



BIOPHILIC DESIGN

Learning Spaces
Inspired by Nature

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White Paper

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White Paper for the Association
for Learning Environments

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Dr. Parul Minhas
Karin Nakano

Association for Learning Environments
Biophilic Design—Learning Spaces Inspired by Nature

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TABLE OF CONTENTS

Introduction	7
What is Biophilic Design?	8
Biophilic Design is Not a New Phenomenon	9
Benefits of Biophilic Design	10
Nurturing Children’s Biophilia	10
Science Proves the Importance of Biophilic Design	11
Biophilic Design Removes Barriers to Learning	12
Obstacles to Implementing Biophilic Design	14
14 Patterns of Biophilic Design	15
Nature in Space	15
Nature Analogs	18
Nature of the Space	19
Biophilic Design Patterns and Biological Responses	21
Examples of Biophilic Designs	23
Vo Trong Nghia’s Farming Kindergarten (Vietnam)	23
The Paul Chevallier School (France)	24
Hazelwood School Glasgow (Scotland)	24
The Garden School (United Kingdom)	26
WeWork’s Microschool (United States)	26
Climbing-Frame Library (Vietnam)	27
How Do You Incorporate Biophilic Design into Learning Environments?	29
Reflect and Check-in	29
Assess the Space	29
Analyze the Space	29
Ideas for Implementing Biophilic Design	30
Get Feedback and Make Changes	30
The Equity Approach: How Does Biophilic Design Contribute to Equitable Education?	31
Conclusion	32
Appendix	33
Endnotes	34
A Pictorial Essay	37

INTRODUCTION

The rapidly developing and urbanizing world has distanced many people from nature and natural processes that used to be a central part of human activity. In fact, by 2050, it is said that 66% of the world will be urbanized,¹ further dissociating humans from nature. While this scenario is distressing for all people, it is particularly harmful to children in their developmental years.

Disconnecting with nature comes at a heavy price for humanity. Studies have revealed that the application of biophilic design in hospitals, workplaces, and schools has demonstrated many positive outcomes. These studies concluded that biophilic environments are health-promoting and restorative. They are known to combat mental fatigue with stress recovery leading to enhanced creativity, relaxation, and excitement. Moreover, other studies have revealed that biophilia not only alters human attitude and behavior but can also positively reduce the so-called “sick building syndrome,” in which people suffer from health symptoms linked to the buildings in which they spend most of their time.² Given the number of hours that children spend indoors in outdated school facilities, they are most at risk of suffering the consequences of an environment devoid of nature and natural elements.

Although most people nowadays do not participate in primitive activities such as hunting and are not concerned about the need to be in a space that is protected from predators, these instincts are still embedded in our brains. Our brains react to certain spaces in certain ways and feeling connected to nature is shown to have a positive impact on our well-being. When people are exposed to a natural environment, they recover significantly faster from ailments compared to when they are exposed to an urban setting.³

Biophilic Design invites urbanized spaces to include natural elements and processes to improve people’s well-being inside buildings and spaces. It is an approach to design that



FIGURE 1.

Image Source: *Learning by Design* by Prakash Nair, Roni Zimmer Doctori, and Richard F. Elmore

aims to connect humans and nature in our living, learning, and working places. As the world becomes increasingly urbanized, not only adults but more children will lose their connection to nature as they grow up. Despite this fact, the basic form of schools remains to have plain walls, a limited number of windows, and made with materials that do not resemble nature. It is important to recognize how meaningful and beneficial it is for schools to incorporate biophilic designs to ensure that children, no matter their backgrounds or identity, are exposed to such designs and can improve their well-being while at school.

WHAT IS BIOPHILIC DESIGN?

Biophilic Design is a design concept that aims to connect humans and the natural world within our built environments and communities. It is the practice of incorporating nature, natural materials, and concepts into human-made environments, creating a closer connection to nature and the surrounding environment. The word “biophilia” can be broken down into two ancient Greek words: “bio,” which translates to nature, and “philia,” which translates to love, pointing to the love of life or living systems.⁴ Biophilia refers to our innate affinity as humans toward nature and natural systems, and biophilic design recognizes this affinity by connecting people to the natural world inside buildings and in our living and learning environments.

People of all ages constantly interact with the space around them. As the world continues to urbanize with technological and industrial architecture, the fundamental connection to nature that we are hardwired to thrive in can feel lost. Biophilic design enables us to create environments that harness this basic human need to be connected to nature as an important way to improve our well-being.

Terrapin Bright Green takes a neuroscientific and psychological approach to biophilic design. They offer an

accessible framework for interpreting and adopting biophilic design principles into practice, known as the “14 Patterns of Biophilic Design.”⁵ We will discuss this framework in detail in a later section.

14 Patterns of Biophilic Design:

Nature in the Space

1. Visual Connection with Nature
2. Nonvisual Connection with Nature
3. Nonrhythmic Sensory Stimuli
4. Thermal and Airflow Variability
5. Presence of Water
6. Dynamic and Diffuse Light
7. Connection with Natural Systems

Nature Analogs

8. Biomimetic Forms and Patterns
9. Material Connection with Nature
10. Complexity and Order

Nature of the Space

11. Prospect
12. Refuge
13. Mystery
14. Risk/Peril



FIGURE 2. Vo Trong Nghia’s Farming Kindergarten

Image Source: Arquitectura Viva <https://arquitecturaviva.com/works/jardin-de-infancia-dongnai-3>

BIOPHILIC DESIGN IS NOT A NEW PHENOMENON

For centuries, humans have incorporated nature themes into their structures, decorative and symbolic ornamentation, and homes and public spaces. Examples include animal figures depicted in Neolithic Göbekli Tepe, the Egyptian sphinx, garden courtyards of the Alhambra in Spain, the aviary in Teotihuacan—the ancient Mexico City, and bonsai in Japanese homes.⁷ The consistency of natural themes in historic structures and spaces across cultures demonstrates how important it is for humans to maintain connections with nature. In an urbanized world, adopting the approach of biophilic design allows us to create buildings and spaces that respond to such fundamental needs as humans.

