



**UNIVERSITI PUTRA MALAYSIA**

***TRANSFORMATION-BIOMIMICRY THEORETICAL FRAMEWORK IN  
CHAIR DESIGN PROCESS BASED ON MALAYSIAN IDENTITY***

**FU CHEW XIANG**

**FRSB 2019 2**



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By

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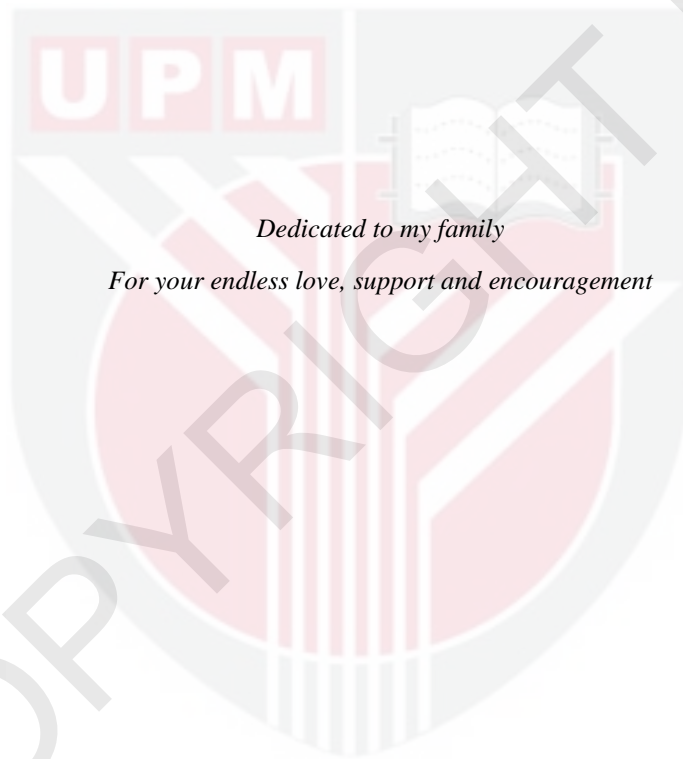
**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**October 2018**

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*Dedicated to my family*

*For your endless love, support and encouragement*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

## **TRANSFORMATION-BIOMIMICRY THEORETICAL FRAMEWORK IN CHAIR DESIGN PROCESS BASED ON MALAYSIAN IDENTITY**

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**October 2018**

**Chairman : Zulkilfi B. Muslim, PhD**  
**Faculty : Design and Architecture**

The government of Malaysia is still trying to identify Malaysian Product design identity. Central to the idea of biomimicry and Malaysian Identity to innovation that seeks sustainability solutions in chair design, this study establishes the connection between science, engineering and design. By emulating Rafflesia's biological design, this research aims to create a theoretical framework, with the goal of providing Malaysian chair designers with an easy starting point to work with Rafflesia-biomimicry in chair design bearing the Malaysian identity. In this study, data were collected concurrently in one phase, which is called the concurrent triangulation design. The results collected from 400 questionnaires and 10 interviews were analysed separately and then compared and combined to cross-validate and corroborate findings. Rafflesia flowering (a blooming process) was studied as the basis for structural development while the applicable Transformation Theory, "Fuse/Divide" was determined. These studies were translated into an initial 3-dimensional chair model representing science, engineering and design, which is essential to contextualise further design development of the Transformation-Biomimicry Theoretical Framework. Chair structure and strategies are sought from

Rafflesia's blooming process for shape-transforming morphologies. The features gathered from the survey research includes providing multi-tasking features with a different configuration, and easy storage. The challenges and perspectives for biomimicry in chair design of Rafflesia's blooming process in the future are also briefly addressed in this study. The results of the study are presented in this thesis as the Transformation-Biomimicry Theoretical Framework which can be used as a guide to the biomimicry design in chair. A workshop consisted of 11 participants was conducted in the validation of the Transformation-Biomimicry Theoretical Framework. It provided valuable information regarding the biomimicry of Rafflesia and address the role of Transformation Design Theory in chair design on a continental scale by bridging the gap between science, engineering and design. This information will likely impact the design of future furniture. Future research is recommended to expand upon the Transformation-

Biomimicry Theoretical Framework in Chair Design Process based on Malaysian Identity and education widely.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

