A Conceptual Framework for Furniture Design Embedded with Living Organisms (FDLOs): Exploring Biophilia, Biodesign, and Bio-Inspired Approaches

Abu Hanifa Ab. Hamid, Dinah Rakhim*, Nurul 'Ayn Ahmad Sayuti

Faculty of Art and Design, University Technology MARA, Kedah Branch, Sungai Petani, 08400 Merbok, Kedah, Malaysia

***Corresponding Author**

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ABSTRACT

The widespread use of natural elements in the contemporary design context with the utilisation of living materials has resulted in a different way of thinking in terms of how nature can be utilized and applied to daily life. Biophilia, biophilic design, bioinspired design, and bio design are design practices that bring natural and biological elements into the process of design and pose new opportunities for sustainable innovation. In this paper, a conceptual framework, Furniture Design Embedded with LIving Organisms (FDLOs' is proposed to guide the inclusion of living organisms in furniture design. The framework is structured into three major dimensions: a) Functionality and practicality, b) Aesthetic and semantic, and c) Experience and Emotion. The framework is presented in the context of design education, in particular Final Year Project (FYP) pedagogy to stimulate students' explorations with radical materials and bio-related design genres. The conceptual model of FDLOs offers theoretical guidance for the designers, educators, and researchers of how to look at living organisms as a design resource of the future sustainable product.

Keywords— Biophilia, Biophilic Design, Bio-inspired Design, Conceptual Model, Furniture Design

INTRODUCTION

Design education increasingly engages with sustainability, biophilia, and radical materials to prepare students for future challenges in design practice. The use of living organisms as part of furniture design represents a novel and experimental domain, expanding how designers consider materiality, human-nature relationships, and well-being. Hence, this paper explores experimental design research-based learning in product and furniture FYP design classes at University Technology MARA Kedah, Malaysia. Students conduct research throughout the project to to review literature, explore product technologies and materials, and analyse the user environment. The multidisciplinary nature of product development requires students to research across disciplinary borders. This experimental research methodology provides both explicit and implicit knowledge, enhancing self-learning through hands-on experience and experimentation. Regarding the topic's connection to the Final Year Project (FYP), students had the freedom to select a bio-related design genre that best suited their interests. Biophilia, biophilic design, bioinspired design, and bio design are design genres that include natural and biological components into their processes. Moreover, this paper focuses on two student design groups (2022–2023) from the BA (Hons) Industrial Design programme at Faculty of Art and Design, University Technology MARA Kedah, during a two-year period of FYP.

This study is proposed to:

1. Introduce students to appropriate research methods in the development of furniture design.
2. Assist students to understand the principles of bio-design/ biophilic design/ bio-inspired design and other bio-related genres in the context of furniture design.
3. Enable students to explore and experiment with new materials that could be proposed for contemporary

or future designs, which are beneficial for designers, manufacturers, consumers, communities, and countries.

The article is structured as follows: the next section provides an overview of the key bio-related design genres, followed by a discussion of FYP and the project brief used for the FYP design projects. The final section delves into the students' approach to incorporating bio-related topics into future design projects and a brief discussion on a simple survey to gain feedback from students on design development and production during the FYP.

LITERATURE REVIEW

Bio-related Design Genres

Biophilia denotes the inherent affinity humans possess for nature and living entities. This idea was proposed in 1973, suggesting that nature provides a conducive environment for human development and growth. Wilson (1984) characterised biophilia as an inherent inclination to concentrate on living entities and realistic phenomena. Biophilic design, as described by Kellert et al. (2008) and Browning et al. (2014), seeks to incorporate the understanding of human affinity for natural systems and processes into the design of the built environment. As seen in Table 1, biophilic design takes into account things like the environment, natural patterns and processes, lighting and space, how things interact with their surroundings, and how people have evolved to be connected to nature. Moreover, Kellert and Calabrese (2015) have developed the new biophilic design experiences and attributes. Recent research on biophilic design has concentrated on the constructed environment, health, workforce productivity, well-being, and design as well. Since the 1970s, numerous studies have explored nature and biophilia, including those by Mehrabian and Russell (1974), Ulrich (1981), Balling and Falk (1982), and Heerwagen (2009). More recent works include Hand et al. (2017), Berto (2018), Hoyos and Fiorentino (2017), Kellert (2018), Xue et al. (2019), Ryan and Browning (2020), Pérez-Urrestarazu et al. (2021), Wijesooriya & Brambilla (2021), Zhong et al. (2022), Russo and Andreucci (2023), and a series of contributions by Sayuti et al. (2015–2024).