Water on site, the sound of streaming water, and the sensation of water respond to our need for drinking water. A breeze and variation in air flow imply that there is fresh air for us to breathe. Having vegetables and fruits on site, and picking and growing them by hand, respond to our need for food. A safe and contained environment with a good view of the landscape was critical for our ancestors to keep an eye out for predators or animals to hunt. Although we don't live in the same world as our ancestors did, we've still inherited such survival instincts, even if we are normally not aware of them. When these basic survival needs are met, people become calmer, exhibit more prosocial behavior, and become more comfortable and happier.⁸



FIGURE 3. Animal figure depicted in Neolithic Göbekli Tepe

Source: Global Heritage Fund

<https://globalheritagefund.org/2017/11/03/gobekli-tepe-discovering-worlds-oldest-religious-site/>

”

Throughout our evolution, we've spent 99.9 percent of our time in nature. Our physiology is still adapted to it. During everyday life, a feeling of comfort can be achieved if our rhythms are synchronized with those of the environment.

—Yoshifumi Miyazaki⁶

BENEFITS OF BIOPHILIC DESIGN

- Students in classrooms that incorporated biophilic design scored 3.3 times higher in math assessment tests compared to those who were not over a seven-month period.⁹
- Having plants in learning spaces can lead to improved performance by 10–14% and reduce the impact of ADHD.¹⁰
- Students in classrooms with the most daylight tested 7–18% higher than those with the least and demonstrated 20–26% faster learning rates.¹¹

Nurturing Children’s Biophilia

Children have an innate tendency to explore and bond with the natural world. Incorporating natural environments into learning spaces can nurture children’s love of nature. Through regular contact and play in the natural world, children can develop empathy and a love of nature, which also leads to positive environmental behaviors and attitudes.¹³ Children who develop biophilia—a love for nature—will be more inclined to learn about the natural world, improve environmental attitudes, and grow up becoming conscious adults who appreciate and respect nature. What is most important is to encourage a positive attitude toward nature, grow the love of nature together, and most of all, bring love and joy to the whole experience.

” *Knowledge without love will not stick. But if love comes first, knowledge is sure to follow.*

—White Hutchinson Leisure and Learning Group¹²



FIGURE 4.

Image Source: *Learning by Design* by Prakash Nair, Roni Zimmer Doctori, and Richard F. Elmore

Science Proves the Importance of Biophilic Design

Research has shown that biophilic design can reduce stress, blood pressure, and heart rates while positively impacting emotions and moods, increasing productivity, creativity, and overall well-being.¹⁴ Neuroscience literature suggests the human brain can easily process patterns with repeating lines in collinear, curvilinear, and radial patterns found throughout nature.¹⁵ Veins of a leaf, branches of a tree, and ocean waves are all examples of such patterns. Research hypothesizes that this ease of processing such patterns allows people to relax and focus and including such design principles in learning spaces would benefit learners as they navigate complex academic problems.¹⁶

Research has shown that children are more sensitive to light exposure than adults. This is because children have larger pupils and significantly greater light-induced melatonin suppression and circadian-system sensitivity to light exposures.¹⁷ “Circadian rhythms are physical, mental, and behavioral changes that follow a 24-hour cycle,” responding primarily to light and dark.¹⁸ Studies have indicated that higher levels of average daylight exposure per day for children are associated with reduced sedentary time both on the weekdays and weekends and with increased levels of physical activity on the weekends. Having access to natural light is shown to increase subjective well-being, have higher levels of alertness, and cognitive processing speed, and leads to better concentration performance.¹⁹ Designing learning spaces with greater exposure to natural light will help to properly maintain a learners’ circadian rhythms and provide a wide range of associated health and performance benefits.

Several studies have shown the positive effects of surrounding green spaces on the learner.²⁰ One study conducted in an elementary school in Baltimore, Maryland, showed how students found green schoolyards as places to retreat from stress, allowing them to build competence and form supportive relationships.²¹ Other studies also have shown the positive relationship between nature near schools and school-wide academic performance. These findings suggest nature allows students to have mental breaks throughout their time in learning communities, contributing to improved attentional functioning.

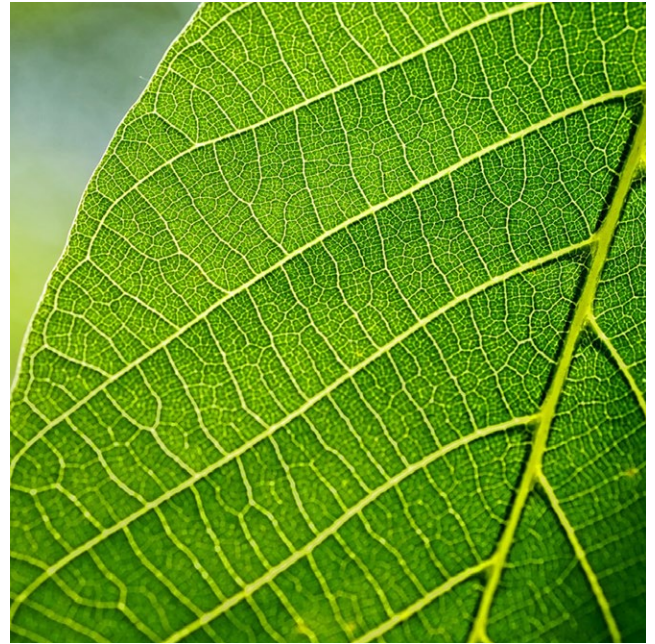


FIGURE 5. *Veins of a leaf are one example of patterns with repeating lines in collinear, curvilinear, and radial patterns found throughout nature.*

Biophilic Design Removes Barriers to Learning

Children spend a significant amount of time in school when not at home. It has been estimated that, globally, one in seven 10–19-year-olds experience mental health conditions.²² Yet, these conditions remain largely unrecognized and untreated. Research has shown that adolescents with mental health conditions are prone to discrimination, social exclusion, stigma, educational difficulties, risk-taking behaviors, and physical ill-health. The primarily built environments where people live, work, learn, and recreate are known to have a direct bearing on the physical and mental health of the occupants. Schools, due to the substantial amount of time that children spend there, are important places to intentionally incorporate biophilic design as a direct way to improve their health and cognitive capacity. By incorporating biophilic design, learning spaces have the potential to positively impact generations of children, promoting early academic success, and setting them on a positive trajectory in life.²³ Biophilic designs are shown to remove barriers to learning by reducing stress, improving cognitive performance, and evoking positive emotions and moods.²⁴

