

ENDEMIC FURNITURE: TRANSFORMATION-BIOMIMICRY THEORETICAL FRAMEWORK IN CHAIR DESIGN

Fu Chew Xiang

Department of Arts, Design, and Media, School of Arts, Sunway University, no 5, Jalan Universiti, Bandar Sunway, 47500 Selangor, Malaysia.

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ABSTRACT

Transformation-Biomimicry Theoretical Framework (T-BTF) helps designers reduce the production costs of materials while optimizing the effectiveness of the furniture to achieve the desired functions. T-BTF has proven its potential in accelerating the chair design process based on a workshop conducted at Sunway University. A group of Interior Design students managed to design a piece of biomimicry chair by using T-BTF as a framework with a more well-thought design facilitating the transformation of Rafflesia's structure in 40 minutes. The outcomes showed new design solutions that portray Malaysian identity most vividly and the efficiency of the furniture is improved.

1. INTRODUCTION

1.1 Nature-Based Framework for Sustainable Furniture Design

In nature, nothing is single-purpose. For example, the ocean is home to many creatures, it regulates the earth's system and absorbs carbon dioxide. Nature has the answers to all design problems, biomimicry helps designers reduce the production costs of materials while optimizing the effectiveness of the furniture to achieve the desired functions. Imagine furniture structures that could accomplish multiple functions just like the ocean.

The chair has always been an important part of our life, we use it for working, drawing, resting, and many more. Population growth required furniture to be optimized, as our needs and life circumstances change, so does our chair. In the past, designers used natural elements in chair design with primitive forms, now, with the support of technology, chair design promises unconventional possibilities. Furniture designers can now develop ideas based on the anatomy and function of what nature has to offer. Looking to nature for inspiration can implement sustainability in the chair as biomimicry is like natural systems, it is self-solving and self-reinforcing. Integrating biomimicry into chair design practice can make our built environment "fits in" again and contribute to the ecosystem we live in by analogizing the functions of nature.

Transformation-Biomimicry Theoretical Framework in Chair Design Process based on Malaysian Identity offers a sustainable solution for furniture designers to create a healthier and more sustainable planet, that will have a positive impact on the future of our bodies and environment.

2. LITERATURE REVIEW

2.1 How does Covid-19 foster Furniture Design?

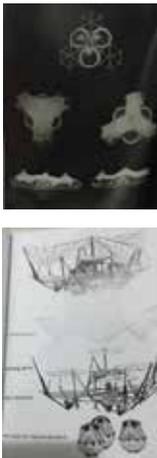
The Covid-19 pandemic made an impact on the home environment, when lockdown required people to stay home, people want versatile furniture. Covid-19 boomed the furniture industry in 2020 as people were stuck at home and the growth can continue (Hyman, 2021). In Kuala Lumpur, especially during the pandemic, the dining chair is used as an office chair, which is unergonomic. The new work-from-home revolution will continue to shape what furniture will be like in the future as workers are struggling to come back to office buildings, this will certainly change office furniture from now on. Considering that many will continue to work from home, office furniture will likely have to be more ergonomic and practical.

2.2 Transformation-Biomimicry Theoretical Framework

There is a close relationship between design, science, and technology, a biomimicry chair that deserves research recognition is unique and highly valued in sustainable furniture design. A variety of biomimicry furniture (nature-inspired solutions) (Lim, 2009) are available in the furniture

market (Table 1) however detailed documentation recording the design analogy and its process is hardly found. Therefore, Transformation-Biomimicry Theoretical Framework (T-BTF) provides guidance for chair design that expose Malaysian Identity with the morphological analogy of Rafflesia and the adaptation of the transformation principle. This outcome will lead to a new lifestyle and makes the chair design pleasant and impressive (Rajasekar, 2013).

Table 1: Plant Structural Analogues Form

Plant Structural Analogues Form			
Plant Name	Madagascar Palm	Hornbeam Leaf	Water Hyacinth
Binomial Name	Genus <i>Dyptis madagascariensis</i>	Genus <i>Carpinus betulus</i>	Genus <i>Eichhornia crassipes</i>
Family	Areaceae	Betulaceae	Pontederiaceae
Plant Structure			
Structural Analogues Form			
Descriptions	The shape provides efficient strength to the form which acts as a lattice shell, for both compression and pressure. The two layers of wooden strips help convey forces to the denser perimeter compression member.	The shape of individual "leaves" was studied and translated into the unfolding pattern. This configuration could unfold the entire canopy by giving force at one point to counter the lateral forces of the moving panels.	Hyacinth was used as the abstract analog to simulate pneumatic floats. The primary floatation devices were made of three hexagonal platforms cantilevered from three inflated hulls.