## **RANGKA KERJA TRANSFORMASI TEORITIKAL BIOMIMIKRI DI DALAM PROSES REKABENTUK KERUSI BERASASKAN IDENTITI MALAYSIA**

Oleh

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Kerajaan Malaysia masih cuba mengenal pasti identiti reka bentuk Produk Malaysia. Penilitian idea biomimikri dan identiti Malaysia terhadap inovasi adalah untuk mencari penyelesaian kemapanan dalam reka bentuk kerusi, kajian ini mewujudkan hubungan antara sains, kejuruteraan dan reka bentuk. Melalui peniruan reka bentuk biologi *Rafflesia*, penyelidikan ini adalah bertujuan untuk mewujudkan rangka kerja teori di mana ia berfungsi sebagai langkah permulaan yang memudahkan reka bentuk kerusi *Rafflesia*-biomimikri yang mengandungi identiti tempatan Malaysia. Penyelidikan ini, data dikumpul secara serentak dalam satu fasa, yang dikenali sebagai persamaan reka bentuk triangulasi. Hasil keputusan yang dikumpul daripada 400 borang soal selidik dan 10 wawancara dianalisis secara berasingan kemudian analisis dibandingkan serta digabungkan untuk pengesahan keputusan.

Pembungaan *Rafflesia* (proses mekar) telah dikaji sebagai asas untuk perkembangan struktur manakala Teori Transformasi yang berkenaan, “Beradun/ Bebahagi” (Fuse / Divide) ditentukan. Kajian ini diterjemahkan ke dalam model kerusi 3-dimensi awal yang mewakili sains, kejuruteraan dan reka bentuk yang penting untuk kontekstualisasi selanjutnya. Seterusnya, perkembangan Rangka Kerja Teori Transformasi-Biomimikri dirangkakan. Struktur kerusi dan strategi ditemui daripada proses mekar *Rafflesia* (perubahan morfologi). Ciri-ciri yang dikumpul daripada tinjauan penyelidikan termasuk konfigurasi yang berbeza dan mengandungi pelbagai fungsi, serta penyimpanan yang mudah. Cabaran dan perspektif reka bentuk kerusi biomimikri *Rafflesia* pada masa akan datang juga diterangkan secara ringkas dalam kajian ini. Hasil kajian dalam tesis ini iaitu rangka kerja Transformasi Teoritikai Biomimikri dalam proses reka bentuk kerusi berasaskan identiti Malaysia boleh digunakan sebagai panduan kepada reka bentuk biomimikri kerusi. Satu bengkel yang terdiri daripada 20 orang peserta telah dijalankan untuk pengesahan Rangka Kerja Transformasi Teoritikai Biomimikri. Ia akan memberikan maklumat yang berharga mengenai biomimikri *Rafflesia* dan menerangkan peranan Teori Reka Bentuk Transformasi mengikut skala kontinental dengan

merapatkan jurang antara sains, kejuruteraan dan reka bentuk. Maklumat ini mungkin akan memberi kesan kepada reka bentuk perabot masa hadapan. Kajian masa depan disyorkan untuk mengembangkan Rangka Kerja Transformasi Teoritik Biomimikri dalam Proses Reka Bentuk Kerusi berdasarkan Identiti Malaysia dan pendidikan secara meluas.





## ACKNOWLEDGEMENTS

The researcher would like to dedicate her sincere gratitude to her advisor Dr Zulkifli B Muslim of the Faculty of Design and Architecture at Universiti Putra Malaysia. The door to Dr Zulkifli office was always open whenever the researcher ran into a roadblock or had a question about her research. Dr Zulkifli consistently allowed this paper to be her original work but steered her in the right direction whenever he thought she needed. Besides her advisor, the author would also like to thank the rest of her supervisory committees, Dr Mohd Shahrizal Bin Dollah and Dr Raja Ahmad Azmeer Bin Raja Ahmad Effendi for their encouragement, hard questions and insightful comments. Her sincere thanks also goes to Ms Nursyida Binti Mansor for helping her to deal with the PhD registration throughout her journey.