In a study by Determan et al., two groups of students were separated into a learning environment that incorporated

biophilic design and one that did not. The study found that students who were in a biophilic learning environment experienced a significant reduction in their stress levels compared to those who were in the control classroom, suggesting that biophilic design helped to reduce students' stress levels during the semester.²⁵ Only 35% of students in the biophilic environment perceived their stress levels to be high compared to 67% of students in the control group (Figure 4).²⁶ Students in the biophilic environment favored their space more and had higher levels of involvement compared to the control group (Figure 5).²⁷ Furthermore, using i-Ready test scores, this study found the biophilic design group to have higher average test scores in math compared to the control group, with the biophilic design group scoring 3.3 times higher than the control group and 7.2% more students in the biophilic group testing at grade level (Figures 6 and 7).²⁸ Qualitative data also showed that students felt "more relaxed, calm, better able to concentrate, easier to focus and have more of a purpose to learn" in the biophilic learning environment compared to other learning spaces.²⁹

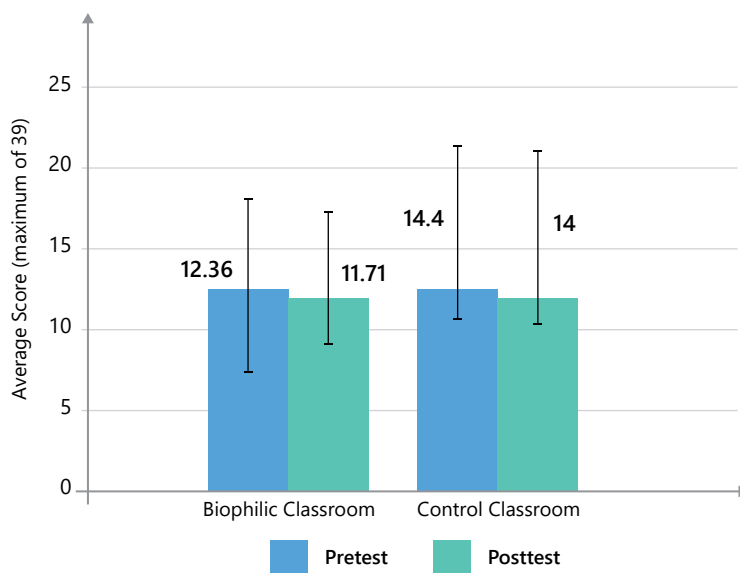


FIGURE 6. Students' opinions about their own stress level comparing the biophilic classroom (n=12) with the control classroom (n=12) at Green Street Academy, Baltimore, MD.

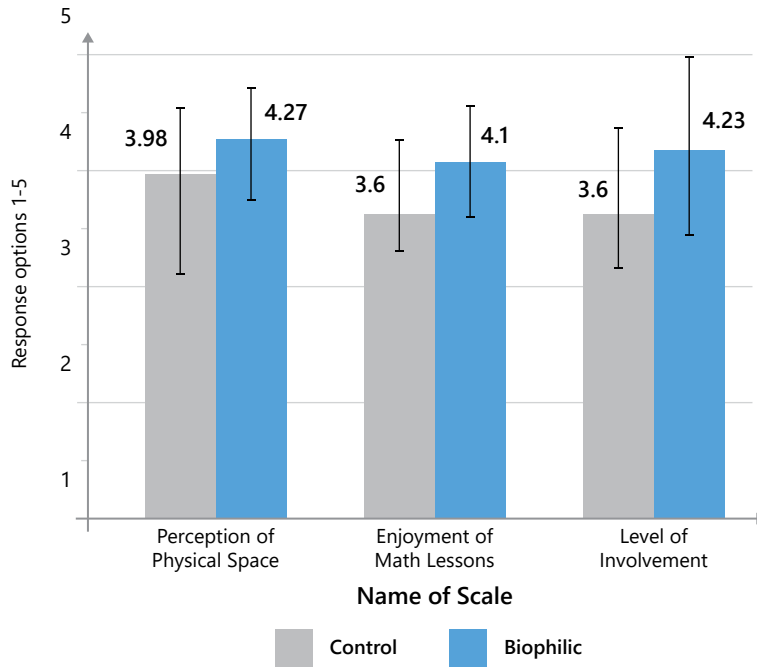


FIGURE 7. Students’ survey responses with error bars comparing a control classroom (n=17) with the purposefully designed biophilic classroom (n=16) at Green Street Academy, Baltimore, MD. Differences for all three variables are statistically significant ($p < 0.01$).

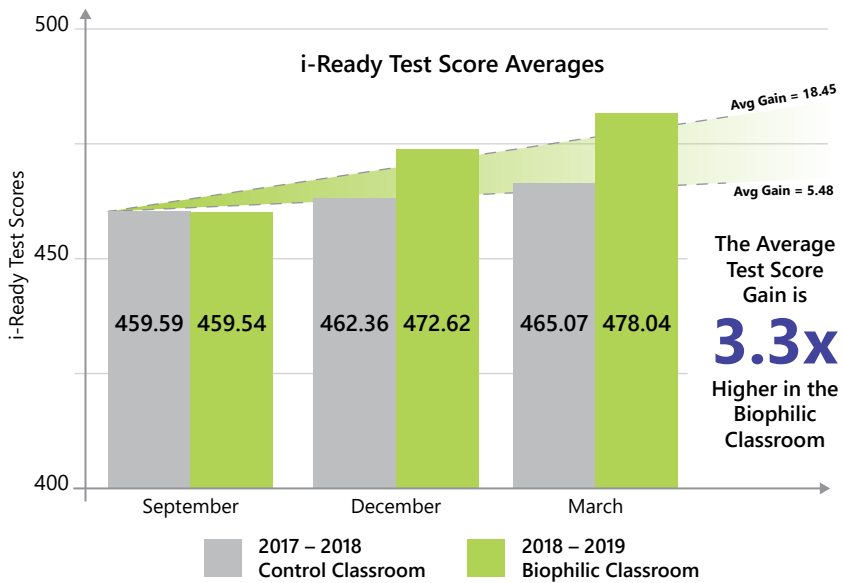


FIGURE 8. Average Math i-Ready scores for the biophilic and control classes.