(Lim, 2009)

Biomimicry furniture can be constructed to perform the same functions a natural ecosystem does. With the application of transformation principles (Table 2) (Vikramjit, 2009) such as expand/collapse, expose/cover, and fuse/divide, furniture has the potential to be truly portable and highly flexible.

Table 2: Transformation Principles and their definitions

Transformation Principles	Definition
Expand/collapse	The transformer product changes its physical dimension to become bigger or smaller in occupied volume along an axis, three dimensions, or in a plane.
Expose/cover	The transformer product opens or covers a new surface to change functionality.
Fuse/Divide	A single transformer product separates itself become two products in which at least one part has a different functionality when separated from the function of the single product.

Transformation-Biomimicry Theoretical Framework (T-BTF) is a framework that involved the identification transfer of transformation principles to the furniture domain. T-BTF uses Rafflesia (plant structural analogs form) in the design process.

A comparative analysis of a series of biomimicry studies including analogical translation systems, Bio-TRIZ, Design Spiral, Nature Studies Analysis, and Typological Analysis (Figure 1) helped observe the similarities, variances, and specific implications of developing an appropriate Transformation-Biomimicry Theoretical framework. This process aids inquiries and understandings of the scale of application in the parallel transference of ideas, notions, and approaches of natural systems to build systems.

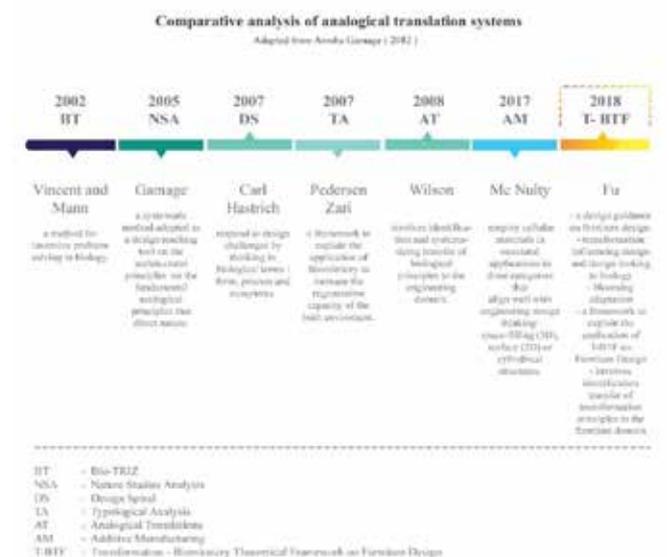


Figure 1: Comparative analysis of analogical translation systems

The greatest potential of the T-BTF resides in its application for transformation as a process rather than as directly mimicking the Rafflesia. This evolution of thinking patterns can be transformed into a sustainable design thinking process for chair design by identifying how transformation principles can be applied; what their function is; who uses them, and how best the functions can be integrated. T-BTF can be extended further using mimicking the inspiration from plants' natural mechanisms such as the wither process and the petals arrangement patterns. Adopting these patterns, mechanisms, and processes can help upsurge the level of diversity and multifunctionality to optimize chair designs.

A chair designed based on T-BTF performs better functions between states that might seem impossible for a single primary-function product. The T-BTF chair is more refined as it has the possibility of converting itself into a different configuration and enhancing new performance all within one system (Brandon, 2007). Its manufacturing cost and sales price are reduced compared with the costs of a set of single primary-function products. A T-BTF furniture piece cuts down complexity and deployment time for many designers, it facilitates new design solutions for products that serve a wide variety of functions. This type of furniture is compact, space-saving, and multifunctional.

2.3 Malaysian Identity through Biomimicry Analogy

The researcher aims to bring out Malaysian Identity by setting Rafflesia as the biomimicry analogy. The Malaysian government has always been asked to establish Malaysian identity as the "Nation" of Malaysia (Leung, 2017). The main issue of design identity is the recognition of national identity for local product design (Shariman, 2015). Rafflesia is one of the significant elements expressing the notion of Malaysia, for instance, the Ten Ringgit Malaysia note issued by the new central bank, Bank Negara Malaysia carried the image of the Rafflesia Azlanii indigenous to Peninsular Malaysia. Thus, it is believed that this primary study of Rafflesia-structure analogs in chair design would bring Malaysian furniture design to another level. This innovative idea of Rafflesia structure analogs in chairs incorporating transformation design principles would be able to trigger a new pragmatic approach that represents Malaysian identity.