The researcher is thankful to the experts who were involved in the data collection and validation survey for this research project. They were Ms. Loke Va Nee (The One Academy), Dr. Mohammad Azroll Bin Ahmad (University Technology Mara), Mr. Shahrul Azman (Universiti Putra Malaysia), Mr. Fignon Tee (Segi University), Mr. Jacky Loke and Ms. Chong May Yee (First City University College), Mr. Mohd Idzuan Othman (Inti International College Subang), Ms. Nurliyana Zakaria (Tunku Abdul Rahman University College), Mr. Saifullizan Bin Abdul Wahab (Limkokwing University of Creative Technology), Ms. Intan Noorazura Bt. Abd. Ghafar (Saito College), Ms. Bibi Zafirah Hanfa Badil Zaman (Hive Studio), Mr. Amirul Idlan Mukhtar (WEDABO Malaysia), Mr. Mark Lim (HOTO Stainless Steel Industries Sdn Bhd), Mr. Wincen Foong Hock Kuen (Sunway University), Mr. Yuen Wei Yao ( Kurz ), Mr. Luk Chee Chew (Main-main), Mr. Jammez Loh (Main-main), Mr. Mohd Nizam Najmuddin and Mr. Nazjimee Bin Amat (Mimos Berhad), Mr. Ivan Yeong Ming-Hun ( My Crafty Ideas Enterprise) and Mr. Tan Wei Jian.

She is grateful to all of those with whom she has had the pleasure to work during this research, each of them has provided her extensive personal and professional guidance and taught her a great deal about research and life in general. The financial support of MyBrain15 is also gratefully acknowledge.

Nobody has been more important to her in the pursuit of this project than the members of her family. The researcher expressed her heartfelt gratitude to her parents, and parents in law, whose love and guidance are with her in whatever she pursues. Most importantly, she wishes to thank her loving and supportive husband, Giam Teik Sheng, and her siblings and best friends who provided her constant inspiration, unfailing support and continuous encouragement throughout her years of study. Thank you.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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## LIST OF ABBREVIATIONS

UKM	Universiti Kebangsaan Malaysia
RS	Research scope and limitation
RQ	Research question
RO	Research Objective
KC	Knowledge contribution
T-BTF	Transformation-Biomimicry Theoretical Framework
BT	Bio-TRIZ
NSA	Nature Studies Analysis
DS	Design Spiral
TA	Typological Analysis
AT	Analogical Translations
AM	Additive Manufacturing
Q	Question
R	Respondent

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

The first part of chapter one deals with the background study, problem and research statement, knowledge gap, research aims and objective, and the relationship between research questions and characteristics of Malaysia endemic plant (*Rafflesia*). Second part discusses on research frameworks, research scope and limitation, significance of research, while the last part summarizes the key criteria of research.

### 1.2 Background Study

Nature has always been the fount of all knowledge. Humans obtain and derive knowledge and skills from nature, at the same time trying to imitate natural forms and structures. Nature has inspired designers with its laudable mechanisms in its complex ecosystems. Observing nature from a different standpoint, comprehending it and seeing the solutions is especially important for designers. There is an unquestionable link between science, engineering and design, thus supporting biomimicry design in various field of design training will definitely reap appreciable benefits.

The researcher is inspired to embark on this research from observing the design process of architecture, from the book 'Bio-structural Analogues in Architecture'. In architecture, there is a strong emphasis on the design process which is not seen in the furniture design industry. This has inspired the researcher to come up with a theoretical framework to aid the process of furniture design for aspiring Malaysian designers. Adding to this, the researcher wishes that this theoretical framework will help bring the Malaysian identity to a global scale in the furniture design industry. The researcher has an idea of bridging the gap between science, engineering, and design through the combination of transformation design principles and biomimicry.

### 1.3 Problem Statement and Research Statement

Science and technology (engineering) hold together to support sustainable development and most likely result in success (Bokova, 2010). Based on the research background discussed in section 1.2, this research is focused on the opportunities at the knowledge gap between engineering, science and design. The researcher is interested in drawing an analogy between *Rafflesia* and chair, where the researcher can use the blooming analogy of *Rafflesia* (science) to develop a chair (design) into a transformer product (engineering) and documenting the design process that enables Malaysian Furniture designers to use it as a guidance in their studies.

As shown in the literature review (section 2.5.3), there are many bio-inspired chair design, however, the detailed documentation in recording the design analogy and its process are hardly found. Furthermore, from the questionnaire findings (question 16), the undergraduates showed poor understanding about biomimicry design and Transformation Principles. Accordingly, the intention of this research is to define the Transformational Principles, which could be used to derive chair design, empower Malaysian identity, and to gather ideas to expand such development based on Rafflesia biomimicry in chair design. Through the emergence of Transformation Biomimicry in Furniture Design and its documentation, Malaysian design undergraduates could soak up new facts and use this new knowledge to innovate more biomimicry designs.

