Biophilic Design Patterns for Primary Schools

Subjects: Architecture And Design

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Existing frameworks for biophilic design have similar strategies and attributes as useful checklists for designers; however, the focus has been on adults rather than children, and there remains the need for more guidance related to school design by extension. The application of biophilia would be a design resolution in schools because of its impact on children's health and well-being, which has been more important since the pandemic started; however, it remains quite unexplored in school design in many countries, including the UK. Biophilic design patterns can be used in school buildings and grounds for greater connectivity between spaces and nature in order to promote children's well-being.

Keywords: biophilic design ; primary school design ; Biophilic evaluative tool ; Children's participation ; Children's well-being ; Biophilic school design

1. Introduction

Existing frameworks for biophilic design [1][2][3][4] have similar strategies and attributes as useful checklists for designers. In addition, the Biophilic Quality Index (BQI) has been devised [5] as a reliable instrument to calculate to what extent a building is biophilic and could also help architects integrate nature in designs; therefore, as the focus of existing frameworks and BQI has been on professionals and design experts rather than building users, particularly children, there remains the need for more guidance related to the biophilic design of schools. The important role that the natural environment plays in maintaining and enhancing mental health and wellbeing has been well established [6][7]. Empirical studies have also highlighted that time in nature, direct and indirect contact with nature, and engaging with nature through simple activities [8][9] are beneficial to wellbeing. The application of biophilia would be a design resolution in schools because of its impact on children's health and well-being; however, it remains quite unexplored in school designs in many countries around the world.

The majority of primary school grounds are made of concrete and grass; however, they can be transformed into varied, ecologically rich places of learning for children. The benefits of outdoor learning have been emphasised by the learning outside the classroom manifesto [10], as school gardens offer significant benefits in terms of learning through experience [11]. In addition, a number of design attributes related to the natural environment have been studied in terms of their educational impacts. A 14.4% improvement in test scores was discovered as a result of natural ventilation [12]. The combination of dynamic lighting and increased ventilation rate indicated boosted positive impact on the speed and concentration of the children [13]. Furthermore, improved outdoor space and access to nature was correlated with a 7% improvement in test results [14]. Therefore, a connection to nature is important for not only children's well-being but also their education. Beneficial and healing relationships between nature and human functioning are well established. Within an educational setting, experiences with nature promote children's academic learning (by providing a calmer, quieter, and safer context for learning; a warmer and more cooperative context for learning) and seem to promote children's development as persons and as environmental stewards [15].

Biophilic design patterns have the potential to reposition the environmental quality conversation to provide individuals' needs equal consideration alongside the conventional parameters for building performance. Biophilic design patterns [2][16] can be used in school grounds and in indoor spaces for greater connectivity between interior design and nature to promote children's well-being, especially for post-pandemic school design. An encouraging study showed improved performance of schoolchildren taught in classrooms that had biophilic ornamental elements, even using simple and restrained renovations [17].

2. Background

In *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, biophilia is described as 'the inherent human affinity to affiliate with natural systems and processes' [1]. It was in the 1960s, however, when biophilia was first conceived within social psychology. Social psychologist Eric Fromm formed the concept of 'bioiphilious,' meaning 'bio' as

in nature and ‘philious’ as in love. This concept was popularised by Edward Wilson in the 1980s as ‘biophilia.’ Although the term ‘biophilia’ is a relatively new concept, it has always been a key component relative to human culture, community, and traditional vernacular architecture.

In the book *Creating Biophilic Buildings* [18], biophilic design was described as ‘.the deliberate incorporation of elements from nature into the built environment’. Within Terrapin’s Bright Greens ‘14 Patterns of Biophilic Design’ [2], biophilic design is divided into three themes: Nature in the Space, Natural Analogues, and Nature of the Space, as **Table 1** presents them. Within these three themes, individual patterns are explored, and their benefits expanded upon, taking reference from the work by Kellert and Calabrese [19]. A slightly different formulation of biophilic design properties is given by Salingaros [20], who compares different lists of attributes proposed by different authors [21].

Table 1. Fourteen Patterns of Biophilic design—adapted from Terrapin Bright Greens [2].

Theme	No.	Pattern
Nature in the Space (Direct Experience)	1	Visual Connection with Nature
	2	Non-Visual Connection with Nature
	3	Non-Rhythmic Sensory Stimuli
	4	Thermal and Airflow Variability
	5	Presence of Water
	6	Dynamic and Diffuse Light
Natural Analogues (Indirect Experience)	7	Connection with Natural Systems
	8	Biomorphic Forms and Patterns
	9	Material Connection with Nature
	10	Complexity and Order
Nature of the Space (Indirect Experience)	11	Prospect
	12	Refuge
	13	Mystery
	14	Risk/Peril

Interfaces booklet’s ‘14 Patterns of Biophilic Design’ [22] incorporates the work of Terrapin Bright Green, describing each pattern and exploring the experience of it. The booklet also highlights practical methods of implementing each pattern. Although the practical examples are somewhat directed at office environments, they do provide a starting point from which to expand and explore the ways in which the integration of biophilic design can be achieved within other built environments, such as schools. However, as part of Nature of Space, pattern 15, ‘Awe’ was also introduced [4].

