

The Creativity in the Design of Hospital Inpatient Rooms with Biophilic Criteria

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Abstract. The inpatient room in hospital facilities has rules and standards but should be optimized with a creative spatial design approach, such as biophilic principles. The principles of biophilic consist of 14 patterns and are categorized into three criteria: nature in the space, natural analogues, and nature of the space with interior design consideration. The biophilic design approach is flexible, while the hospital facilities have standards that could limit the design exploration. This study aims to see the potential of biophilic principles in hospital design by young designers. This research was conducted by a design project and involved lecturers and design experts from the industry related. The method used was teaching in class and encouraging the creativity and activeness of participants by conducting studies individually and in groups. The main topics in class were enriched with biophilic material and design standards for hospital inpatient rooms set by the Ministry of Health of the Republic of Indonesia. Various results were found; there are 15 inpatient room designs, all with biophilic criteria based on students' creativity. The design project successfully enhanced the creativity of biophilic criteria implemented in the inpatient room, although there are various constraints in hospital design standards.

1 Introduction

The principle of biophilia is the notion of biology, which consists of the word "bio", which means life/nature and philia as "likes" [1]. An ecologist, Edward O. Wilson 1984, said that biophilia is the innate of tendency to focus on life and lifelike processes [1,2]. Considering that human life is changing from rural to urban, artificial materials and other built environment elements affect human preferences and habits. In urban areas, more people live a rush lifestyle, and unhealthy daily consumption that leads to psychological problems.

The more surrounded by artificially built environments, the more the humans desire back to nature. Contact with nature is a way to promote psychological comfort and well-being as a restoration from stress [3]. This basic principle of biophilia can be found in the direct experiences of natural elements that attract human attention such as natural lights, air, water, plants, animals, landscapes, and other indirect experiences of nature; images of nature, natural materials, and cultural attachment to place [4].

Physical illness and psychological burden are two things highly found in healthcare facilities that conduct stress. Improving the health and well-being of the hospital occupants by performing a therapeutic potential from nature is a hypothesis of a biophilia way to reduce stress. Various positive things are obtained by adopting biophilia as a design strategy in hospitals such as feeling calm, relaxed, comfortable, and satisfied [5] for promoting health. This statement becomes the main idea

of this research by exploring the biophilia potency in the inpatient room as a study case by doing a design project.

2 Biophilic: In Theory and Design

2.1 Biophilia and Biophilic

Biophilia is a term coined by Erich Fromm in 1964 a social psychologist from German describing the human attraction to all things alive and vital [6]. The biophilic is a design philosophy that adopts biophilia in terms to suggest the built environment to be more restorative by incorporating natural elements [4]. The goal of biophilic design is to create artificial environments as similar as possible to natural ones, to ensure the positive effect that nature has on people's health and well-being [1,7].

The biophilic design could practically benefit humans who instinctively cannot be far from nature as their living environment. The biophilic design also creates a solution in a built environment that supports our innate human attraction to nature and natural processes, and all together contributes to a feeling of well-being [2]. The biophilic design approach was verified successful in offices and educational spaces and then more studies reveal that nature has healing effects when it is applied in healthcare facilities to reduce stress and anxiety [8].

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2.2 Biophilic and Healing Environment

Since the beneficial effects on human well-being, the biophilic design is considered a part of the healing environment, especially in healthcare facilities. Florence Nightingale in Her 1863 book *Notes on Hospital* mentions that natural elements such as daylight, fresh air ventilation, and heating played a role in supporting patient's recovery process faster while hospitalized. During the era, the idea had a crucial contribution to inpatient room standards related to spatial layout and the quality of the environment [9].

The ideas of the natural environments exposure to hospital developed over time, the attention restoration theory (ART) by Kaplan in 1990, and stress reduction theory (STR) by Ulrich in 1991 both had a different view of the mechanism of how nature affects human health, but both emphasized that exposure to natural environment could improve restoring capacities, including attention restoring and psychophysiological stress recovery [8].

The concept of exposure to nature and biophilia in hospital facilities is a positive approach considering the psychological burden experienced by the patient while being treated in the hospital and will increase if the surrounding environment does not support the patient's comfort while they are living in that place. Supported by R.M. Kaplan (1993), said that environmental factors 40% have a greater influence on patient recovery than any medical factors 10% and other factors in the hospital [10]. In the context of the built environment, architecture and interior design are considered to respond to the empirical evidence of the works of previous studies about biophilic. There are 14 patterns that have a wide range of concerns and addressed universal issues of human health and well-being [11]. Nowadays, due to the hospital's design guide, rules and constraints, the biophilic patterns should be constructed in a strategic and full of considerations to improve the quality of the physical hospital environment and also enhance health and well-being for individuals and society.

