

Design Studio Environment: Using Biophilic Patterns for Creative Performance

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1 ABSTRACT

In design education, the architectural design studio environment is one of the most significant environments that should be a stimulator of creativity. It's known for the amount of time students spend there, so it's considered their second home. Researchers aspire to create a unique and different design studio environment that motivates students' creativity. This study presents the biophilia theory as a technique that generates a creative design studio environment. The purpose is to determine the applicability of the biophilic design theory patterns to the design studio environment, which in turn has an impact on motivating the students' creativity. The research method will be conducted through a comprehensive analysis of several world-famous architectural schools, by understanding the application of the principles of nature and connecting them with biophilic patterns. As a result, the research has yielded applicable criteria for biophilic patterns in existing design studios.

Keywords: Architectural design studio, Creative learning environment, Biophilia, Biophilic design studio, Biophilic Patterns

2 INTRODUCTION

Creativity is described as the ability to create something unique. As a result, creative talents are required in many forms of education and jobs. Creative students are necessary for all sorts of education, including the arts, music, sciences, mathematics, and engineering, and architecture is one of them (“10 Jobs That Require Creative Thinking Skills”, 2023; “Best Degrees for Creative People”, 2022; Easton & Djumalieva, 2018; Rufener, McCaulley, & Sealey-Morris, 2023; Vilorio, 2015). The design studio has always been a rich material for investigation. Its impacts on interpersonal interactions, academic performance, and meeting students' psychological needs are crucial (Dhanapala, 2021). As a space, it extends beyond just being a box-shaped classroom to play a larger role. It has to be configured to encourage students to work and unwind when they encounter conceptual difficulties (shaqour, 2021); in addition, it has to be a source of inspiration and imagination (Davies et al., 2013; McCoy & Evans, 2002; Thoring, Desmet, & Badke-Schaub, 2018; Thoring, Gonçalves, Mueller, & Badke-Schaub, 2017; Vyas, van der Veer, & Nijholt, 2012). Actually, architecture students want spaces for chilling, places for socializing and conversing, suitable furniture, views rather than just walls, and a corner for laptops with the necessary equipment (Lewinski, 2015; Vyas et al., 2012). These needs are reflected in the studio's furnishings, which are usually divided up into smaller groupings to create a more intimate setting that supports the desired social interactions (Utaberta, Hassanpour, Handryant, & Che Ani, 2013). In addition, they prefer a panoramic view of the surrounding landscape, especially greenery elements in all the interior and exterior spaces, outside nature, green open spaces, green elements, indoor greenery, and indoor plants, as they feel comfy while working (shaqour, 2021). This is according to many references (Dhanapala, 2021; Ibrahim & Utaberta, 2012; Lewinski, 2015; Obeidat & Al-Share, 2012; shaqour, 2021). They have highlighted incorporating aspects of the natural environment as a prerequisite to its optimal performance as a catalyst for creativity.

Biophilia is a biological tendency to affiliate with nature (Stephen R. Kellert, 2012; WILSON, 1984). Biophilic design, as a reflection of the Biophilia principles in the design studio, presents a viable translation of “nature” to shape the design studio environment and accordingly affect its creativity potential (Stephen R. Kellert & Calabres, 2015). The challenge lies in the applicability of the biophilic patterns to the physical configurations of the design studio. It has to be addressed within a proper understanding of students' perceptions as related to incorporating elements of nature into the architectural design studio (WILSON, 1984).

This paper raises questions about the creative potential of applying biophilic design patterns to the existing design studio. To answer these questions, it reviews related literature to come up with a solid understanding of the typology of the 'creative design studio' on one hand, and the relation between nature-based interventions that influence these creativity potentials. In addition, three featured examples (mentioned within the leading 10 existing schools of architecture worldwide) are analyzed. A correlation analysis between the natural features of these schools and the related biophilic patterns is used to conclude a framework for applying the biophilic patterns in design studios to enhance their creative potential, This methodology has been shown in Figure 1.