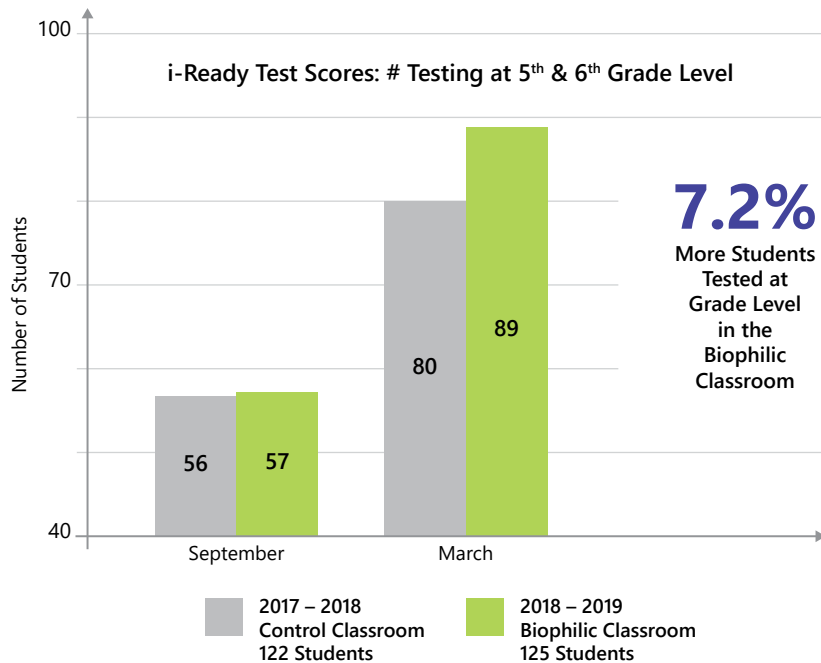


FIGURE 9. Average number of students testing at grade level.

Figures 6–9 Source: Determan, J., Akers, M. A., Albright, T., Browning, B., Martin-Dunlop, C., Archibald, P., & Caruolo, V. (2019). *The Impact of Biophilic Learning Spaces on Student Success*. BRIK. <https://www.brikbase.org/content/impact-biophilic-learning-spaces-student-success>

OBSTACLES TO IMPLEMENTING BIOPHILIC DESIGN

In the past decade, biophilic design has gained prominence as a critical concept. However, there may still be challenges that prevent people from implementing biophilic design:

- Lack of understanding of the significance of biophilic design
- Perception of materials for biophilic design as being expensive
- Competing priorities dictating function over considering design as a way of improving health and well-being
- Not understanding the emotional, physiological, and psychological effects of physical space
- Lack of support from coworkers and other community members
- Concerns about maintenance of the space
- Allergy and other health-related concerns (for gardens and other outdoor environments)
- Requiring access to expertise in design

14 PATTERNS OF BIOPHILIC DESIGN

The 14 Patterns of Biophilic Design is a framework for understanding and incorporating various biophilic design strategies into both indoor and outdoor spaces, developed by Terrapin Bright Green. It organizes biophilic design into three categories: Nature in Space, Natural Analogs, and Nature of the Space.

Nature in Space

Nature in Space addresses the direct presence of nature in a space, including plant life, animals, water, breezes, sounds, scents, and other aspects of nature.³⁰ It allows people to see, hear, taste, smell, and feel nature directly. “Potted plants, flowerbeds, bird feeders, butterfly gardens, water features, fountains, aquariums, courtyard gardens and green walls or vegetated roofs” are all examples of this.³¹ Nature in Space includes seven design patterns:

1. Visual Connection with Nature

This pattern simply speaks to the visual presence of nature and living systems and processes in the space. Simply adding greenery to the space or having access to natural views outside the window would fit into this pattern.

2. Nonvisual Connection with Nature

Any sound, smell, taste, or touch that has a positive reference to nature and living systems belongs to this pattern. Examples would be hearing the sound of the trees bending with the wind, smelling the flowers, and touching the soil in a small pot plant. Digital simulations of nature sounds and fabric that mimic natural material textures are examples of constructed stimuli that fit into this pattern.

3. Nonrhythmic Sensory Stimuli

Nonrhythmic sensory stimuli refer to both natural and constructed stimuli that occur unexpectedly and lasts a very short time. These stimuli are “brief but welcome distraction[s]” that come across as “something special, something fresh, interesting, stimulating and energizing.”³² Moving clouds, bubbling water, movements of insects and animals, and the chirping sounds of birds are examples of naturally occurring stimuli that belong to this pattern. “Billowy fabric or screen materials that move or glisten with light or breezes, reflection of water on a surface, shadows or dappled light that change with movement or time, and natural sounds broadcasted at unpredictable intervals” are examples of such stimuli.³³



FIGURE 10. Renovated Studio at International School of Dusseldorf with Nature Views.

4. Thermal and Airflow Variability

This pattern refers to the subtle changes in air temperature, airflow, humidity, and surface temperatures that imitate nature.³⁴ The key to this pattern is variety: Humans prefer to have access to a variety of surfaces, thermal temperatures, and airflow.³⁵ Things as simple as shadows and shades, controlling HVAC (heating, ventilation, and air conditioning), and opening/closing windows could be effective in making this pattern work.



FIGURE 11.

Image Source: Flickr Karen Mardahl
<https://www.flickr.com/photos/kardahl/14403311147/>

5. Presence of Water

Any connection to water would tap into this pattern. This includes being able to see, hear, or touch the water in space. Examples of naturally occurring stimuli are rivers, streams, oceans, ponds, wetlands, and rainfall.³⁶ The presence of water can also be achieved by constructed waterfalls and streams, water walls, fountains, reflections of water, and images that include water in some form.



FIGURE 12.