2.3 The Patterns of Biophilic Design

A study organized the biophilic design into 14 patterns [11], in this discussion, the 14 patterns will be divided into three criteria (Table 1) [2,11] based on the application in the space.

Table 1. The Biophilic Criteria and Patterns

Biophilic Criteria	No	Biophilic Patterns
A. Nature in the Space	1	Visual Connection with Nature
	2	Non-Visual Connection with Nature
	3	Non-Rhythmic Sensory Stimuli
	4	Thermal & Airflow Variability
	5	Presence of Water
	6	Dynamic and Diffuse Light
	7	Connection with Natural Systems
B. Natural Analogue	8	Biomorphic Forms & Patterns

Biophilic Criteria	No	Biophilic Patterns
	9	Material Connection with Nature
	10	Complexity and Order
C. Nature of the Space	11	Prospect
	12	Refuge
	13	Mystery
	14	Risk/Peril

In biophilic design, the design was organized into three criteria: nature in the space, natural analogues, and nature of the space. These criteria are used as a framework for understanding how to use the diversity of strategies in the design environment.

A. Natural in the Space:

Nature in space means contributing direct contact with nature or the natural system. These criteria consist of 7 patterns each of which contributes to providing direct contact with a natural condition such as; providing visual to the element of nature, living system, auditory, olfactory, tactile and gustatory stimulation from the ecosystem, providing vibrant natural-like environment, object or materials that unpredicted as found in nature (e.g: grass swaying/ripples on water/ leaves in a breeze), the change of air temperature, airflow across the skin that mimic the natural environments, seeing or hearing the water and others.

B. Natural Analogues:

Natural analogues in biophilic means design strategies that use references to, or representations of, nature. These criteria explain the indirect approach that provides symbolism of forms, materials, complexity and order that mimic nature. For example, the use of contoured material and texture from elements that reflect the specific ecology of nature to create a sense of place, a place that adheres to a spatial hierarchy similar to nature.

C. Nature of the Space:

Mimicking the spatial qualities of natural environments to evoke/enhance human responses in a space that provides a sense of safety and being protected from environmental changes. In this situation, human has a role to control the surrounding they want to perceive comfort, stability, and safety.

3 Methodology

This research was conducted through an exploratory design project in the classroom [12], involving 45 students from interior design backgrounds. The data was analysed and assessed by lecturers and experts by using a qualitative approach. All the student participants were from interior design backgrounds and already have fundamental insight into design.

The design project scheme consists of several sessions that begin with providing insight related to healthcare facilities standards, rules and regulations, biophilic materials and theories delivered by the lecturer (described in Table 2).

Table 2. Creative Design Project

Wallas's Four Stages (1926)	Discussion	Design Project Activities
1. Preparation Stage	The problem is first perceived and defined (Conscious stage)	<ul style="list-style-type: none"> Lecturing: Hospital Design Standards, Biophilic Design Patterns, Technologies and Innovation
2. Incubation, Stage	In the mind, manipulate the problem (Unconscious Stage)	<ul style="list-style-type: none"> Group Discussion, Brainstorming
3. Illumination Stage	Due to the limited time, finally, students decided on the solution (Conscious-Conscious Stage)	<ul style="list-style-type: none"> Concepts, 3D model making Completing design in a presentation board
4. Verification Stage	Evaluate the final design as the final decision (Conscious stage)	<ul style="list-style-type: none"> Judging by Lectures and Expert

This design project also involves creative design process methods to generate the biophilic in healthcare facilities for more innovative results (described in Figure 1).

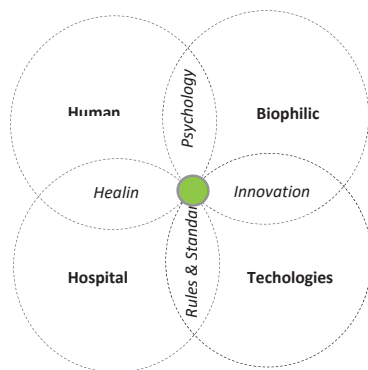


Fig. 1. The Project Brief: Design Aspect

The picture above describes the framework for the idea of this project's design activities. There were four aspects between humans, hospital facilities, biophilic design, and technology. The four objects are the main study that had an intersection with another and become the focus of the research, including human nature and habits related to psychology, especially in terms of recovery, standards and rules that apply to hospitals regulated by countries. Nowadays, rapid changes in technologies led to the environmental approach focusing on medical inventions. Technologies and innovations are required to support the application of biophilic. The four of them are studied more intensely so that later students will find the essence of a design invention (green point) which will later become a source of inspiration and new findings that contribute to the

development of interior designs specifically for health facilities.