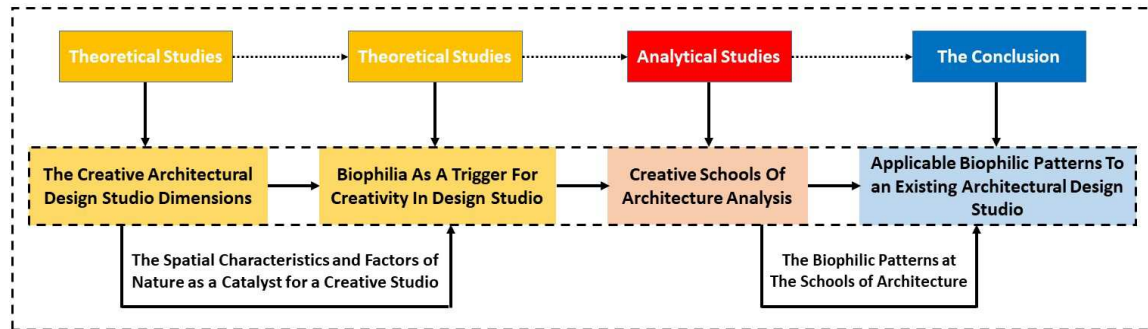


Fig. 1: The Research Methodology. Source: Researchers.

3 THE CREATIVE DESIGN STUDIO

The design studios' physical environment should be a trigger for creativity and innovation (CANNON & UTRIAINEN, 2013). because It is not only important to improve students' performance but also to make them more inventive and increase their creativity potential to create innovative products (Thoring et al., 2018). To establish an educational environment that inspires students to be more creative, several guidelines can be followed. Several literature reviews have mentioned certain spatial principles, characteristics, or requirements that can be applied to the educational environment. Many sources discussing spaces as triggers for creativity within academic, practice, or other innovation environments were identified.

The spatial requirements that can be applied were pointed out. Through these references, it was discovered that there are several spatial guidelines that are constantly repeated in different references and which turned out to be related to the natural environment. Some of the literature reviews allude to various learning environments in general. (Bramble, 2017; McCoy & Evans, 2002; Thoring, Desmet, & Badke-Schaub, 2019; Thoring, Guerreiro Goncalves, Mueller, Badke-Schaub, & Desmet, 2017; Thoring, Mueller, Desmet, & Badke-Schaub, 2020; Williams, 2013). Additionally, some other literature reviews were cited specifically pertaining to the architectural design studio. (Muniandy, Khan, & Ahmad, 2015; Obeidat & Al-Share, 2012; shaqour, 2021; Thoring et al., 2018; THORING, LUIPPOLD, & MUELLER, 2012.). Practitioners, educators, and researchers can use the presented overview to investigate the possible impact of creative space design and to identify research gaps for conducting further research in the field. The spatial characteristics that are connected with nature as a trigger for creative space will be analyzed in Table 1.

3.1 The Spatial Characteristics and Factors of Spaces as Triggers for Creativity

The first factor is the visual connection with nature. That factor can be applied by using open views and making many openings, windows, or curtain walls, which give a wider perspective. Additionally, using greenery, which can be used in the space by using living indoor plants and flowers of various shapes, sizes, and types (CANNON & UTRIAINEN, 2013; Davies et al., 2013; De Paoli & Ropo, 2017; Dul & Ceylan, 2014; McCoy & Evans, 2002; Muniandy et al., 2015; Oksanen & Stähle, 2013; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Gonçalves, et al., 2017; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012.; Thoring et al., 2020; Williams, 2013).

The second factor is the components of the space, which focus on furniture arrangement and design as well as unusual and activating furniture, which can be applied by using different shapes of furniture that express nature. Also, using visual details in the interior design gives rich sensory information. Furthermore, the size and shape of internal object organization follow a spatial hierarchy similar to those found in nature. (CANNON & UTRIAINEN, 2013; Ceylan, Dul, & Aytac, 2008; De Paoli & Ropo, 2017; Dul & Ceylan,

2014; McCoy & Evans, 2002; Muniandy et al., 2015; Setola & Leurs, 2014; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020; Williams, 2013).

Factor	Identification	Factor	Identification	Factor	Identification	Factor	Identification
Connection with nature	Open Views	components of the space	Interior Haptics and Finishing	Stimulating	Stimulation	Natural light	Light, Quantity of light
	view of natural environment		less use of manufactured materials.		Sensory stimulation		Use of Natural Daylight
	extended views		Complexity, Complex Shapes		Sound (positive sound)		Use of Ambient, Soft Light
	Use of Outdoor Spaces		Size, Shape Internal Organization of Objects	Materials	Smell (Positive Smell)	Natural colours	Pale Colors, Calming, Inspiring Colors
	Use of Open Space				Natural Textures		
	Use of Park Theme Inside		Visual Detail	Transparency, Semi-Transparency	Fewer Cool Colors		
	Greenery		Furniture Design & Arrangement	Use Of Natural Materials	Warm Color		
	Living Plants Indoor		Unusual Furniture	Ventilation	Micro-Climate	Energetic Colors, Bright Colors	
	Vista				Indoor Climate		
	Activating Furniture		Fresh Air				

Table 1: Overview of The spatial characteristics that are connected with nature as a trigger for creative space. Source: Researchers.