Image Source: Flickr Donnie Ray Jones
<https://www.flickr.com/photos/donnieray/16098680386/>



FIGURE 13.

6. Dynamic and Diffuse Light

This pattern refers to the varying intensities of light and shadow that change over time. Daylight is dynamic as it changes color from blue in the morning to orange as it approaches sunset and then the black of night. Human bodies interact with such light and receive signals for when to be alert and when to start calming down for rest. Examples of stimuli that belong to this pattern are sunlight from different angles, direct and indirect sunlight, firelight, moonlight and starlight, bioluminescence, electric light sources, color tuning lighting, or circadian color reference that produces white light during the day and minimizes blue light at night, and dimming controls.³⁷

7. Connection with Natural Systems

Natural systems refer to natural processes, such as seasonal and temporal changes that are representative of a healthy ecosystem.³⁸ This pattern evokes a relationship to the

greater whole, promoting environmental stewardship of healthy functioning ecosystems. Climate and weather patterns, hydrology, geology, and animal behavior such as predation, feeding, foraging, mating, and habitation are examples. Pollination, growth, aging, and decomposition of insects, flowers, and plants, diurnal patterns such as shadow casting and tidal changes, night sky and cycles of the moon and other planets and stars, and seasonal patterns are also examples of natural systems that occur naturally.³⁹ These systems can be experienced through constructed stimuli such as gardening and exposure to water structure as well.



FIGURE 14.

Image Source: Flickr Jennifer C.

<https://www.flickr.com/photos/29638108@No6/8573417138/>

Nature Analogs

Nature analogs include the use of natural materials, textures, patterns, and colors that remind us of nature. Nature Analogs include three design patterns as shown in 8, 9, 10:

8. Biomorphic Forms and Patterns

Biomorphic forms and patterns include organic shapes that use curvy lines, patterns, textures, and numerical arrangements that exist in nature. Examples include fabrics, carpet, and wallpaper designs based on the Fibonacci series or the Golden Mean, columns shaped like trees, and wallpaper patterns that represent animals and natural objects.⁴⁰



9. Material Connection with Nature

The use of materials and elements from nature will be part of this design pattern. Humans prefer to be surrounded by the color and materials of nature. Natural materials should reflect the local ecology or geology and create their own sense of space.⁴¹ Wood, leather, stone, fossil textures, bamboo, rattan, and dried grasses are materials that could be used in decor as well as wall construction and furniture.⁴²

The use of natural colors, especially the color green is shown to have positive psychological effects on humans. Research has shown that having exposure to green before working on a task facilitates creativity and performance.⁴³ Certain colors are known to have certain psychological effects, as illustrated in the figure.

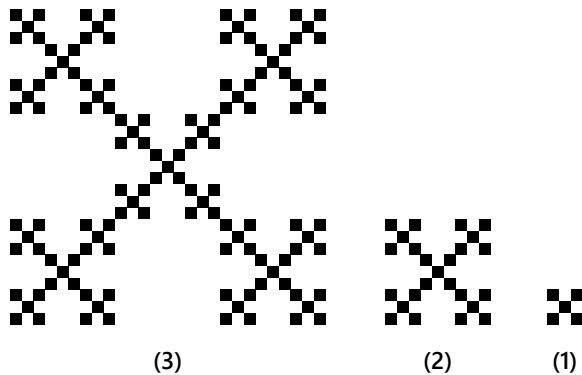


FIGURE 15. Psychological effects of four natural colors.⁴⁴

10. Complexity and Order

The complexity of nature has an order to it and a space with such a design pattern feels engaging and full of information with a healthy balance between being bored and overwhelmed. Research has found that “nested fractal designs with [a scaling factor of three] are more likely to achieve a level of complexity that conveys a sense of order and intrigue, and reduces stress.”⁴⁵

This pattern incorporates symmetries and fractal geometries into the space. They can be included in wallpaper, carpet, and window designs, and can be achieved through a selection of various plants and placement and exposed structure and mechanical systems.⁴⁶



A square ■ with a scaling factor of 3 is more impactful than to a factor of 2.

FIGURE 16.

Image Source: Health, O., & Goode, E. (2018, June). *Creating Positive Spaces Using Biophilic Design*. *Interface*. https://www.interface.com/IN/en-IN/campaign/biophilic-design/Biophilic-Design-Campaign-en_IN

Nature of the Space

Nature of the Space speaks to our primordial need for safety, security, excitement, and exploration and addresses the spatial arrangements in nature.⁴⁷ Humans have an “innate and learned desire to be able to see beyond our immediate surroundings” and are fascinated by the “slightly dangerous or unknown, obscured views and revelatory moments [and] sometimes even phobia-inducing properties when they include a trusted element of safety.”⁴⁸ Nature of the Space includes four design patterns as shown in 11, 12, 13, 14:

11. Prospect

This design pattern taps into the human’s desire to see vast vistas from a safe perch for supervision and planning. Examples of this pattern include the use of “transparent materials, balconies, catwalks, staircase landings, open floor plans, elevated planes, [and] views including shade trees, bodies of water or evidence of human habitation.”⁴⁹

12. Refuge

As the name suggests, this pattern refers to spaces that allow people to withdraw from environmental conditions such as the weather, the main activity, or the flow, and feel protected. Refuge spaces can have characteristics such as a space with several sides covered—such as booth seating, reading corner, canopy beds and trees, covered walkway, porches; or a space with all sides nearly or completely covered—such as meeting rooms, private booths, and tree houses.⁵⁰ These spaces could protect people from the weather, have audio or visual privacy, or be reserved for specific purposes such as “reflection, rest, relaxation, reading, or complex cognitive tasks.”⁵¹ Such spaces have features such as adjustable or translucent shades, blinds or partitions, lowered ceiling, and varied light intensity, color, and temperature.



FIGURE 17. Shorecrest Preparatory School, St. Petersburg, Florida



FIGURE 18. American School of Bombay

13. Mystery

Humans have an innate desire to explore. This pattern provides people with a sense of anticipation, denial, and reward that compels further investigation. Spaces with a mystery pattern may include small windows that only reveal parts of the space ahead, a stairway that bends over, curving edges, winding paths, and variation in brightness.