3.1 Preparation Stage

All preparations stage are delivered by lecturing and reviewing the main problem in design related to human health and well-being. Humans as patients and their needs/wants are first perceived and defined. Biophilic and the introduction of technology in design were also inducted to students in class. In the other session, the hospital aspects such as standards and regulations by the Indonesian government were introduced as a basic insight and knowledge of students before doing a design.

3.2 Incubation Stage

In the next stage, students independently in groups were asked to discuss and explore more about the intersection factors and relation between; human and biophilic, human and hospital, hospital with technologies, and technologies to the biophilic. Each intersection generates sub-factors that are considered the main factor of design in this project design case. In this stage, the project design brief was given with one module of an inpatient room as a case to develop.

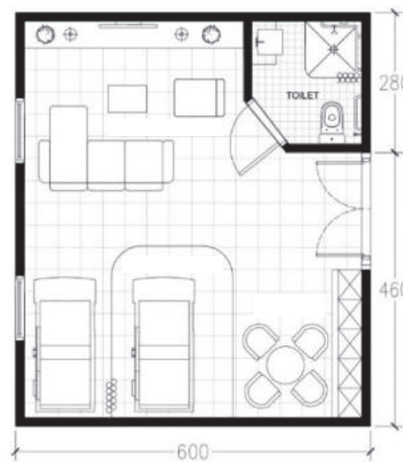


Fig. 2. The Project Brief: Inpatient Room Layout Study Case

Students in groups were encouraged to play roles to create inventions about inpatient rooms with biophilic design through design aspects they learnt before (patient's psychology; healing requirement procedure; the hospital standard, rules, and its restriction; and the innovation through technologies) in a 75m² inpatient room that divided into several areas.

3.3 Illumination Stage

By having the lecturer's materials, brainstorming, and discussion, every student had a role and participated by giving ideas and practising their abilities to implement the decision of design. Firstly, each group expressed their work by making concepts and using the 3D digital model for presentation as the final result. This stage is

considered the longest stage because of took time in the trial-and-error process and the making decision process.

3.4 Verification Stage

In this stage, all student designs (3D render and concept) collected on a presentation board become data for lecturers and experts to assess. The assessments carried out; the quality of design, technical capabilities to implement each of the 3 biophilic criteria, innovation, and design development potency.








4 Result and Discussion






4.1 Result

The design project (in groups) resulting 15 designs of inpatient rooms with various biophilic approaches. All designs were various and displayed in Table 3. The result found that various approaches used the biophilic criteria in the design. All interior elements and features (wall, floor, ceiling, and furniture) were treated with forms, shapes, colours, and materials usage. The lighting, amenities and decoration also added to build the ambience of the space. The integrated application of technologies was also found to support the biophilic criteria explained by the design concept.

Table 3. Design Project Result

No	Design Project	Biophilic Criteria		
	<i>Inpatient Room Design</i>	A	B	C
1		√	√	√
2		√	√	√
3		√	√	√

No	Design Project	Biophilic Criteria		
	<i>Inpatient Room Design</i>	A	B	C
4		√	√	√
5		√	√	√
6		√	√	√
7		x	√	√
8		√	√	√
9		√	√	√
10		√	√	√

No	Design Project	Biophilic Criteria		
		A	B	C
	<i>Inpatient Room Design</i>			
11		X	√	√
12		√	√	√
13		X	√	√
14		√	√	√
15		√	√	√

The design projects were analysed and discussed with an expert to define the best way to apply the biophilic design in inpatient rooms as the finding in this study. Findings were described in the discussion that highlights the whole visual from the inpatient room in the hospital should be required.

4.2 Discussion

The final design reported that the three criteria of biophilic design; nature in space, nature analogues, and nature of the space were infused into the design result. Found that most of the group focused on the “nature in space” biophilic criteria used in their design. Applying the principle of “nature in space” is practically easy for designers by directly providing a design full of natural elements to enliven the nature living system and built a vibrant natural-like environment assessed in Table 3. However, these things need to be considered as potential

risks regarding rules and standards in healthcare facilities that are kept clean and hygienic. Seen that living plants provided in the design might cause the possibility of risk in relation to the physical health of occupants. Studies investigated those microorganisms such as bacteria and fungi risk hospital-acquired infection in potting soil [13], which means living plants are not recommended to be applied to indoor spaces, especially in hospital wards. Each design was assessed in detail by analysing the visual appearance provided (Figure 3).