Stimulation is the third factor. That factor can be applied by using furniture that imitates elements of nature and biomorphic forms and shapes. And any suggestions for simulating nature in space (Bramble, 2017; CANNON & UTRIAINEN, 2013; Davies et al., 2013; Jindal-Snape et al., 2013; McCoy & Evans, 2002; Muniandy et al., 2015; Oksanen & Stähle, 2013; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Gonçalves, et al., 2017; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020).

The fourth factor is the material connection with nature. This factor can be applied by using natural materials and textures in the space on furniture, walls, floors, ceilings, and any other elements in the space (CANNON & UTRIAINEN, 2013; Davies et al., 2013; De Paoli & Ropo, 2017; De Paoli, Sauer, & Ropo, 2018; McCoy & Evans, 2002; Muniandy et al., 2015; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Gonçalves, et al., 2017; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020).

The fifth factor is natural ventilation and airflow. These factors affect the indoor microclimate that can be created by using many sources of natural ventilation, such as windows, courtyards, and atriums (CANNON & UTRIAINEN, 2013; Jindal-Snape et al., 2013; McCoy & Evans, 2002; Muniandy et al., 2015; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020; Williams, 2013).

The sixth factor is natural light. The quantity of natural daylight and ambient, soft light affects students' mental and physical health. Therefore, using natural light enhances our wellbeing, which impacts students' creativity (Davies et al., 2013; De Paoli, Sauer, & Ropo, 2017; Dul, Ceylan, & Jaspers, 2011; Jindal-Snape et al., 2013; Makhmalbaf & Do, 2007; McCoy & Evans, 2002; Oksanen & Stähle, 2013; Peschl, 2014; Thoring et al., 2018; Thoring et al., 2020; Williams, 2013).

The seventh factor is natural colors, which have a positive influence. Colors affect our feelings. Natural, pale, bright, calming, and inspiring colors create a connection with nature. Warm and energetic colors create a feeling of power. All this can create a creative space (Bramble, 2017; CANNON & UTRIAINEN, 2013; Davies et al., 2013; Eismann et al., 2021; Jindal-Snape et al., 2013; McCoy & Evans, 2002; Muniandy et al., 2015; shaqour, 2021; Thoring et al., 2018, 2019; Thoring, Guerreiro Goncalves, et al., 2017; THORING et al., 2012,; Thoring et al., 2020).

After recognizing the role of nature in stimulating creativity in the design studio, theories have been explored through which the experience of nature can be applied. The biophilia theory is one of these theories.

4 BIOPHILIC DESIGN

Biophilia, our biological connection to natural environments (Browning, Ryan, & Clancy, 2014; Stephen R. Kellert, 2012; WILSON, 1984) has been theoretically linked with creative output and performance. (Ulrich, 1993). The justifications for selecting the biophilia hypothesis as a foundational approach to applying the experiences of nature in design studio environments are:

- Biophilic design's fundamental objective is to handle these imperfections of contemporary or current building and landscape practice by setting up a new framework for the fulfilling experience of nature in the constructed and built environment (Browning et al., 2014; Stephen Robert Kellert, 2008; Stephen R. Kellert & Finnegan, 2011).
- Biophilic design aims to create useful habitat for people as an organic and biological organism in the built environment that improves people's creativity, productivity, health, fitness and wellbeing (Browning et al., 2014; Calabrese, 2015; Stephen R. Kellert & Finnegan, 2011).
- The biophilic theory was chosen based on some research and literature reviews that carried out quantitative and computational experiments on some space users and measured their creativity in different environments (Chulvi, Agost, Royo, & García-García, 2020; McCoy & Evans, 2002; Ulrich, 1993), including: a) The first one is the neutral study space; b) The other one is the same educational space, but a simulation of the natural environment inside this space was made by relying on the biophilic theory; and c) The last environment is the natural environment itself (the outdoor natural environment), as shown in Figure 2. The results indicate that both types of environments – simulated (biophilic) and natural settings – have higher creative values than a neutral situation.