14. Risk/Peril

This pattern refers to designs that include identifiable threats coupled with a reliable safeguard. A space with this design pattern contains the possible risks of falling, getting wet and hurt, and losing control that is created by attributes such as height, gravity, water, and possible predator-prey role reversal.⁵² Examples of such spaces include a climbing wall, balcony or catwalk connected to a high atrium, a railing or floor that is transparent, a path that passes under, over, or through water, and proximity to an active honeybee apiary or other animals that put humans into danger.⁵³

Biophilic Design Patterns and Biological Responses

Biological responses⁵⁴ in *Table 1* illustrate how each design pattern is shown to be effective in the following three categories: stress reduction, cognitive performance, and emotion, mood, and preference.⁵⁴ Each pattern is marked with zero to three asterisks that indicate the amount of empirical data that supports the shown functions. The pattern with more asterisks implies that it is supported by more rigorous data, there is a high number of good quality peer-reviewed evidence, and has the potential for great impact.⁵⁵ No asterisk indicates that there is little research that supports the biological relationship between health and design, but there is sufficient and irresistible anecdotal information that allows us to hypothesize its importance and potential impact.⁵⁶



FIGURE 19. A climbing wall is a perfect example of the Risk/Peril strategy. Climbing on a steep surface is an inherently risky activity that has been engineered to retain the thrill while keeping students safe.

TABLE 1. *Biophilic Design Patterns and Biological Responses*

14 Patterns	*	Stress Reduction	Cognitive Performance	Emotion, Mood, and Preference
Nature In The Space				
Visual Connection with Nature	***	Lowered blood pressure and heart rate	Improved mental engagement/attentiveness	Positively impacted attitude and overall happiness
Nonvisual Connection with Nature	**	Reduced systolic blood pressure and stress hormones	Positively impacted cognitive performance	Perceived improvements in mental health and tranquility
Nonrhythmic Sensory Stimuli	**	Positively impacted heart rate, systolic blood pressure, and sympathetic nervous system activity	Observed quantified behavioral measures of attention and exploration	
Thermal and Airflow Variability	**	Positively impacted comfort, well-being, and productivity	Positively impacted concentration	Improved perception of temporal and spatial pleasure
Presence of Water	**	Reduced stress, increased feelings of tranquility, lower heart rate, and blood pressure	Improved concentration and memory restoration. Enhanced perception and psychological responsiveness	Observed performance and positive emotional responses
Dynamic and Diffuse Light	**	Positively impacted circadian system functioning. Increased visual comfort		
Connection with Natural Systems				Enhanced positive health responses; shifted perception of environment
Natural Analogs				
Biomorphic Forms and Patterns	*			Observed view preference
Material Connection with Nature			Decreased diastolic blood pressure. Improved creative performance	Improved comfort
Complexity and Order	**	Positively impacted perceptual and physiological stress responses		Observed view preference
Nature of the Space				
Prospect	***	Reduced stress	Reduced boredom, irritation, fatigue	Improved comfort and perceived safety
Refuge	***		Improved concentration, attention, and perception of safety	
Mystery	**			Induced strong pleasure response
Risk/Peril	*			Resulted in strong dopamine or pleasure responses

Source: Terrapin Bright Green. (September 12, 2014). *14 Patterns of Biophilic Design*. <https://www.terrabinbrightgreen.com/reports/14-patterns/#rediscovering-the-intuitively-obvious>

Link to Google Sheets: *Biophilic Design and Biological Responses* at: <https://tinyurl.com/mrwkv4cj>

EXAMPLES OF BIOPHILIC DESIGNS

Vo Trong Nghia's Farming Kindergarten (Vietnam)

- This kindergarten in Vietnam has a knot-shaped roof with a vegetable garden on top and three protected courtyard playgrounds.
- The surface of the roof is covered in grass and plants to incorporate additional green into the learning space. By interacting with nature and growing vegetables on the roof, children learn the importance of agriculture and find connections to nature.
- One end of the slope goes down to the ground and the other rises up to the second floor of the building.



Image Source (for both images): Dezeen <https://www.dezeen.com/2014/11/11/farming-kindergarten-vo-trong-nghia-architects-vietnam-vegetable-garden/>

The Paul Chevallier School (France)

- The Paul Chevallier School in Lyon, France, utilizes natural materials to increase contact with nature throughout the building. Wooden cladding covers the interior and exterior walls and prompts tactile human-nature interaction, reducing stress, and providing energizing and relaxing experience.
- Both the elementary and nursery school are built in V-shapes surrounding the outside space. The green roofs, at the same time, expand the outdoor space for children to explore and interact with the outdoor environment.
- The school also encompasses a vegetable garden and faces a woodland park, which offers a view of nature from the learning communities.
- Corridors have windows that extend from the floor to the ceiling, bringing natural light to the indoor space.
- The roofs have walkways that invite children to a different atmospheric space.



Image Source: Dezeen <https://www.dezeen.com/2013/09/09/school-complex-in-rillieux-la-pape-by-tectoniques/>

Hazelwood School Glasgow (Scotland)

- Hazelwood School in Glasgow, Scotland, is a school for children and young people with sensory impairment and complex learning needs.
- The building is designed to bring in maximized levels of natural light and incorporate visual, sound, and tactile clues.
- The curvilinear building has cork tiles on interior walls that guide children throughout the building.





Image Source: *Hazelwood Aerial—Showcase: 4th screenshot, Alan Dunlop Architect,*
<http://www.alandunloparchitects.com/>

The Garden School (United Kingdom)

- Located in Hackney, United Kingdom, The Garden School is an outstanding school for 4–16-year-olds with special educational needs, particularly autism.
- The learning space has textured carpets with varying pile heights and wallpapers reminiscent of woodland with multiple trees painted, providing tactile and visual references to nature. These can be used to reduce stress, energize, and relax children and are particularly important for those with special educational needs.
- The playful built-in hexagonal seating areas and spaces serve as small shelters for children to relax and restore their physical and mental energy.