All design has their own approach due to points the biophilic criteria, from these cases, the consideration of hospital rules and standard about hygiene purpose, plants should be placed outdoors as a landscape for a more pleasant view is determined. Since creativity is defined as endless and open to any possibility, any obstacle can be handled by using technology as strategies. The use of technology is widely prevalent in medicine, science, industry, and design. The high intention of placing plants close to the occupants for raising the presence of nature, technology is used by providing the natural elements by manipulating the environment, such as air circulation system, the natural element (plants or greeneries) in LED screen, the dynamic lighting mimicking the outside condition, or providing artificial intelligence for direct interaction with the occupant’s motions or emotions.

Figure 3 (project design no.3 described in Table 4) was analysed through elements that were applied in the 3D perspective. The concept is defined as a willingness to create a living environment which is “healthy”, “safe”, “peaceful”, “clean”, and “comfortable” for the occupant by putting a lot of indoor plants, maximising the natural lighting, outdoor landscape (wide open view window), floor-wall-ceiling treatment and so on. The goals of the design are fully concerned with promoting the value of “nature in space” that is able to cure behavioural and mental health, but it has high potential risks to support the presents of pathogenic microorganism fungal/bacterial components which cause infections and allergic issues.

A strong emphasis on biophilic design for these healthcare facilities needs to balance the priorities and performance standards that are addressed to anticipate the whole patient's well-being. The review of design quality and its potential were assessed in Table 4 below.

Table 4 above showed a variety of results, students have an in-depth understanding of the basics and principles of biophilic design and its criteria. The biophilic design practical ability is 75% in the medium to high phase with creativity. Contrary students gain less enough knowledge about the design rules and principles of the hospital itself, so the design priorities for healthcare and standards are ignored. All designs used various technology as added features but just 25% of them were related and concerned to manipulate the indoor air quality from the mould and bacteria that caused the presence of indoor plants.



Fig. 3. Assessment: Project Design No.3

Table 4. Design Project Assessment and Review

Design No	Students Project		Lecturer Review	
	Innovation and Technologies Features	Biophilic Design Features	Design Quality Phase	Development Quality
1	<ul style="list-style-type: none"> • Artificial Intelligence Alarm, • Smart Temperature Detector • Smart Bed • Smart air circulation 	<ul style="list-style-type: none"> • Natural light through plenty of large windows • Plants on the floor, shelves, in planters and trellises • Exposed wooden greenhouse structure • Wooden floors and furniture • Leather seat coverings • Recycled materials used • Open views around the resort offer prospect 	Medium	High
2	<ul style="list-style-type: none"> • Ceiling Projector • Smart Low Partition Ventilation/Conditioning System 	<ul style="list-style-type: none"> • Moving screens, projections of patterns • Organically shaped furniture • Columns like trees. • Low Partitions, Window seat • Transparent materials; glass/polycarbonate walls/floors. partitions 	High	High
3	<ul style="list-style-type: none"> • Air Filter Robot • Virtual care (visit) • Automation panel (controller) • Wall Digital screen • Elsi Smart Floor 	<ul style="list-style-type: none"> • Digital moving screen • Natural light • Plants on the floor, shelves, in planters, and trellises • Vegetation content • Textured carpet on the floor • Natural Texture on the Wall • Organically shaped furniture 	Medium	Medium
4	<ul style="list-style-type: none"> • Smart Room Controler • Air Flow Sensor 	<ul style="list-style-type: none"> • Natural light • Plants on the floor, shelves, in planters, and trellises • Natural material • Non-Toxin • Visual connection with Nature • Non-rhythmic sensory Stimuli • Dynamic & diffuse light 	Medium	High