Figure 1: Attributes of Biophilic Design

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 angles	Bounded spaces
Views and vistas	Simulation of natural features	Transitional spaces
Facade greening	Biomorphy	Linked series and chains Integration of parts to wholes
Geology and landscape	Geomorphology	Complementary contrasts
Habitats and ecosystems	Biomimicry	Dynamic balance and tension
Fire		Fractals
		Hierarchically organized ratios and scales
4. Light and Space	**5. Place-based relationships**	**6. Evolved human-nature relationships**
Natural light Filtered and diffused light	Geographic connection to place	Prospect and refuge
Light and shadow	Historic connection to place	Order and complexity
Reflected light	Ecological connection to place	Curiosity and enticement
Light pools	Cultural connection to place	Change and metamorphosis Security and protection
Warm light	Indigenous materials	Mastery and control
Light as shape and form	Landscape orientation	Affection and attachment Attraction and beauty Exploration and discovery
Spaciousness	Landscape features that define building form	Information and cognition
Spatial variability	Landscape ecology Integration of culture and ecology	Fear and awe
Space as shape and form Spatial harmony	Spirit of place	Reverence and spirituality
Inside-outside spaces	Avoiding placelessness	

Source: (Kellert et al., 2008)

Bio-inspired design (Massimo et al., 2017) incorporates natural elements into designs to solve problems. It

involves using nature as inspiration and as a design constraint. Bio-design involves incorporating living biological materials or ecosystems to create renewable and sustainable systems. Myers (2018). Magnan (2018) emphasises the use of visual images in bio-design thinking to enhance creative thinking, scientific and technical innovations. The convergence of these varied disciplines has necessitated a more radical design approach, wherein biological materials have emerged as a crucial element for both designers and scientists, since this shift in the design domain is undeniable.

The fifth edition of the Dictionary of the English Language (2011) defines biological materials as biomass, chemical substances, tissues, or cellular components. Examples of living beings include animals, plants, bacteria, fungi, algae, and other life forms (Dictionary of the English Language, Fifth Edition, 2011). The phrase "biobased products" was introduced by Waltz (2008) to describe "industrial or commercial commodities derived from biomass or biological feedstock." Naleway et al. (2015) suggested a unique approach of eight structural design components for bioinspiration. These structural characteristics have developed to fulfil particular multifunctional roles and environmental constraints, enhancing the mechanical properties of the product.

Since nature has significantly influenced industrial design and other design genres, it is important to take into consideration the following themes that are relevant to nature and biology for this current and ongoing FYP: bio-design, biophilia and biophilic design, biological and living materials, bio-inspired design, biomimicry, biomimetics, biomorphisms, bionics, or biomechanics.

Final Year Project (FYP)

This FYP course intends to equip students with the ability to comprehend industrial design research and development for BA Hons Industrial Design of Faculty of Art and Design, University Technology MARA Kedah. This course allows students to apply their expertise in design and research techniques. Additionally, it helps students understand the needs of users in terms of design performance, usability, manufacturability, and commercial value. The course aims to oversee students in formulating their Final Year Degree Project (FYP) proposal and to assist them with their thesis writing course. Based on their submitted subjects, a designated supervisor will assist them with any matters pertaining to product design. Furthermore, the experience of conducting research-based design projects will familiarise them with the industry requirements for R&D and UX, which will serve as a platform to prepare them for their future careers and employment.

The results led to the proposal of the Major Project Development Model (MPD Model), which developed a computer-integrated system of design methods for major projects. Among the latest studies, Burnik and Košir (2017) on students' academic and industry collaboration FYP projects provide industrial-grade experience and show above-average commitment and accountability to the engineering and soft skills projects, which also help boost careers and improve students' academic and industry preparedness. Acar (2004) uses literature searches and field studies to examine students' design processes in a graduation project, aiming to provide insights for design education by analysing students' processes, design problems, and academic schemes. The findings can inform future developments in educational curriculum and academic schemes. Green (2007) conducted a study where he surveyed academics in Australia and overseas to understand students' approaches to final-year industrial design projects and their incorporation of design processes and methods.