3. METHODOLOGY

3.1 Prior Research and Methods

The origin of the Transformation- Biomimicry Theoretical Framework (T-BTF). T-BTF was developed using mix-method approaches to identify the transformation principle and the significant element expressing the notion of Malaysia. There are 3 sets of transformation principles (Table 2) to choose from and decide on a plant representative of Malaysia. In doing so, Cross-Sectional Survey Design was used to administer the survey once to a group of design-related participants sample, and procuring data

on the Rafflesia-structural analogs criteria measured characteristic during the survey. The factual data were concluded in a descriptive way, which included the testing of the engagement of Rafflesia and Transformational Design Theory with chair design (relationships among population characteristics). The above-stated, researcher has explained in detail in the Ph.D. thesis entitled "Transformation-Biomimicry Theoretical Framework in Chair Design Process based on Malaysian Identity". What follows will be a brief description of the prior research.

Firstly, a pilot test was conducted to pre-test the questionnaire and refined based on the pre-testing result. The finalized questionnaires took two forms: close-ended items, open-ended items, and Likert-scale items.

Then, a self-administered questionnaire was used as the survey instrument in this study. The researcher had briefed the research objectives and background before conducting the survey. A clear guide was provided and the language was not ambiguous. Respondents were required to read the instructions and mark their answers. The self-administered questionnaire was divided into two parts: demographic questions and content items. Demographic questions obtained information about the respondents, for instance, gender, level of education/profession, and university/company. On the other hand, content items are questions to collect respondents' personal views, attitudes, knowledge, and design behavior, such as what participants' opinions on biomimicry chair design or where they stand on such issues as using Rafflesia plant as a chair design inspiration. This part of the questionnaire is subjective, in which there is no right or wrong answer.

For the questionnaire survey, the population selected in this study included individuals from age 18 and above to be represented and a sample refers to design-related individuals. The design-related field in this study refers to Interior Design, Industrial Design, Furniture Design, and Product Design. The researcher selects a sample of 405 participants from a design-related field as a population of interest for this research project, then the researcher makes principles and logic based on the sample results.

The questionnaires consist of 29 questions which comprise three sections as follows:

- i. Demographic data
- ii. Transformation design process in significant correlation to chair design
- iii. Awareness and preferences of respondents in promoting Malaysian Identity to be used as the design criteria in T-BTF
- iv. Indicating preferences of respondents in biomimicry chair design to be used as the design criteria in T-BTF
- v. The effectiveness and benefits of Rafflesia-chair analogy

Next, the researcher conducted an in-depth interview (semi-structured) that provide a clear set of open-ended questions for the interviewers. The conversation may diverge from the interview guide; therefore, the researcher chose to tape-record the interviews and later transcribed these records for analysis. The interview questions were structured based on Krueger's Focus Group Interview methods.

The respondents to these interviews comprised a group of practicing designers and were not part of the group that answered the questionnaire. The ten respondents selected are key personnel in their company, decision-makers, and experienced designers. There were nine semi-structured questions in the interview which elicit open-ended responses, each interview required 30 to 45 minutes.

The two common sampling considerations were chosen: convenience sampling and random sampling. The convenience sampling technique is time and money-saving. Participants such as college and university students volunteering for the study are called "a student population". Random sampling is important in survey research design as it provides a stratified sample of participants from multiple groups of ages, professions, and socio-cultural. Practicing designers, design manufacturers, freelance designers, and design academicians fall under random samplings which are preferred in these in-depth interviews to collect non-biased data.

The researcher considered the population from age 18 and above to ensure they have their perceptions and judgments in design. The stratified samples provide a wide range of diverse opinions. Students are more creative and innovative, they have no limit in imagination; practicing designers know the emerging trends and market in design; manufacturers understand the prototyping process and academicians know the concepts.

10 questions were asked in the interview as listed below:

- i. Do you like the biomimicry chair idea?
- ii. What is your opinion about Rafflesia biomimicry design?
- iii. How is Transformation Design Theory affecting chair design?
- iv. Do you think Rafflesia Biomimicry in chair design promotes Malaysian Identity?
- v. How are designers, educators, and students benefited from Rafflesia biomimicry in chair design?
- vi. Any disadvantages to the concept of Rafflesia biomimicry in chair design?
- vii. Do you think this concept will contribute to Malaysia's furniture industry?
- viii. Do you think this idea is original, innovative, and sustainable?
- ix. Will you buy this chair?