In addition, the Malaysian government is still trying to identify Malaysian Product design identity (Shariman Zainal Abidin, 2015). Introducing Rafflesia biomimicry in chair design could have unique features which showcases the Malaysian identity to some specific localities which offer endless experience in promoting local culture in Malaysia (Ahmad Zamil Zakaria, 2014). Supported by Chiou (2008), the success of the research in chair design will deduce significant guidance for Malaysian furniture designers in chair design development process based on the Rafflesia Biomimicry.

#### **1.4 Research Questions**

The research questions are derived by the knowledge gap, research statement (as discussed earlier in this chapter) and research hypothesis as outlined as below,

Three research questions have been derived from the hypothesis above including:

- How does Transformation Principles and Transformation Design Theory affect biomimicry in chair design?
- Why Rafflesia flower is appropriate Malaysian Identity biomimicry resemblance in chair design?  
How does Transformation-Biomimicry Theoretical Framework benefit Malaysian chair designers?

##### **1.4.1 Relationship between Research Questions and Characteristics of Malaysia Endemic Plant**

The Malaysia endemic plant mentioned here refers to Rafflesia. First, a thorough study of Rafflesia were collected and analysed in Chapter Two (literature review). Then, through the review of quantitative and qualitative findings, the researcher found out which transformation principles and analogy of Rafflesia is more suitable to be used as the analogy in the chair design. Hence, this observation can answer research question (2) and (3), in which “fuse and divide” and “blooming analogy” are the representational and associate thinking to the idea of a design strategy in developing the biomimicry chair. For example, in research question 2, Rafflesia is the associate thinking of Malaysia

identity, therefore, when blooming analogy of Rafflesia is used as the biomimicry analogues, it will help Malaysia to gain an international prestige. The findings subsequently become the guidance where the design process and detailed research are documented precisely in Chapter Four and Five. As a result, question (3) will be answered. This is how the characteristic of Malaysian endemic plant are linked to the questions.

### **1.5 Research Aims and Objectives**

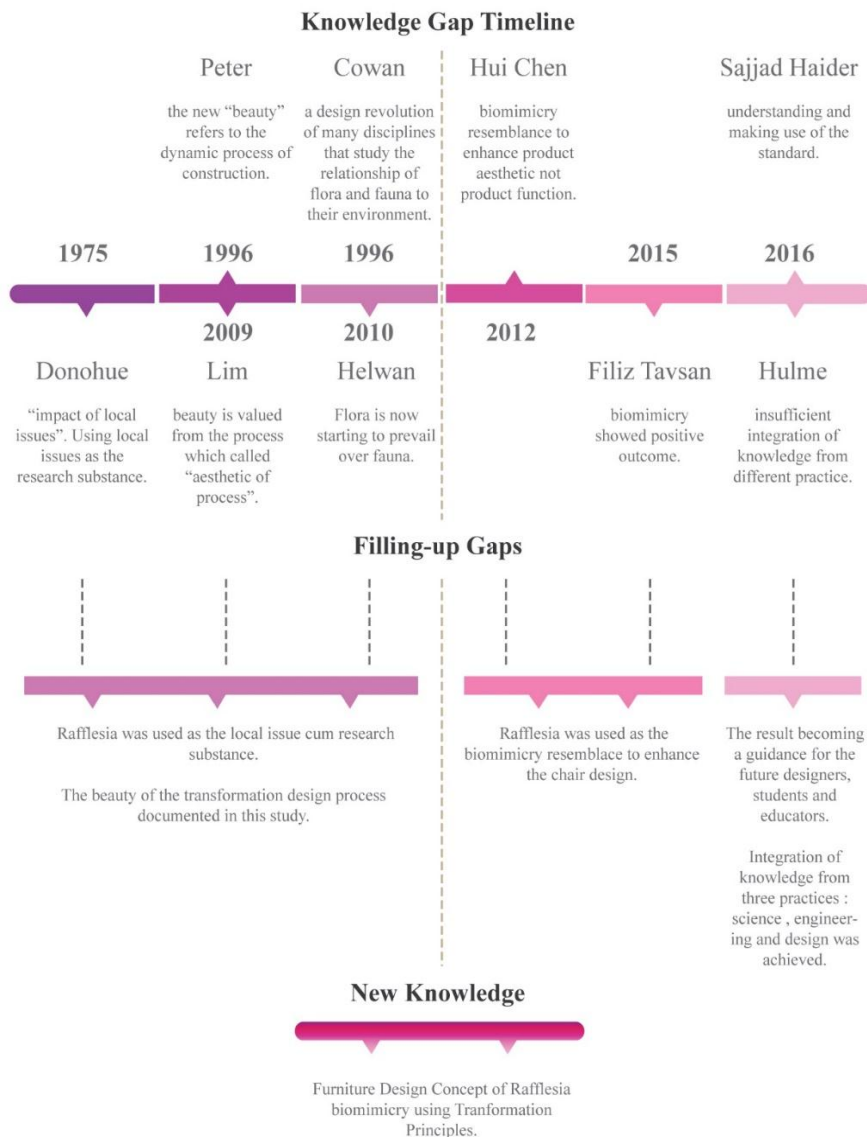
This research is set out with the principal aim of seeking an appropriate chair transformation process of design analogous to Malaysia endemic plant, Rafflesia with reference benchmark of Transformation Design Theory (A Meta-Analogical Framework) in mechanical domain.