Project Brief (PB): Radical Materials and Bio-related Design Genres: Designs for Contemporary and Future

The degree Final Year Project (FYP) is structured to oversee students as they design their research and design proposals while also assisting them with their thesis writing. The students were required to propose a furniture design with the incorporation of nature/biology elements. The students were provided with a Design Project Brief (PB) that is used as a guideline for them to research their desired topic, which was within the framework of radical materials and bio-related design genres. They learnt about 1) biophilia and biophilic design, which includes the principles and experiences attributes of biophilic design (Kellert et al., 2008; Kellert and Calabrese, 2015); 2) biodesign, which a brief explanation of what biodesign is; 3) Biomimicry, which includes biomimetics, bionics, and biomechanics, along with a biomimicry taxonomy (Biomimicry Institute, 2008, 2021). 4) Biological/living materials with the typology of four categories of biological materials by Sayuti (2020); 5) bio-

inspired design with examples from the typology of design inspired by nature by Hoyos (2010) and mangrove species of the Sungai Merbok project (Sayuti et al., 2019) are featured (Sayuti et al., 2019) as the example projects.

Furthermore, the students should identify potential concepts and solutions utilising biological materials by conducting a thorough literature search and research explorations. The project should consider the furniture design functionality, safety, eco-friendliness, modularity, space saving, durability, ease of assembly, and price. Moreover, students should identify customer requirements, consider using local materials and technologies, and apply aesthetic elements that meet customer needs and preferences. Students were also advised to identify the purposes of design by considering the biophilic design attributes by Kellert (2008) and Kellert and Calabrese (2015), biomimicry taxonomy, and the purposes of living organisms/biological materials conceptual model (Sayuti, 2016; Sayuti et al., 2020) to support or guide their early research proposals and design development.

Design Projection with Anticipated Outcomes

There were two classes involved in the FYP projects within two years, where each class took two semesters to complete the FYP. 11 students chose to design Furniture Embedded with Living Organisms (FDLOs) and completed the projects during their final year of BA Hons. As listed in Table 2 below are the eleven (11) FDLOs designed by the FYP design students.

Design Projection 1: Algae bookshelves

This research explores the use of algae in indoor farming to meet Sustainable Development Goal 2's goals of ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture. Algae, with its energy and beneficial chemicals, can serve as functional food additives.

Design Projection 2: Beekeeper’s wall shelves

This study aims to investigate the adaptability of indoor beehives in Malaysian homes and determine the prerequisites for integrating biodesign (honeybee shelves) into these homes. Factors to consider include the size and design of the interior space, climatic factors like temperature and humidity, and bees' access to resources like food and water. The inner area needs to be sufficiently large to accommodate the hive and provide sufficient ventilation, while the location should not pose any risks to spectators. To ensure the indoor bee housing is suitable for Malaysia's climate, proper ventilation, insulation, and shielding from bugs, predators, and other annoyances are essential. The architecture of the hive determines whether indoor bee housing is appropriate for Malaysia's hot, humid environment (Department of Agriculture Malaysia, 2022) (Leven & Boot, 2005).

Design Projection 3: Kitchen shelves

This research incorporated biophilic design elements in design with hydroponic systems in kitchen shelving furniture design. The focus is to adapt the hydroponic systems in small spaces while integrating natural elements to improve green living quality. The combination of these elements aims to enhance people's connection to nature and to encourage indoor edible plant gardening and to grow their own fresh vegetables at home, which is an easily accessible hydroponic system.

Design Projection 4: Coffee table with terrarium

This table features a cement bowl, also known as a terrarium, filled with tiny, vibrant plants and adorned with pebbles and various decorative items. The objective of the coffee table is to alleviate stress in adults and promote improved health via social interaction. Furthermore, the expectation is to enhance physical fitness, reduce blood pressure, and increase comfort and enjoyment while improving the overall health and well-being of its users.

Design Projection 5: Moss Coffee Table

Adding moss to the coffee table creates a unique pattern and enhances the space and the users' experience. The embedding of moss can help to improve air quality in the house, as indoor green plants not only help reduce

indoor air pollutants and improve the indoor environment. Furthermore, they also have a positive impact on people's psychology, education, health, and comfort. The main objectives of this design are to identify the type of moss that is frequently used in living spaces and to design the ideal moss for an eye-catching moss pattern design that is suitable for a coffee table.