Using a mix-method, the researcher compared data collection through a questionnaire survey and interview in a complementary fashion. The inquiry approaches in this study yield essentially the same result which offers credibility. From the findings of the study, a conceptual model has been developed and termed as "Transformation-Biomimicry Theoretical Framework".

3.2 T-BTF Drawing Workshop

Once the criteria were drawn from the survey and interview, the Validation of the Transformation-Biomimicry Theoretical Framework was carried out in a drawing workshop, which consists of two sections (Wan Noor Faaizah, 2015). This workshop involved 11 students from Sunway University who study a Diploma in Interior Design and are also taking the Furniture Design Module. In this measurement, the test aims to find out the result before and after T-BTF implementation; therefore, a small number of participants was sufficient to validate T-BTF. To find out the difference between T-BTF implementation, the workshop was divided into two sessions with the same students. This situation allows the comprehension level to be apparent after the test execution. This will help to validate which T-BTF helps as a guide to assist chair designers in Malaysia. The process of the T-BTF validation workshop is shown in the Figure below.

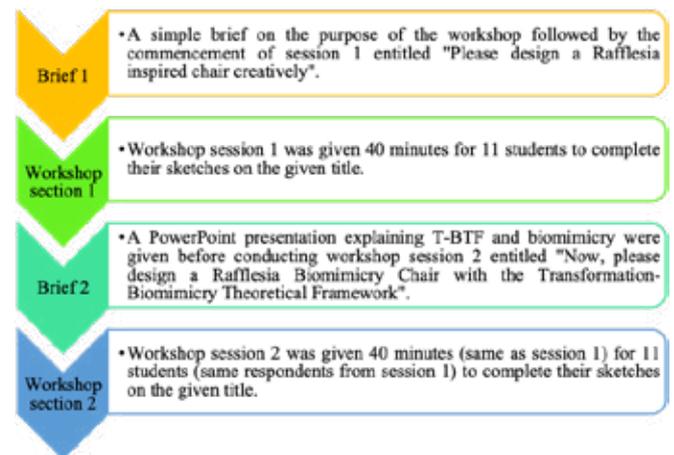


Figure 2: Process of the T-BTF validation workshop

This workshop highlights the way of thinking before and after the implementation of T-BTF. In workshop session 1, students were required to use their creativity in developing their ideas for a Rafflesia-inspired chair with no explanation or guidance given. In workshop session 2, the same students from workshop session 1 were introduced to the T-BTF and biomimicry using PowerPoint slides. Then, students were required to design the Rafflesia biomimicry chair using T-BTF.

In this workshop test, sketches were used as a medium to evaluate the guidance of T-BTF for chair designers in designing a piece of Rafflesia-inspired chair. The workshop was divided into two sessions, in which 40 minutes were given to produce the sketches both.

4. RESULTS AND DISCUSSION

4.1 Results from Survey Questions and Interviews

There were 405 responses from undergraduates, academic staff, and designers from colleges and universities in Klang Valley. They were University Technology Mara, Limkokwing University of Creative Technology, Universiti Pura Malaysia, Asia Pacific University, Segi University, Sunway University, The One Academy, Saito College, First City University College, Inti International College, Tunku Abdul Rahman University College. The respondents' age ranged from 18 to 55 which fits the requirements set by the researcher because they were from one of the four fields Graphic Design, Interior Design, and Industrial Design. Their opinions are relevant and significant.

The open-ended interviews with the 10 chosen respondents were recorded, transcribed, and then translated into nine transcriptions based on the interview questions. The interviewees were from The One Academy, University Technology Mara, University Putra Malaysia, Segi University, First City University College, Inti International College, Saito College, Hive Studio, WEDABO Malaysia, HOTO Stainless Steel Industries Sdn Bhd, Sunway University, Kurz, Main-main, Mimos Berhad and My Crfty Ideas Enterprise.

In summary, the respondents agreed that a transformable chair has noticeable potential in the Malaysian market and great promise in facilitating chair design. The design criteria collected from the survey can be concluded as below:

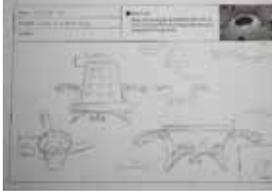
- “Fuse/ Divide” is the preferred Transformation Principle to be used in T-BTF
- Sofa is the most popular option to be the subject of the transformer chair
- The function of a transformer chair must serve a wide variety of functions.
- Rafflesia is the most-voted plant showcasing Malaysian identity
- Science, engineering, and design work better together.