Within the ‘Practice of Biophilic Design’ [19], it is suggested that in order to successfully create a biophilic design, five principles must be followed about ‘biophilic design’:

- It requires repeated and sustained engagement with nature;
- It focuses on human adaptation to the natural world that over evolutionary time has advanced people’s health, fitness, and wellbeing;
- It encourages an emotional attachment to particular settings and places;
- It promotes positive interactions between people and nature that encourage an expanded sense of relationship and responsibility for the human and natural communities;
- It encourages mutual reinforcing, interconnected, and integrated architectural solutions.

The benefits to the integration of biophilic design are wide ranging and can positively affect mental wellbeing, physical health, and brain function [23][24] (although the claimed biophilic qualities of the Maggie's Centres is disputed [21]). The benefits of integrating biophilic design into educational environments include improved test scores, optimal health, and

increased learning. It also highlights the benefits to including biophilic design strategies with playtime environments such as the playground, providing children with the capacity for improved behaviour, focus, and mental restoration. In an increasingly urban environment, where the opportunity for children to be exposed to nature is continually reduced, it has been found that 96% of children prefer to be outdoors, with studies attributing lower stress levels in children who have nature within their surroundings than those without [23].

3. Case Studies

A review of the literature shows that there are not many examples of systematic case studies related to biophilic design in schools. There are few case studies of schools that present biophilic design [4][18]; however, they are presented more as descriptive examples than analytical cases alongside other types of buildings without comparison. For this study, the selected cases (in two climates) represent different models of school design and approaches as follows.

- School design with full integration of nature;
- School design that integrates some natural elements;
- School design that integrates the imitation of nature.

The case studies have been analysed to identify (1) the main design considerations in integrating nature (directly and indirectly) and (2) the main biophilic patterns and elements applied in the design of schools (indoors and outdoors).

3.1. Vo Trong Nghia's Farming Kindergarten

This kindergarten in Vietnam is a two-storey school with a knot-shaped roof and a vegetable garden on top with three protected courtyard playgrounds. The surface of the roof is covered in grass and plants to create an extra garden. It slopes down to the ground at two ends to allow easy access, then rises up over two levels of classrooms. With facilities for up to 500 pupils, it was designed by Vo Trong Nghia Architects. Despite a tight budget, the architects wanted the building to become a prototype for sustainable school design, where children can learn how to grow their own food. The outer walls are shaded behind concrete louvres that encourage the growth of climbing plants, while the green roof above serves as a form of insulation. Windows on both external and courtyard-facing walls offer natural lighting and cross ventilation throughout the building; therefore, the kindergarten operates without air conditioners in the classrooms despite being located in a harsh tropical climate. Other sustainability initiative includes the use of solar power to heat water and the recycling of waste water from the factory to irrigate greenery and flush toilets [25].

3.2. The Green School

The Green School, opened in Bali in 2008, is committed to education that promotes sustainability and shapes future green leaders. It currently serves more than 800 students aged 3–18 [26]. The Green School, a giant laboratory built by PT Bambu, is located on a sustainable campus straddling both sides of the Ayung River in Sibang Kaja, Bali, within a lush jungle with native plants and trees growing alongside sustainable organic gardens. The campus is powered by a number of alternative energy sources, including a bamboo sawdust hot water and cooking system, a hydro-powered vortex generator, and solar panels. Campus buildings include classrooms, gym, assembly spaces, faculty housing, offices, cafes, and bathrooms. A range of architecturally significant spaces from large multi-storey communal gathering places to much smaller classrooms comprises features of the campus. Local bamboo, grown using sustainable methods, is used in innovative and experimental methods that demonstrate its architectural possibilities. The result is a holistic green community with a strong educational mandate that seeks to inspire students to be more curious, more engaged, and more passionate about the environment and the planet [27].

3.3. Barn Klong Bon School and Art Spaces

With this project, Vin Varavarn Architects aimed to design a new building for Barn Klong Bon School situated on Koh Yao Yai Island of Phang-Nga province, Thailand, replacing the old structure that had deteriorated over time. The design team ended up rearranging the floor plan of the classrooms on the second floor to deviate 90 degrees from the original position, consequentially separating the classrooms and reconnecting them using the corridor at the back of the building. The new configuration not only creates a space between each classroom but also keeps the upper floor spacious, unobstructed, and well-ventilated, interestingly facilitating a spatial connection between the upper floor and the ground floor where the art classroom is located. The difference of the floor levels causes the ground floor of the building to be situated at different levels, which results in the different ceiling heights. The design accentuates the spaciousness and openness of the area

where the ceiling is higher. One of the interesting details of the building is its use of translucent corrugated panels with the steel frames of the windows and doors. The design brings in natural light while protecting the interior spaces from the rain. The walls on the second floor are cladded with bamboo wood, generating a friendly vibe in the space while resonating with the natural surrounding outside [28]. Openable opaque facades allow the occupants to experience the natural environment from the internal space. Curtains are used to divide spaces and also enable the occupants to connect to nature through non-rhythmic sensory stimuli, as the air movement through the building gently move the curtains. Natural materials, open facades, and indoor plants connect the occupants to nature.