Design Projection 6: The aquaponics coffee table

The main objective of this design is to create a table with an aquarium. Significantly, a fish tank is a wonderful way to provide natural sounds that create a tranquil atmosphere, as there are beneficial effects of interacting with fish in aquariums on human health. One of the findings stated that fish contemplation can help people fall asleep and feel calm, as it fosters tranquilly through their auditory and visual attributes. In addition, it contributes to the creation of a peaceful atmosphere and a calming experience. Apart from that, it also serves educational opportunities for kids, as observing and taking care of a home aquarium can teach the importance of responsibility and discipline among them.

Design Projection 7: Hanging chair, inspired by pitcher plants

Pitcher plant-inspired furniture helps public spaces feel more inviting. This piece uses the pitcher plant's shapes and structure to make elegant and functional community furniture. The pitcher plant's curves, forms, and organic lines inspire attractive and functional seats, tables, and other items. Nature-inspired designs calm and stimulate environmental awareness. This connection with nature brings calm and softly raises environmental awareness, reminding the community of their biodiversity preservation role. These works can engage the audience and encourage natural love through design. Renewable materials and eco-friendly manufacturing can help the furniture promote environmental goals. Pitcher plant-inspired designs can use biodegradable materials, low-energy production, and durability. Furniture design inspired by the pitcher plant can provide aesthetics as well as bring us closer to nature. This study aims to explore the various/diverse forms of pitcher plants in order to design furniture within the public space context.

Design Projection 8: Moss Study Table

This research has shown the potential of the application of moss onto home furnishings for the purpose of alleviating stress and improving mental well-being. The study results show that people have a generally positive opinion about the idea. Most of the people who answered the survey agreed that furniture could contain living things, specifically moss. Further study on how moss reacts to being grown indoors shows that the best environment to keep the moss thriving is in a nice, humid environment with no direct sunlight, making it the perfect indoor plant. Moreover, findings show that moss can help reduce stress for haptic people through providing tactile stimulation. The soft texture of most moss species provides a soothing effect for the user.

Design Projection 9: Mycelium Side Table

This research focuses on the experimentation of mycelium as a new proposed material for furniture design. Mycelium contributes to the ecosystem's energy cycle by decomposing organic matter and recycling it into beneficial compounds for the soil food web. Enzymes are secreted by mycelium aid this cycle. The enzymes degraded the substrate and the surrounding dead organic matter. In addition, mycelium, an intriguing radical material, finds application in furniture production and in enhancing the fire resistance, strength, and lightness of building materials.

Design Projection 10: Mycelium Armchair

Mycelium is used as an alternative material in furniture design. “Sillón de Micelio” is an armchair design incorporating mycelium as a sub-material. Materials derived from mycelium can meet specific structural and functional requirements, such as fire resistance or thermal and acoustic insulation, due to the variety of substrates that can be used and the controlled processing techniques that can be used for them (for example, environmental growth and hot pressing) (Arifin and Yusuf, 2013, Haneef et al., 2017; Abhijith, et al. (2018).) Butu et al. (2020).

The aims of this research are to investigate the feasibility of utilising mycelium as an alternative material for

furniture design production and to determine which species of mycelium are the most suitable for use in the production of furniture. The study's results show that most users agree that combining furniture with a bio-living material depends on how the piece works (for example, an armrest that can collect mushrooms.

Design Projection 11: The Hanging Table Aquaponic System Design

The project focuses on the hanging table rail balcony and the aquaponic system. This hanging table for a balcony rail will include an aquaponic system that incorporates living fish and plants (a human-nature relationship) in a small aquarium. Aquaponic is a combination of aqua and ponics. Aqua means raising fish in a controlled environment, and ponic means "to work" in Latin, growing in media without soil. In this aquaponic system, fish eat and produce ammonia, then beneficial bacteria convert the ammonia into nutrients. The system recirculates water after the plants absorb natural fertilizer. The aim and objectives of this project are to introduce starters to small-scale farming with aquaponic systems to B40 who live in apartments in Malaysia and to encourage people to stay connected with nature for human physical, mental health, and well-being.