4.2 The T-BTF Results

Based on the sketches result from the drawing workshop session 1 and 2, the understanding of T-BTF plays an important role in the overall design process for translating a Rafflesia into a piece of chair. Implementation of T-BTF not only acted as guidance in designing a chair bringing out a sense of Malaysian Identity, but it also helped students to understand biomimicry in the chair design process.

As we can see from drawing workshop session 1 (before introducing T-BTF), their design looks like a direct analogy. The form and structure of Rafflesia were translated directly without much design thinking. The chair retains its original function. On the other hand, in workshop session 2 (after introducing T-BTF), the role of T-BTF has been clearly shown in their sketches (Table 3).

Table 3: The T-BTF drawing workshop result

Set	Drawing workshop session 1 (before introducing T-BTF)	Drawing workshop session 2 (after introducing T-BTF)
1		
2		
3		
4		
5		

In summary, their chair design suggested new possibilities facilitating the transformation of Rafflesia's structure. From set 1, after introducing T-BTF, chairs are separable whereby every part of the chair plays a different function when separated from the function of the single product. Meanwhile, in set 2, the chair has become more portable, flexible, convenient, and serves a variety of functions than before. It improves the effectiveness and efficiency of the chair. In sets 3, 4, and 5, the understanding and appreciation of biomimicry concepts in chair design were truly comprehended which generated better ideas after introducing T-BTF in the chair design process. These chairs are now complying with the T-BTF which acts as transformable furniture that serves multiple functions carrying the Malaysian Identity, further strengthening science, engineering, and design work better together.

In addition, students shared their reflections upon completing the drawing workshops such as they feel good about T-BTF during the design process, it helps them to think differently and it is a

strategy that helped them learn and draw better. T-BTF also help them to understand the concept of biomimicry and Transformation Principles.

To conclude, we can see the understanding of T-BTF plays an important role in the overall process of designing a Rafflesia Biomimicry Chair, especially in the process of looking for ideas and creating design solutions. This important finding from the workshop is not only evident in the analysis of the study, but also intimately linked with the understanding of all the aspects of the theoretical framework.

This study has identified that user needs and preferences were important factors that should be considered by related designers and professionals in the furniture industry. According to the findings, transformation principles are much needed to be regarded as multipurpose furniture for households. Overall, the user needs and preferences are statistically significant as listed below:

- The concept of biomimicry in chair design is in favor
- The concept of Rafflesia biomimicry analogues in chair design is original, innovative, and sustainable
- Biomimicry chair design must showcase Malaysian identity, comfortable and highly innovated
- The preferred transformation principle is fuse/divide
- T-BTF meets the needs of design criteria as listed above

T-BTF identifies the transformation principle, design criteria, Malaysian identity, and Rafflesia analogy in the context and development of Rafflesia biomimicry in chair design. It is believed that the T-BTF recommended in this study will form an important and beneficial guide to biomimicry in furniture design in the Malaysian furniture industry and for education in general.

5. CONCLUSION

Transformation-Biomimicry Theoretical Framework (T-BTF) has proven its potential in accelerating the chair design process. By using T-BTF as a framework, the chair design is more well-thought facilitating the transformation of Rafflesia's structure. The outcomes showed new design solutions that portray Malaysian identity most vividly, (Wan Noor Faaizah Wan Omar R. K., 2015) and the efficiency of the furniture is improved too.

The formula for the Transformation-Biomimicry Theoretical Framework (T-BTF) is $F = T + B$, which has these variables: F stands for Furniture (chair), T for Transformation Principle (Fuse/Divide), and B for biomimicry analogy (Rafflesia Blooming analogy). This formula can be replicated in other design environments by changing the variables, for example, F can be a table, T can be Expose/Cover and B can be Rafflesia Cellular Structure analogy. In this study, the researcher set the scene for Rafflesia analogs in chair design with transformation design theory based on the criteria collected from the questionnaire and interview results. Fuse/ divide was the preferred transformation principle while the sofa is the selected type of chair.

This Rafflesia Chair will provide design knowledge in the form of sustainable design with the concept of biomimicry. The T-BTF guidance will be a catalyst to contribute to a new chair design trend bearing Malaysian Identity.

Future research is suggested to consider not only chair design as the findings of this research can be applied more generally such as in furniture design, product design, interior design, graphic or architectural design. The researcher believes that the remaining transformation principles: expand/collapse and expose/cover should be explored in furniture design as worthwhile areas of future research in biomimicry contexts. Also, the analogy of Rafflesia structure can be explored in a detailed way, aside from the blooming process. Rafflesia Cellular Structure analogy is one of the recommended knowledge gaps to be filled.

Now that's a promising future for the furniture industry.

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