Fig. 2: Photos showing 1) Real nature: outdoor garden area. 2) Simulated nature by biophilic theory: artificial representation of the garden indoors. 3) Neutral environment: normal lecture room. adapted from: (Chulvi et al., 2020).

With the aforementioned justifications, it can be concluded that biophilic design can create a creative design studio. Therefore, it was necessary to know the components of biophilia theory, which consist of principles and patterns (Browning et al., 2014; Stephen R. Kellert & Calabres, 2015). Several fundamental principles must be followed in order for biophilic design to be successfully implemented, which are:

- Frequent and continuous contribution to nature;
- Focusing on human willingness to accept nature;
- Encouraging emotional linking to similar environments and places;
- Strengthening the interaction between people and nature, which helps to increase the sense of responsibility towards human and natural societies;
- Inspiring the existence of interconnected and integrated architectural solutions (Browning et al., 2014; Stephen R. Kellert & Calabres, 2015).

There are 14 patterns of biophilic design that can be used when applying biophilic design within any space, and the 14 patterns fall into three groups: nature in space, natural analogues, and nature of space (Browning et al., 2014; Stephen R. Kellert & Calabres, 2015; WILSON, 1984), as shown in Table 2.

Based on this, it was determined that the biophilic theory is concerned with interior environments that are surrounded by nature. It can also provide a sense of the natural context, even if this interior space is in the center of a city in a built environment. Through various treatments and the application of additional principles and patterns within the space, it is possible to convey a sense of the natural environment and

context even though that space is inside the built environment. This is possible thanks to biophilic theory (Browning et al., 2014; Stephen Robert Kellert, 2008; Stephen R. Kellert & Finnegan, 2011).

NATURE IN THE SPACE	P1	Visual Connection with Nature	NATURAL ANALOGUES	P8	Biomorphic Forms and Patterns	NATURE OF THE SPACE	P11	Prospect
	P2	Non-Visual Connection with Nature		P9	Material Connection with Nature		P12	Refuge
	P3	Non-Rhythmic Sensory Stimuli		P10	Complexity and Order		P13	Mystery
	P4	Thermal and Airflow Variability					P14	Risk/Peril
	P5	Presence of Water						
	P6	Dynamic and Diffuse Light						
	P7	Connection with Natural Systems						

Table 2: showing the biophilic design patterns and its description. Source: Browning et al., 2014.

5 CREATIVE SCHOOLS OF ARCHITECTURE'S ANALYSIS

Some examples from a number of the top architectural schools in the world will be singled out based on the Quacquarelli Symonds Rankings (QS) ("QS World University Rankings", 2022). The criteria for selection depend on the existence of the largest number of natural principles, creativity simulation, Their existence in a built or natural environment, and the availability of data. At the school, an analysis of the natural characteristics as a creative space trigger will be conducted in relation to the factors in Table 1. The main goal is to know the differences in the application of nature and natural elements in different locations, like a built environment, a tropical climate environment, and a mixed environment. As a result, the application of those natural characteristics will be connected through biophilic patterns. The three schools are: 1) TU Delft Faculty of Architecture and the Built Environment (rank 2), which is located in a mixed area (built-up and natural areas). 2) National University of Singapore School of Design and Environment (rank 6), which is located in a natural area. 3) Manchester School of Art (rank 7), which is located in a built-up area.

The following descriptions are analyzed based on some literature reviews, which contain journal articles, papers, reports, websites, and books that were utilized to describe the building designs and the aim, purposes, and values of the three architectural schools.

5.1 TU Delft Faculty of Architecture & the Built Environment

In terms of research and education, the faculty of architecture and the built environment is a global leader. The faculty's solid research reputation as well as the passion, enthusiasm, and creativity of its academic community and student body are what drive its success (Hoeven et al., 2022; Voordt, Jonge, & Hans; Wamelinck, 2010). Academics and students have been working on enhancing the built environment to create a creative learning environment for students to become excellent, brilliant, and creative architectural engineers (Avermaete et al., 2014; "BK CITY, DELFT: a vibrant educational environment", 2022; Hoeven et al., 2022; ir-arch. T. (Tom) Coppens, Dipl.-Ing. Dr.techn. I. (Iva) Kovacic, G. (Gabriele) Lobaccaro, D.M. (Despina) Stratigakos, & Verbakel, 2023; Rooij, Klaassen, Cavallo, & Arts, 2019; "TU Delft Architecture and the Built Environment: About the faculty", 2022; Voordt et al., 2010).