METHODOLOGY

Research Design

This study adopts a two-part, mixed-method conceptual design approach, spanning a full academic year, to examine how design students integrate biomaterials into sustainable furniture development. The project is structured into two main parts:

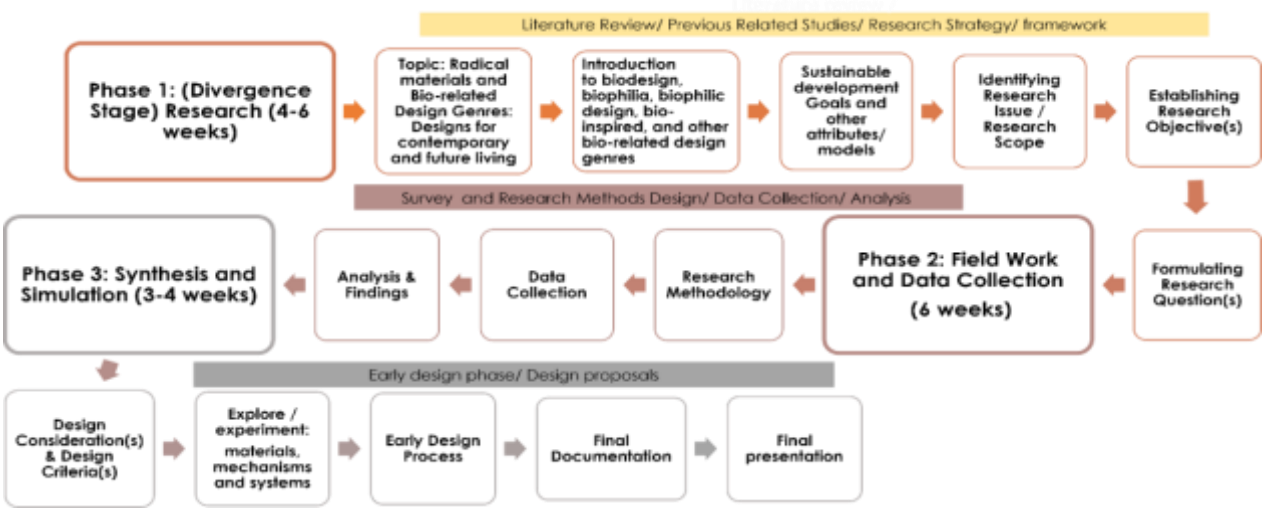
(i) Part 1: Research, Fieldwork, and Synthesis and (ii) Part 2: Design Development and Biomaterial Exploration.

Part 1: Divergence, Fieldwork, and Synthesis

Part 1 consisted of three structured phases (Figure 2), spanning approximately 14–16 weeks:

1. Phase 1: Divergence Stage – Research (4 - 6 weeks). Students conducted literature reviews and analysis of related studies to identify key issues, determine research scope, and establish objectives. This stage enabled grounding in theoretical and empirical foundations relevant to biodesign, bio-inspired design, and biophilic approaches.
2. Phase 2: Fieldwork (6 weeks). Students employed their proposed research methods to collect and interpret data. The output of this stage consisted of initial findings that informed early design directions.
3. Phase 3: Synthesis and Simulation (3 - 4 weeks). Findings were translated into design proposals through ideation, sketching, and prototyping. Students compiled a comprehensive portfolio integrating research, experimentation, and preliminary prototypes, forming the basis for the final evaluation of Part 1.