3.4. Eureka Centre in Anglo Colombiano School

This school building contains two half-moons slightly separated from each other, defining a longitudinal axis which generates access points to the building. Moreover, the two clay half-moons embrace a central forest-like courtyard with an ‘oval’ configuration in the form of a leaf. The kinetic form of the patio is in contrast to the static cubic blocks of the rest of the school. The shape of the building and its functional principle perform as an exhibit itself, where the classrooms and events happening around are visible due to the transparency provided from the materials; this enhances the possibilities of seeing and being seen. The central space is the main building articulator connecting the different floor plans via a ‘helical’ system of circulations ending at the student lounge at the top floor plan and, afterward, connecting onto the building terrace that performs as an additional academic area. On the other hand, the classrooms foreseen in the perimeter of the ‘oval’ patio become interconnected via the ‘helical’ system of circulations. Plants at the ground floor can be seen from the circulation space around the atrium [29]. Natural materials and colour palettes are used alongside planting relative to the internal spaces, creating a material connection with nature.

3.5. Hazelwood School

Hazelwood School in Glasgow was designed for children and young people with sensory impairment and complex learning needs. It aims to create a bespoke building that avoids long dark corridors with maximised levels of natural light and incorporated visual sound and tactile clues. The school caters for 60 students aged from two to 19 with multiple disabilities and a combination of two or more of the following impairments: sight, hearing, mobility, or cognition. The design focused on creating a safe and stimulating environment for pupils and staff and incorporated cork-clad walls and weaving walkways to help students find their way around. Various sensory lighting has been used to engage children with vision-related disabilities. Facilities including a hydrotherapy pool place the sensory stimulation aspect at the heart of the school [30]. The architect eliminated any institutional feel by creating a bespoke building that maximised levels of natural light and incorporated visual, auditory, and tactile clues. The school steps and curves around the existing beech trees create a sequence of safe, landscaped teaching gardens. High level clerestory glazing forms a substantial part of the façade of the north-facing classrooms, allowing maximum daylight to penetrate deep into the spaces and ensuring an even distribution of light [31]. This school presents the use of biophilic design for children and young people with special needs, including autism and particularly designing to encourage free movement.

3.6. The Garden School

The Garden School is a school for four to sixteen years old with special educational needs (especially autism) in Hackney, England. The design includes varied seating, including a window seat that offers views onto the playground as well as playful built-in hexagonal seating for children to relax and restore their energy. The hexagonal plinths vary in height and are made from natural wood, creating a material connection with nature. Textured carpets with varying pile heights and wallpaper with images of woodland provide tactile and visual connections to nature, which is mainly important for children with special educational needs. At one end of the space, there is a multi-sensory feature that children can interact with and control artificial lighting. When each of the natural surfaces touched, the colours of the LED lighting discs will change softly, and natural sounds will be triggered. Touching two surfaces will cause overlapping sounds, and two sets of lights to be illuminated. There are colour changing LED lighting disks on the ceiling, and their colours change softly when the interactive feature is touched. The colours represent the natural tones that we experience throughout the day, i.e., dawn, midday, or dusk (yellows, oranges, reds, blues, and purples) [32].

3.7. Paul Chevallier School

This wooden nursery and elementary school complex in Lyon by French architects, Tectoniques, is located on a sloping site. One of the major characteristics of the project is the relationship between architecture and nature. It has hilly rooftops carpeted with plants and walkways for children to explore. There is also a vegetable garden. Therefore, the project harmonises vegetation on the upper and lower levels. The volumes in wood are separated by the broad, planted-out roofs, with their waves of colour. The two-storey and three-storey buildings were designed with V-shaped plans. The

nursery school frames a garden, while the elementary school wraps around a narrow courtyard. The two schools operate independently but share some facilities. Timber cladding covers most of the building's interior and exterior, but is interspersed with a few yellow-painted panels on the walls and ceilings. Spacious corridors run between classrooms and feature floor-to-ceiling windows in order to increase natural light. From the inside, nature is framed by the large windows of the classrooms, and its close proximity makes it an element of the children's educational needs. Wood is of pre-eminent presence—there are wood panels throughout for the walls, façades, and floors. They are left exposed on the inside surfaces, giving solidity and depth to the walls and partitions. The tactile exposed wooden cladding stimulates the sense of touch [33].

The case studies of these seven schools have presented application of various biophilic design patterns; however, based on the location and climate, there have been differences in the application of these patterns indoors and outdoors. The analysis is useful for the designers; however, it cannot be discussed with primary school children to gather their views about these patterns and their applications. Therefore, an age appropriate evaluative tool needs to be designed in order to involve children in the biophilic design process of their schools.

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