5.1.1 Spatial Characteristics of Nature Principles as a Creative Space Trigger Related to Table 1

One of the factors at the TU Delft Faculty of Architecture and the Built Environment is the connection with nature. It's demonstrated inside the school through the presence of different plants, gardens, parks, and a backyard gathering area, as shown in Figures 3 and 4. The studio walls are mostly glass curtain walls, allowing views of nature. The second is components of the space, which are similarly characterized by complex geometries, internal haptics, and distinctive finishing. Then, as seen in Figure 5, there is a simulation of plants and other natural elements using their colors, shapes, and functions. The utilization of natural materials in multiple places is one of the distinctive characteristics. The studio at TU Delft is distinguished by its significant reliance on natural light, which enters through the ceiling's 17 skylights and curtain walls. As seen in Figure 6, the design studio is also defined by the presence of natural colors that provide many sources of inspiration. (Avermaete et al., 2014; "BK CITY, DELFT: a vibrant educational environment", 2022; Hoeven et al., 2022; ir-arch. T. (Tom) Coppens et al., 2023; Rooij et al., 2019; "TU Delft Faculty of Architecture & the Built Environment", 2022; Voordt et al., 2010).



Fig. 3: The faculty’s surrounding context. Fig. 4: Outdoor gathering area. Both adapted from: “BK CITY, DELFT: a vibrant educational environment”, 2022.



Fig. 5: The design studio hall. Fig. 6: The orange hall. Both adapted from: “BK CITY, DELFT: a vibrant educational environment”, 2022.

5.2 National University of Singapore School of Design and Environment

The aim of the school is to become a top one that brings creative minds together to create a better future ((NUS), 2019 ; P, 2021; “School of Design and Environment”, 2021). The design seeks to emphasize learning as a communicative, collaborative, and creative method. The design concept isn't just to create a creative learning environment for students but also to benefit the entire system by opening up the debate over design in general. So what distinguishes the building design is not only creating a learning environment that helps students communicate, be more creative, and collaborate ((NUS), 2019; Lasternas, 2018; “National University of Singapore School of Design & Environment”, 2019; “NUS School of Design & Environment” " 2022; P, 2021; Poh et al., 2018; “SERIE ARCHITECTS”, 2022).

5.2.1 Spatial Characteristics of Nature Principles as a Creative Space Trigger Related to Table 1

The building is widely connected with nature in many ways; it's extremely open. Nature and the landscape all around the building, as shown in Figure 7, As seen in Figure 8, there are various terraces and planted balconies. A huge overhanging roof protrudes along the south façade, integrating a tropical porch surrounded by mature trees. The building's architecture is adaptable and efficient. There are no formal distinctions between study, work, and social environments, as shown in Figure 9. The raw and natural features of the building materials have a major relationship with the biophilia notion. The ventilation at the school depends on natural sources. The building is called a "climate-responsive building." The majority of the rooms may be exposed to the prevailing winds, and more than half of the space is naturally ventilated. When necessary, only air conditioning is used. The school also depends on natural light. Parts of the façade can be taken apart and replaced with new methods and systems. a veil-like metal curtain that filters sunlight. There are also about 1,200 solar photovoltaic panels above the roof, as shown in Figures 10 and 11 ((NUS), 2019 ; Lasternas, 2018; “National University of Singapore School of Design & Environment”, 2022; “NUS School of Design & Environment”, 2022; P, 2021; Poh et al., 2018; “SERIE ARCHITECTS”, 2022).



Fig. 7: The building's surrounding. Fig. 8: The building's terrace. Fig. 9: The design studio hall. Both adapted from: “NUS School of Design & Environment”, 2022.



Fig. 10: Longitudinal Section components. Fig. 11: Cross Section components. Both adapted from: (“NUS School of Design & Environment”, 2022).