Figure 2. Research procedure for Part 1 of FYP

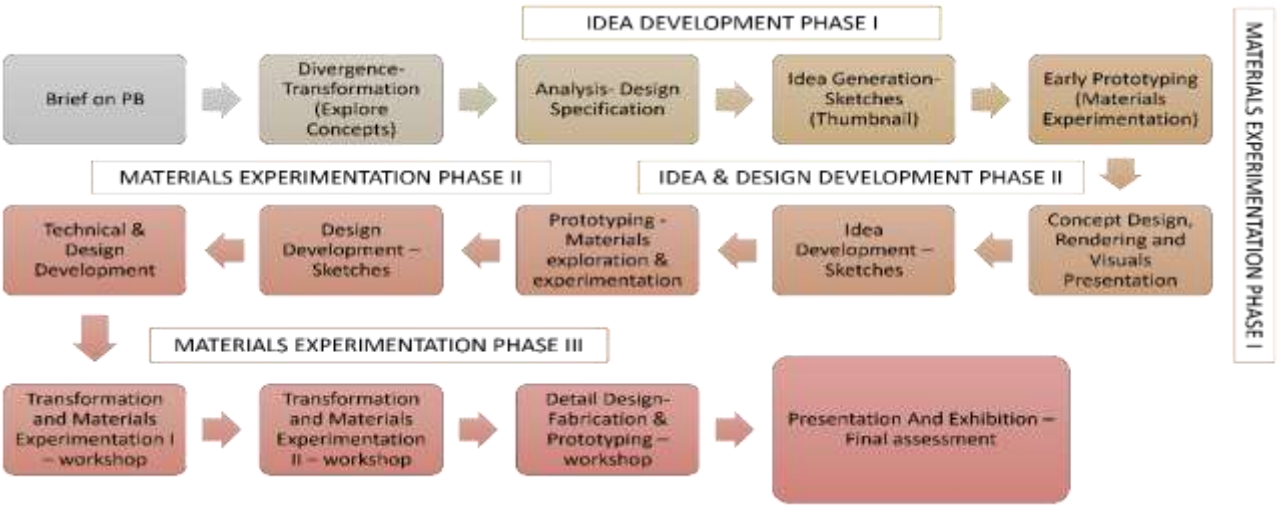


Part 2: Design Development and Biomaterial Exploration

Part 2 extended into iterative design development with a focus on material experimentation (Figure 3). This phase emphasized progressive prototyping and validation of biomaterials as design inputs, encompassing:

1. Idea Development Phase I. Generation and refinement of design concepts aligned with user-centered objectives.
2. Materials Experimentation Phase I. Initial exploratory trials of biomaterials. Design Development Phase II. Further refinement of concepts based on experimental outcomes and feedback.
3. Materials Experimentation Phases II & III. Systematic validation of biomaterials in terms of usability, durability, and functional integration.
4. Finalisation. Completion of design outputs, culminating in prototype fabrication, final presentation, and exhibition.

Figure 3. Design development and biomaterials exploration in Part 2 of the FYP



This two-part structure ensured that conceptual grounding (Part 1) and experimental practice (Part 2) were systematically integrated, reflecting best practices in design-based research (Zimmerman, Forlizzi, & Evenson, 2010; Koskinen et al., 2011).

Data Collection

Data collection adopted a mixed-methods approach (Creswell & Plano Clark, 2018), combining structured surveys using 5-point Likert scales to capture user preferences on functionality, aesthetics, and biomaterials, with semi-structured interviews involving potential users and peer reviewers to provide deeper insights into perceptions of biophilic and bio-inspired design features. Importantly, data collection was conducted iteratively across Part 1 and Part 2, ensuring continuous feedback loops that informed design iterations.

Data Analysis

The collected data were analysed through both quantitative and qualitative strategies. Quantitative data were examined using descriptive statistics to identify trends and divergences in user responses (Hair et al., 2022), while qualitative data were analysed using thematic content analysis (Braun & Clarke, 2021) to extract recurring themes related to functionality, aesthetics, sustainability, and usability. Both strands were triangulated to strengthen validity and provide a more robust basis for design refinement.

Variables and Measurement

Four key variables were examined in this study: (i) Design Functionality: usability, ergonomics, and efficiency of the proposed furniture concepts; (ii) Material Performance: durability, sustainability, and adaptability of biomaterials used; (iii) Aesthetic Perception: user responses to visual and tactile qualities of designs; and (iv) Sustainability Value: user awareness of ecological and circular design principles. These variables were operationalised through validated survey items and interview protocols, ensuring direct alignment with the research objectives.

Reliability and Validity

Methodological rigor was ensured through multiple strategies. Survey reliability was tested using Cronbach's alpha, with a threshold of ≥0.70 considered acceptable (Hair et al., 2022). Interview validity was enhanced through member checking, where participants reviewed summaries of their responses to confirm accuracy (Lincoln & Guba, 1985). Triangulation was achieved by cross-verifying findings across surveys, interviews, and design iterations (Flick, 2018). Finally, construct validity was reinforced by aligning the study variables with established frameworks in design research and sustainability literature (Koskinen et al., 2011; Zimmerman et al., 2010).