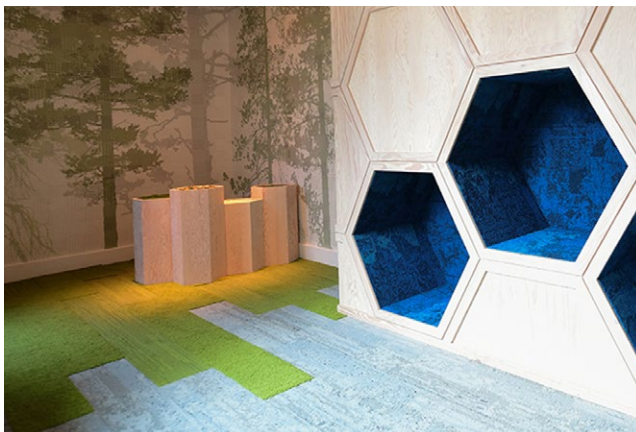
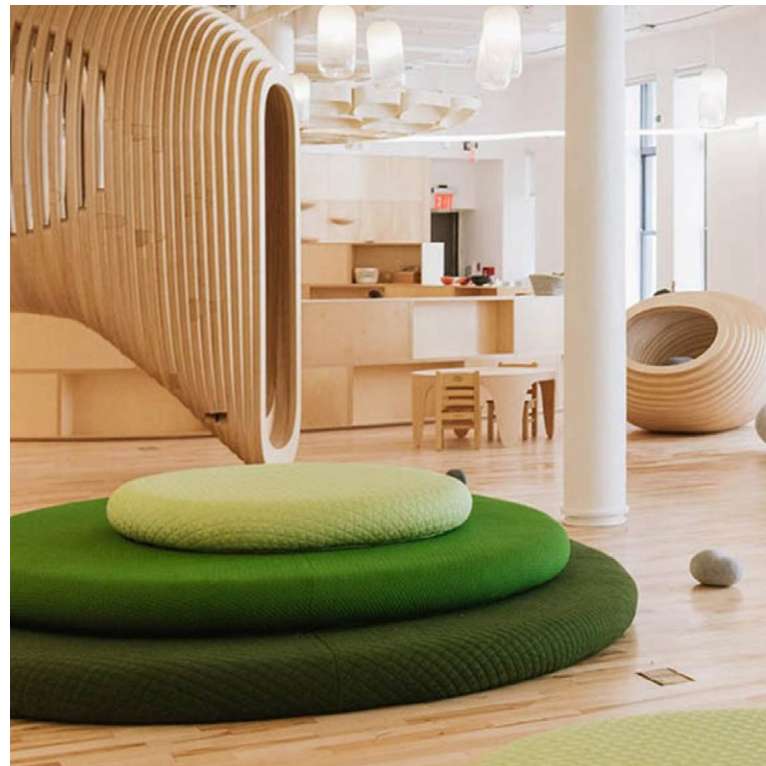


Image Source: *Oliver Heath Design*
<https://www.oliverheath.com/case-studies/the-garden-school/>

WeWork's Microschool (United States)

- WeWork created its first microschool in Manhattan, New York, USA.
- The space includes lots of elliptic objects, creating a learning environment that is dense and rational, while at the same time free and fluid in the interior.⁵⁷
- It encompasses modular classrooms, tree houses, a vertical farm, and uses natural materials and neutral colors.

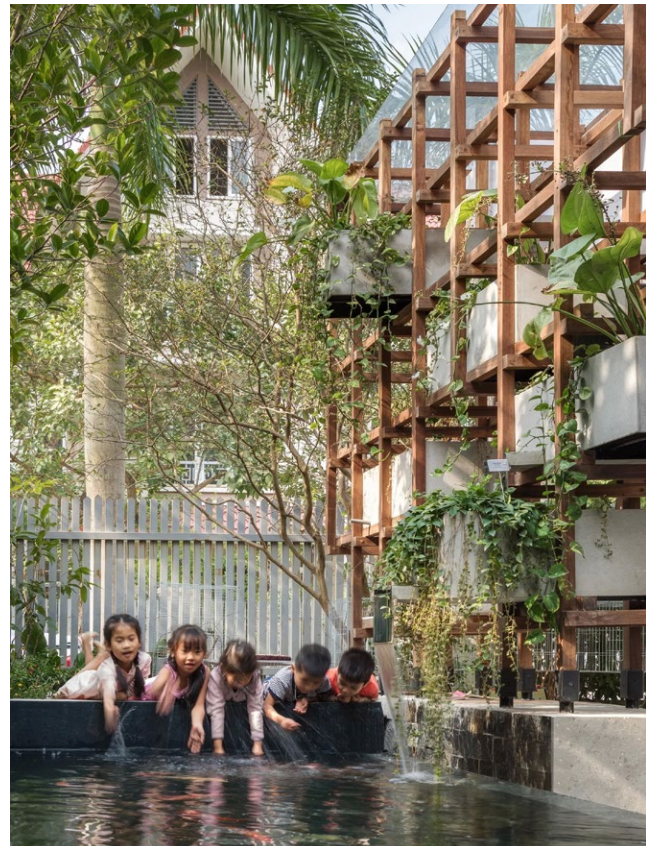
Image Source: *World Architecture Community* <https://worldarchitecture.org/architecture-news/ephcg/big-completes-weworks-first-microschool-with-superelliptic-objects-in-new-york-city.html>





Climbing-Frame Library (Vietnam)

- Climbing-Frame Library is a library in Hanoi, Vietnam, that has a thriving aquaponics system.
- It is made with a large wooden climbing-frame with concrete stepping stones that children could use to climb, read books, and interact with each other.
- The library incorporates solar-powered aquaponics* to keep vegetables and plants, koi carp, and chickens in the area. The chickens also contribute to the library's small ecosystem, laying eggs that children and other community members could eat, and they provide manure to fertilize the vegetables.⁵⁸
- Through this library, children can learn about self-sustaining ecosystems.



* Aquaponics combines the growing of fish with hydroponics—growing plants in water—to make use of the wastewater that fish produce as a nutritious resource for plants and the plant's ability to purify water to provide fresh water for fishes.⁵⁹



Image Source: Dezeen
<https://www.dezeen.com/2019/01/20/vac-library-farming-architects-hanoi/#>

HOW DO YOU INCORPORATE BIOPHILIC DESIGN INTO LEARNING ENVIRONMENTS?