To achieve the aims, the following objectives were formulated at an early stage for this research:

- To identify the Transformation Principle and design theory in relation to Biomimicry.
- To establish the Rafflesia flower as the biomimicry resemblance in chair design based on Malaysian Identity.
- To develop a Transformation-Biomimicry Theoretical Framework in assisting chair designer in Malaysia.

### **1.6 Knowledge Gap**

Knowledge gaps are physical and cultural capital related (Mariotti, 2016). According to Mariotti, physical knowledge gaps include knowledge relating to understanding and making use of the standards, the latter concerning on the improvements of work practice. Moreover, Professor Hulme (Martin, 1996) outlined that insufficient integration of knowledge from different practice and an addition of new definition and essence to our understanding of real life are part of the knowledge gaps to perceive. Figure 1.1 provides a timeline of the knowledge gaps identified in previous studies.



**Figure 1.1: Knowledge Gap**

## 1.7 Research Scope & Limitation

The limitation was established from the outset. This research focuses specifically in Malaysia and the main research problem focuses on the analogue between Rafflesia and chair design involving Transformation principle (Fuse/ Divide). Thus, the scope of the research centres on identifying the transformation principle in relation to Rafflesia biomimicry that can be further developed into Transformation Biomimicry Theoretical Framework. The conceptual framework in section 3.7 evaluates Fuse/Divide with the



concept of biomimicry based on Malaysia endemic plant, Rafflesia, in order to ensure the success of a Chair design bearing Malaysian Identity. The researcher's goal is to generalise theoretical framework and not to design a series of furniture. Therefore, the thesis uses the preferable type of chair, flower that represent Malaysian identity and Transformation principle chosen by the participants from the questionnaire sample. This helps to confine the research within the parameters set by the researcher.

## **1.8 Significance of the Research**

This study establishes the knowledge gap and perspectives in the aspect of biomimicry in furniture with selection of transformation principles, respondents' preferences, and the design criteria that would act as a guide for future designers and professionals. It is hoped these could be used as one of the guides and references for furniture making in developing and designing furniture products, particularly Rafflesia biomimicry in furniture design.

The search for Malaysian furniture design identity is growing pervasively. According to (Awang, 1996), product design identity was discovered during the problem-solving process. Product design conforming completely to the given criteria such as the needs and aspiration of the target users would later become the standard work norm that fits the users' lifestyle. This study solves the problems of furniture design identity in Malaysia, the Rafflesia-analogues in chair design becomes a well-defined identity when its part effectively meet the defining criteria: differentiation and continuity (Roy, 1986). Rafflesia-analogues in chair design is something to set off from others as it is the differentiation of Product Design Identity. High involvement purchase decision is a problem solver in furniture design. Rafflesia-analogues in chair design have symbolic significant on customers' need based on consumer selection criteria.

## **1.9 Summary**

Chapter One has laid the fundamentals for this thesis. It shows the gaps specifically in the area of biomimicry chair design in relation to Malaysian identity. The conceptual framework of the study was outlined and the research questions were introduced. The purpose of this study is to identify the transformation principle in relation to biomimicry that can be further developed into Transformation Biomimicry Theoretical Framework in assisting chair designers in Malaysia. In addition, this study contributes in chair design process that improves the function, aesthetic values of the chair, and reflects Malaysian identity. Following this, the limitations of the study are presented.



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