Table 1: Methodological Flow Table

Stage	Part / Phase	Duration	Main Activities	Data Collection	Data Analysis	Output
Part 1	Phase 1: Divergence (Research)	4–6 weeks	Literature review, defining scope, objectives	Secondary data from articles, books, prior studies	Content mapping & synthesis	Literature review & research framework
	Phase 2: Fieldwork	6 weeks	Surveys, interviews, site/contextual observations	Surveys (Likert scale), semi-structured interviews	Descriptive stats; thematic coding	User needs, insights, and design opportunities
	Phase 3: Synthesis & Simulation	3–4 weeks	Ideation, sketching, simulation, prototyping	Iterative peer/user feedback	Comparative review with research objectives	Research portfolio & early prototypes (basis for assessment of Part 1)
Part 2	Idea Development Phase I	2 weeks	Concept generation & refinement	Focus group feedback, peer review	Qualitative coding	Initial concept directions
	Materials Experimentation Phase I	2 weeks	Exploratory biomaterial trials	Lab notes, photography, observations	Content analysis	First iteration biomaterial samples
	Design Development Phase II	3 weeks	Refinement of design concepts	User testing of concept sketches/prototypes	Descriptive trends & coding	Improved design solutions
	Materials Experimentation Phase II & III	4 weeks	Systematic biomaterial validation (durability, usability, aesthetics)	Lab trials, testing protocols, peer review	Comparative analysis of material performance	Refined biomaterials integrated into design
	Finalisation	2–3 weeks	Prototyping, documentation, exhibition prep	Exhibition feedback, panel critique	Cross-validation with objectives	Final prototype & portfolio for presentation

The methodology followed a two-part iterative structure. Part 1 (Research, Fieldwork, and Synthesis) established the theoretical and empirical foundation through literature review, user research, and exploratory prototyping. Part 2 (Design Development and Biomaterial Exploration) advanced these insights into iterative design development, material experimentation, and prototype validation.

Data collection (surveys, interviews, contextual observation, lab trials) and data analysis (descriptive statistics, thematic coding, comparative review) were embedded throughout both parts to ensure continuous refinement. This cyclic process of research → design → testing → reflection reflects the principles of design-based inquiry.

DISCUSSION

This conceptual exploration highlights the growing relevance of biophilia, biodesign, and bio-inspired design in the way we think about furniture and design education. The FDLOs framework shows how living organisms can be woven into furniture design with three main purposes in mind: function and practicality, aesthetic and semantic value, and experiential or emotional engagement. These ideas connect well with earlier research that points to the positive impact of biophilic attributes on human health, well-being, and productivity (Ryan & Browning, 2020; Kellert, 2018; Russo & Andreucci, 2023).

From a teaching perspective, bringing these principles into the Final Year Project (FYP) curriculum allows students to experiment with unconventional materials and innovative design processes. Studies have shown that project-based learning and real-world collaborations encourage critical thinking, creativity, and transferable skills (Almulla, 2020; Burnik & Košir, 2017). In this case, exploring living organisms as design elements not only broadens material knowledge but also invites students to reflect on ethical, ecological, and cultural aspects of their work.

Another important implication of this study lies in its potential link to sustainability goals. Malaysia's furniture industry continues to grow rapidly, but this growth brings challenges such as deforestation and material waste (MATRADE, 2023). Using biomaterials and living organisms can offer more sustainable alternatives, aligning with ideas of the circular economy and low-carbon innovation (Zhong et al., 2022). This direction also connects with global sustainability priorities, especially SDG 12 on responsible consumption and production, and SDG 15 on life on land. At the same time, the FDLOs framework suggests that design is not just a technical task, but also an experiential and cultural journey. Furniture that incorporates living organisms has the potential to deepen human–nature relationships, reduce stress, and support well-being through biophilic experiences (Berto, 2018; Hand et al., 2017). For students, engaging with these ideas provides a transformative learning process that prepares them for future challenges such as climate change, urban pressures, and sustainable living.

Overall, the FDLOs framework serves both as a teaching model and a conceptual foundation for innovation in sustainable design. Still, more work is needed to test these ideas in practice. Future studies should look at how users respond, how the materials perform, and how such designs can be scaled up meaningfully.

Future Work

While this paper establishes the FDLOs framework as a conceptual model, further work is required to validate and operationalize its application in design education and practice. The next phase of research, to be presented in a subsequent paper, will focus on empirical outcomes derived from Final Year Project (FYP) case studies. Which includes evaluation of the FYP projects (DP1-DP11) that implemented elements of FDLOs altogether with Analyse survey and feedback data from students, assessing their perceptions of biophilia, biodesign, and biomaterials as applied in furniture design.

CONCLUSION

This paper has set out a conceptual framework of the Furniture Design Embedded with Living Organisms (FDLOs), which helps designers and students reconceptualise how living materials can shape the future of furniture. By looking at design through three lenses, function, aesthetics, and experience, the framework offers a simple but useful way to explore new directions in design education and practice. The FDLOs framework

encourages students to experiment with fresh ideas and alternative materials, while also reminding us that design can play a role in building a more sustainable relationship with nature.

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