5.3 Manchester School of Art

The vision of the school is to be an inclusive art gallery for the people of Manchester and the wider world, opening minds to the essential role of creativity in making a healthy society and contributing to social change (Fallon, 2018; Jefferies, Stone, & Kwan, 2017; “Manchester Art Gallery”, 2022; university, 2016). The Manchester School of Art’s significant expansion by Feilden Clegg Bradley Studios has helped raise the prominence of the university and the art school by creating a creative, vibrant, interesting, and engaging environment for staff and students to work in (Fallon, 2018; Jefferies et al., 2017; “Manchester Art Gallery”, 2022; “MANCHESTER SCHOOL OF ART”, 2015; ofsted, 2013; University, 2013, 2016).

5.3.1 Spatial Characteristics of Nature Principles as a Creative Space Trigger related to Table 1

The school is characterized by a great connection with nature through the presence of living indoor plants and flowers of different types and shapes. A hybrid creative environment was created. There is also a green roof for the gathering, called the design garden, and a skylight. The size of the internal configurations is appropriate, and the visual details are simple. The arrangement of the interior furnishings of the studio, workshops, and cafes is active and unusual. There is a simulation of some elements in the school. There are some motifs on the column faces, including plants and small flowers, as shown in fig. 12. Most of the surfaces in the space and the furniture are made of natural materials, such as wood. There are no complex manufactured materials inside the space. The interior design of the space provides good ventilation and air renewal due to the presence of the atrium, which ends with a skylight. The building facades are curtain walls, so the whole building relies on natural light. Also, the colors inside the school are natural, calm, and motivating colors that generate a feeling of inspiration and creativity, as shown in fig. 13 (Fallon, 2018; Jefferies et al., 2017; “Mnchester school of art”, 2015; “Manchester School of Art”, 2022; ofsted, 2013; University, 2013, 2016).

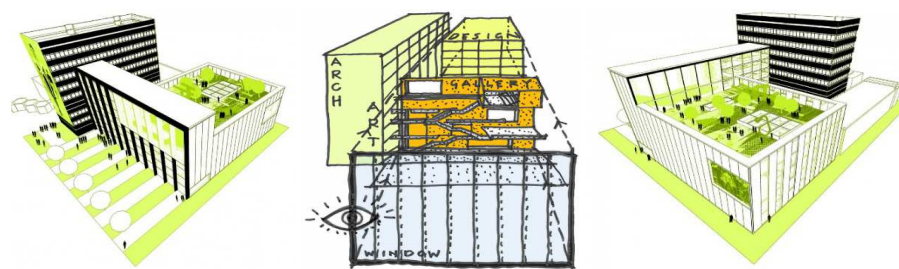


Fig. 12: Photos showing 3D shot showing the green roof and the outdoor green areas around and above the building. Adapted from: “Manchester School of Art”, 2022.

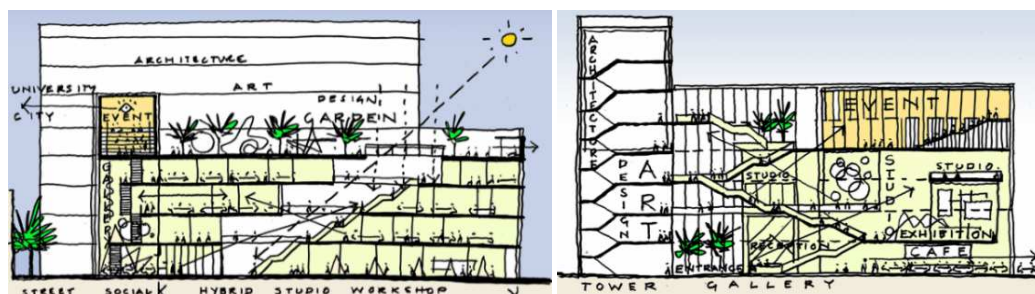


Fig. 13: Photos showing Two orthogonal sections of the building zoning showing the biophilic patterns in the different zone of the building. Adapted from: “Manchester School of Art”, 2022.

5.4 Results: The Biophilic Patterns at The Previous Schools of Architecture

In order to create a creative architectural studio environment that depends on the application of biophilia theory as a translation of nature's principles, it was necessary to know how to connect the principles of nature and the biophilic patterns. The following paragraphs will explain how the aforementioned Spatial characteristics of nature principles have been applied to the biophilic pattern for each school.

