design that uses rattan, banana trunk as the material looks natural. For me, as long as the material looks natural, it is related to nature.
Student 2	Natural materials usage		
Student 3	Yes, the designs are based on natural elements around us	**Lecturer 2**	Yes, but only 50% of students who understand and have used both concepts well in this project.
Student 4	Yes, the designs are based on nature around us		
Student 5	Yes, because both of it using natural materials and recycled materials	**Lecturer 3**	In certain design where the ratio of the material usage uses more towards nature, instead of industrial/ chemical material (resin, steel etc.)
Student 6	Yes, I see the connection		
Student 7	Yes, we can try to combine the materials	**Lecturer 4**	Yes, because it follows the same method.
Student 8	Yes, the mixture of natural materials can make the design more unique and attractive		

Table 11: The connection between biophilic design and nature inspired design projects

All of the respondents answered that they could see the relation of the biophilic design and the nature inspired design projects produced by the Group A students when all of the students used natural and locally sourced materials in their furniture design. Similarity of the answer can be seen from the Students (Group B) where all of the students saw the connection of biophilic design elements with nature-inspired design in terms of the usages of natural materials in the designs. Their answers all supported by the responses by design lecturers.

5. Discussion and Conclusions

The design project was executed with the main aim to explore the usages of locally sourced natural materials in furniture design. The local materials can be easily obtained as there are locals who are selling the raw materials which are generally used to produce craft products. This nature – inspired project is also provided an alternative way to expand the

local natural and raw materials usages in order to show the locals of what more can be produced. The usages of natural materials in design can be related to biophilic design elements, *the environmental features* and *natural shapes and forms*. This project findings were also further validated with the indirect experience of nature attributes by Kellert and Calabrese (2015). These validations were made to see the relation and connection in this genre in the use of natural materials. Furthermore, it also can help to identify the characteristic of nature which can be used to influence the designs. As the outcomes, it created more unrestricted shape or form with more spontaneous characteristics. Nature has incorrigible features and this helps in the exploration of new ideation and development process stages. The verification of this attributes shows the connection and relation towards the topics or areas which could be used to help the students to evolve further in the idea generation process. The biophilic design principles also can be further explored in furniture design through different focuses, by the application in the usages of images of nature, botanical motifs, natural materials, natural colours, geometrically and organically shapes and forms (which are inspired from shells and spirals, egg, oval and tubular forms and etcetera, as listed in the *natural shapes and forms*) which were explored in this study. Moreover, the students were given freedom to explore and develop the designs as they wished with no restriction. Their responses and feedback towards the project were gathered in order to see their understanding on the given topic and how they relate it to other theories in design, which also enabled them to identify the problems arises and suggest solutions while exploring new materials. However, these two design genres (biophilic design and nature- inspired design) are different from the design genres, namely, biomimicry, biomorphic, bionic, eco-design, and sustainable designs as these genres do adapting the functionality of nature but in different connotation and understanding towards nature application, which can be more complex and need more in-depth studies towards the functionality of nature in design. Finally, this study can also open up new possibilities for more research works in the future with the application of local natural raw materials in furniture design studies with the collaboration of other nature-oriented design topics.

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