Design No	Students Project		Lecturer Review	
	Innovation and Technologies Features	Biophilic Design Features	Design Quality Phase	Development Quality
5	<ul style="list-style-type: none"> Smart Adaptive Window 	<ul style="list-style-type: none"> Natural light Natural Texture on Floor and Wall 	Low	Medium
6	<ul style="list-style-type: none"> Smart air circulation 	<ul style="list-style-type: none"> Plant on wall and table Natural Texture on Floor and Wall Warm tone colours 	Medium	High
7	<ul style="list-style-type: none"> Smart Thermostat 	<ul style="list-style-type: none"> Natural Texture on the Wall Double window and view access outside Natural Texture on Ceiling 	Low	Medium
8	<ul style="list-style-type: none"> Light Projector Interactive Floor Projection Self-Cleaning Machine 	<ul style="list-style-type: none"> Plant on wall and table Window planters Landscaped gardens Nature Patterns, floor tiles, wallpaper, screens of etched glass view over a distance for surveillance 	Low	High
9	<ul style="list-style-type: none"> LED Ceiling HEPA air purifier Oxygen concentrator 	<ul style="list-style-type: none"> Organic shape Vegetation content Organic Furniture Natural Texture on the Floor Impression of refuge by Zoning Impression of relieved prospects 	High	High
10	<ul style="list-style-type: none"> LED Screens HVAC & Built-in Air Purifier and Humidifier 	<ul style="list-style-type: none"> Natural light Indoor plants Window seats to observe the outdoors Natural materials (wood, stone) Nature-inspired wall and ceiling treatment Calming colours used throughout 	High	High
11	<ul style="list-style-type: none"> Virtual Assistant Mood Lighting Smart Thermostat Smart Curtain 	<ul style="list-style-type: none"> Natural analogues (mountains scenery) Earth tone colours Natural Texture on the Wall 	High	High
12	<ul style="list-style-type: none"> Smart Bed Automatic Blind Smart Window For Energy Efficiency Adjustable Temperature 	<ul style="list-style-type: none"> Plants on the wall, Artworks Earth tone colours Terrarium Natural Texture on the floor 	Medium	Low
13	<ul style="list-style-type: none"> Hepa Filter Nurse Call Bell Temperature Control 	<ul style="list-style-type: none"> Thermal & Airflow Variability Material Connection with Nature 	Low	Medium
14	<ul style="list-style-type: none"> Air Conditioner with HVAC & Nano-tmX Smart vertical garden Smart Glass 	<ul style="list-style-type: none"> Landscaped gardens with seating areas Natural colour, texture and pattern Transparent materials 	Low	Low
15	<ul style="list-style-type: none"> HEPA Filter Room Temperature Control Nurse Call Bell Streth Ceiling : Plafond Membrane Switchable PDLF Film 	<ul style="list-style-type: none"> Natural colour, texture and pattern Hanging glass partitions (or semi-obscured with frosted glass) 	High	High

The last point in these cases is about the ability to define the best material feature for hospital standards. The hospital has specific standard requirements for the material used. The hospital should have high-durability materials, easy to maintain and against the risk of

bacteria, mould, and other microorganisms, another consideration such as;

- Use solid and high-durability for floor material (Homogeneous tiles or vinyl-type roll) with a matte or polished finishing.

- Natural plants should be put outside or required in a closed terrarium.
- Avoid the use of artificial plants to prevent dust deposition.
- Avoid the use of textured material (carpets) to prevent dust deposition.
- Avoid walls, ceilings and, floors with different levels or contoured.
- Avoid fabric for any upholstery or cushion, use synthetic leather instead.
- Avoid highly reflective material that supports glare.
- Artificial lighting should be provided vary considered in multi activities and purposes.

5 Conclusion

The exploration of hospital inpatient design as a student case study is interesting and has great potential to be developed. The learning of a design project for young designers by giving stimuli in the form of “real problems” found in healthcare facilities is a method that can improve student’s sensibility of creativity. Each biophilic design obtained has a unique approach and can provide many alternatives and new variations in the development of hospital inpatient room designs. Even though biophilic design is very broad and flexible and also sometimes its application conflicts with hospital design standards (such as the application of live plants in inpatient rooms), these limitations are not a barrier, creative thinking by using technology is another way to present the nature performance as a healer. Students can learn more deeply about biophilic as an issue that can be applied to their future study or project that concerns improving human well-being, especially in hospitals and other public places. And addition there are also some suggestions that can be used as consideration in designing a room with a biophilic approach:

- Of the 3 criteria (14 biophilic design patterns), should be considered that not all of them need to be applied in inpatient room design. Biophilic criteria and pattern applications can adopt just some of the points or combine each criterion according to the purpose of design regarding rules and regulations.
- The nature in the space (the 1st criteria that has direct access to nature such as indoor plants) can risk occupants with any dangerous problem caused by microorganisms and pathogen bacteria. Although the using of technology (air purifiers and HEPA filters) can’t assure the hygiene quality of the air and should be tested in other research and experiment.
- The use of the finishing materials in the interior that promotes natural analogues (the 2nd criteria) should have hygienical standard features and be tested for quality of health and maintenance purposes.
- Open-view access to outdoor landscape views is better to promote nature than “bringing plants to the interior”. Maximizing the outdoor view with controlled features is one of the biophilic design acts (nature of the space: the 3rd criteria) that provide a positive distraction for occupants and avoid the experience of prolonged boredom.

- Biophilic design in hospitals or healthcare facilities should balance the priorities and performance standards and address anticipated the whole patient well-being.

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