The Visual Connection with Nature pattern was applied at the three schools in different ways. It mainly depends on green plants, which can be employed in any style of interior design, like residential, educational, and office settings. The focus here is on how it is employed within the architectural studios, and the following can be used to determine this: It was applied at the first school by creating views of nature from windows and curtain walls, the existence of parks with seasonal plants, pots, bushes, and trees, gathering gardens, and inner plants. But at the third school, it depends on the curtain wall on the north façade, windows on walls in the other façade called "windows on the arts," and a roof with green plants that is called a terraced hybrid environment. However, this pattern is stronger in the second school, by making terraces, planted balconies, and constructing a tropical portico, inner areas and exterior spaces can be in close proximity to the surrounding landscape. The non-visual connection with nature pattern was implemented at all three schools in a similar way, by relying on the indoor plants' smell and sounds from the outer gardens through birds, insects, and plants' movements and seasonal outdoor plants' changes.

At the first school, the non-rhythmic sensory stimuli pattern was performed by combining emerging with rich, layered ground and wall coverings, skylights, and tall trees. At the second school, it was applied by making outdoor and indoor seasonal plants. Then at the third one, they used various ground and wall coverings, a skylight, and tall grass. The thermal and airflow variability pattern was utilized at the first and third schools by creating curtain walls and operable skylights. In the second example, a majority of the rooms are exposed to the prevailing breezes, areas are created to capture natural light throughout the day, and more than 50% of the space is naturally ventilated. Only air conditioning is utilized when necessary, as the biophilic theory can deal with the spaces found in a natural setting to apply "climatic, or eco-design, using natural processes" due to its availability. However, if the spaces are located inside a built environment, mechanical or artificial methods (such as natural ventilation, direct sunlight, solar electricity production, etc.) may be used. In case of the inability to use the natural processes (Browning et al., 2014; Stephen Robert Kellert, 2008; Stephen R. Kellert & Finnegan, 2011).

At the three schools, there is no presence of the Water pattern. The dynamic and diffuse light pattern is achieved in the first school by adding 3-sided curtain walls, 13 skylights, and dynamic artificial warm lighting. Then at the second school, there is a veil-like metal curtain that filters sunlight and emphasizes a link to the environment. The four facades are curtain walls with light filters. But the third school includes skylights, window units on the other facades, and an oblique court. The connection to natural systems was visible in the first and third schools through seasonal changes in vegetation in the gardens. However, the second school contains a landscape that improves water quality; nearly 50% of the plants selected are native species, and most are from the southern tropics; 1200 solar photovoltaic panels on its rooftop; and an innovative hybrid cooling system that supplies rooms with 100% fresh pre-cooled air.

The pattern of biomorphic forms and patterns at the first and second schools was applied by making one-colored spaces, motifs, and ornaments of natural elements; most of the colors and materials are from nature. At the third school, that pattern was implemented by using a curtain wall that allowed a view of the old buildings with ornaments and motifs that simulated elements from nature. The Material Connection with Nature pattern was implemented at the first and third schools by designing furniture and space elements from natural materials. At the second school, the building has a strong biophilic component, which is the deliberate use and celebration of the raw and natural characteristics of the materials. also the use of natural colors and materials for walls, floors, and columns, such as wood, stone, and glass.

The Complexity and Order pattern was applied at the first school by making patterned ceiling and wall tiles. On the second, there are patterned wall tiles; different sizes and textures of the stone are utilized; patterned ceiling tiles for lighting fixtures; and ordered facade panels. Patterned vertical ceiling tiles and orderly window units were used in the third one. The Prospect pattern was used at the first and second schools by creating a studio layout with views across for surveillance, an unobstructed view from the mezzanine floor, and an upper level elevated above street level. Besides that, the third school added open floor plans for

studios and galleries. The Refuge pattern appeared at the first school by relying on a landscaped courtyard to separate it from the city. Then, at the second one, there are many outdoor terraces and corridors. Finally, at the third school, there were enclosed conference and work rooms. The mystery pattern didn't appear in the first school. But at the second school, it was applied by creating a partially obscured view of plants from the studios and the hallway; an entry switchback creates visual intrigue. At the third school, there were glimpses of plants and greenery through openings in the walls. The risk/peril pattern wasn't significantly represented in the three examples.

After realizing the biophilic patterns that were applied to the previous three architectural schools, the common patterns that were applied in the schools were extracted at Table 3. as they are essential patterns that can be applied to any design studio.

The Biophilic Design Patterns		TU Delft Faculty	Singapore University	Manchester School	Common Biophilic Patterns between the school	
NATURE IN THE SPACE	P1	Visual Connection with Nature	yes	yes	yes	Nature views; open views; extended views; large windows; curtain walls; exterior plants, park, and gardens; private gathering open spaces and gardens; inner Living indoor plants of different types, such as greenery, pots, trees; view of the natural environment.
	P2	Non-Visual Connection with Nature	yes	yes	yes	The plants' smells, sounds, and movements; Birds, insects, and bees exist; seasonal plants.
	P3	Non-Rhythmic Sensory Stimuli	yes	yes	yes	Native landscaping; tall trees; rich and various layered wall and floor cover; seasonal plants.
	P4	Thermal & Airflow Variability	yes	yes	yes	Operable Curtain wall, tall windows, skylight.
	P5	Presence of Water	x	x	x	Not significantly represented in the project.
	P6	Dynamic & Diffuse Light	yes	yes	yes	Curtain walls; tall windows; skylights.
	P7	Connection with Natural Systems	yes	yes	yes	seasonal changes in the plants, gardens, and parks outside and inside; possibilities to observe interactions between plants, bees, insects, and birds.
NATURAL ANALOGUES	P8	Biomorphic Forms & Patterns	yes	yes	yes	motifs and ornaments of natural elements; most of the colors and materials are from elements of nature.
	P9	Material Connection with Nature	yes	yes	yes	Natural colors and materials for most surfaces; pale colors for walls and floors; many wooden surfaces for furniture, walls and floors.
	P10	Complexity & Order	yes	yes	yes	patterned tiles for the ceiling, walls, and curtain walls; different sizes and textures of furniture and materials.
NATURE OF THE SPACE	P11	Prospect	yes	yes	yes	A clear view over a long distance for observation, surveillance and planning.
	P12	Refuge	yes	yes	yes	Outdoor terraces and passageways that can be used to create a secure area where one can withdraw from their surroundings or the main activity stream while yet being shielded from above and behind.
	P13	Mystery	x	yes	yes	partially obscured views and glimpses for the surroundings
	P14	Risk/Peril	x	x	x	Not significantly represented in the project.

Table 3: The common methods of applying the biophilic patterns at the previous schools. Source: Researchers.

6 CONCLUSION: APPLICABILITY OF THE BIOPHILIC PATTERNS TO THE ARCHITECTURAL DESIGN STUDIO

The educational environment affects students in several ways. It motivates students to provide their best performance, particularly for architecture students. Therefore, the design studio learning environment should

foster creativity. After research and analysis, it was discovered that connection with nature, such as using living plants, greenery, open views, and other guidelines that promote nature's connectedness, can help create a creative learning environment while also enhancing students' creative performance. As a result, theories were investigated to determine how nature could be applied within the space. The biophilia theory, which expresses the human proclivity for nature, consists of 14 patterns that can be used to create a connection with nature within a space. In order to find out how these patterns can be applied, a number of examples of different biophilic environments were analyzed. Through the examples' analysis, it has been concluded that these patterns can be applied through many of the methods that have been mentioned.

After discovering how to apply the biophilic pattern, it was found that some patterns could be applied to an existing design studio but others could not. The following will present an analysis of the biophilic patterns that can be applied to an existing design studio. The patterns: visual connection with nature; non-visual connection with nature; non-rhythmic sensory stimuli; thermal and airflow variability; dynamic and diffuse light; connection with natural systems; material connection with nature; Biomorphic Forms and Patterns; complexity and order, can be applied to an existing design studio as long as its application capabilities are available and affordable. The methods, additions, and treatments by which they can be applied are listed in Table 3. As for the "Presence of Water" pattern, that wasn't applied to any school due to the lack of application capabilities.

The prospect and refuge patterns were applied to the three schools; the mystery pattern was applied to only two of the three schools; and the risk/peril pattern also wasn't applied to any schools. However, those three patterns are difficult to implement in an existing architectural design studio. because mostly those patterns depend on the location in which the studio's building is sited and also the surrounding spaces around the studio. And with this, the aim of this paper was reached, which was to find out the possibility of applying the biophilic patterns to an existing architectural design studio and to determine the methods by which these patterns could be applied. In order to give all existing design studios, the opportunity to transform their usual design studio into a biophilic design studio, which helps improve their creative performance and enhances their efficiency.

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