Reflect and Check-in

Before diving into implementing a biophilic design in the space, it is important to reflect on the feelings and concerns regarding this type of design as an individual as well as a community. Below are some questions to consider:

- How do I feel in this space?
- What does my body feel? Do I feel pressure in my chest? Tightness in my throat?
- What can I hear? Smell?
- What does my skin feel?
- What emotions come up as I am in this space?
- What am I reminded of?
- How am I breathing? Am I taking deep breaths? Or are they shallow, slow, or rapid?

Assess the Space

The checklist below helps assess what qualities of biophilic design the space includes:⁶⁰

Nature in the Space

- Views of nature: What nature can I see?
- Sounds, tastes, touch, and smells of nature: What nature can I taste, touch, smell, and/or hear?
- Nonrhythmic sensory stimuli: Can I gaze up at clouds and/or hear bird songs?
- Variations of airflow and temperature: Can I control my sensations of warmth and coolness? Can I feel a breeze?
- Access to water: Are there bodies of water nearby that are clean and natural?
- Access to daylight: Can I see shadows and sun? Can I tell whether it is morning, midday, or evening?
- Seasonal changes and natural cycles of life: Can I grow plants and care for animals? Do I know what the weather is like?

Natural Analogs

- Natural forms: Are there curves and other shapes from nature in the environment?
- Natural materials: Can I identify what things are made of?
- Complexity and order: Is the environment engaging and restorative as opposed to boring or stressful?

Nature of the Space

- Prospect: Can I see far away?
- Refuge: Is there a space I can retreat to?
- Mystery: What entices me to explore the environment?
- The experience of risk with an element of safety: What feels a little scary in the environment?

Analyze the Space

What strengths, weaknesses, opportunities, and “threats” does the space have?

- **Strengths:** Which patterns of biophilic design are visible in the learning space?
- **Weaknesses:** What aspects of your space are not biophilic?
- **Opportunities:** What opportunities do you have for adding biophilic design elements to the learning space? If a parent owns a gardening shop, they may be able to donate plants.
- **Threats:** What external systems, beliefs, and/or processes are preventing you from adding elements of biophilic design to your space?

Once you have analyzed the weaknesses and threats of the space, it is worth brainstorming how you might turn them into strengths and opportunities. For example, if you have beige walls that are not biophilic, you could also see that as an opportunity to apply additional colors to make them biophilic. If someone in your community is concerned about including plants in the space, consider it as an opportunity to communicate, and get to know them and their concerns.

Ideas for Implementing Biophilic Design

Biophilic design does not always mean incorporating actual and simulated views of nature into the space. Nature represented in patterns, fishes, and objects that have biomorphic forms and fractals can also be a representation of nature. Below are some ideas for ways to incorporate biophilic design in your space: ⁶¹

- **Go outside!**
Take classes outside whenever possible, and try to make the time spent indoors and outdoors equal.
- **Increase natural light**
Open blinds, turn off artificial lights, add individual task lights
- **Bring in natural air**
Open doors and windows whenever possible, introduce fans, take small frequent breaks outside, practice breathing through the nose
- **Space out**
Have less furniture in the space, de-clutter, introduce furniture with curves and a variety of textures, and bring in fractal images
- **Create caves**
Place pillows under tables, create cozy reading and studying nooks, and arrange quiet spaces to sit and think
- **Place perches**
Add bar stools and café tables around the perimeter of spaces, position them near a view of nature or nature-based artworks
- **Add color**
Add colors that are regional and culturally relevant to nature, hang nature-based artworks, and paint murals
- **Invite water into the space**
Add a mini-fountain, go outside in the rain, provide access to fresh clean water, build a pond or a rain garden, and play sounds of water
- **Engage children in learning about biophilic design and designing indoor and outdoor learning spaces together!**

Additional ideas for implementing biophilic design in learning spaces are located in the appendix.

Get Feedback and Make Changes

Multiple cycles of trial and error make the success of implementing biophilic design possible. Take the time to reflect and get feedback on the space. Below are some questions you could ask:

- What worked?
- What didn't work?
- What would you do differently next time?
- What ideas do you have? What would you share with others about biophilic design? How would you share them?
- What questions do you have?
- What would you want to try next?
- Who else might want to help/get involved?

THE EQUITY APPROACH: HOW DOES BIOPHILIC DESIGN CONTRIBUTE TO EQUITABLE EDUCATION?



Equitable access to public green spaces is a critical component of both social and environmental justice.

—Emma Urofsky and Robbie M. Parks

As the world becomes more urbanized, many children around the world are living in environments of poor quality due to pollution and lack of access to natural environments. Moreover, many children of color grow up in neighborhoods that have limited access to nature due to systematic racism.

By integrating nature into school designs, schools will ensure children have experience in and build relationships with nature through their everyday learning, no matter their background or identities. Any child who spends their time in school buildings can equally receive the benefits of the biophilic design described in this white paper. Furthermore, by nurturing children's biophilia through biophilic design, schools can teach the importance of nature and be in an environment that incorporates such elements. This will allow every child to make positive choices that improve their well-being and health as they move on to selecting their own environments.



Decades of systematic racism have left many people of color living in areas without access to nature.

—Alejandra Borunda

CONCLUSION

Lockdowns during COVID-19 disconnected many people around the world from nature due to architectural practices that failed to make such connections possible. As a result, the integration of nature into the built environment is celebrated even more. Biophilic design provides various benefits to people's health and well-being, and incorporating it into schools carries great opportunities for positively impacting generations of children and removing barriers to learning. When children learn in environments that promote holistic well-being and health, they can experience less stress and anxiety and create meaningful relationships. What is needed in schools as they prepare children for various challenges of the 21st century is to ensure an environment where each and every child could meet the needs of their mind, body, and spirit as it serves as the foundation of their growth and learning.

APPENDIX

Additional ideas for implementing biophilic design in learning spaces:

Link to table: *Biophilic Design in Learning Spaces* at: <https://tinyurl.com/367ppbkk>

Source: "An Introduction to Biophilic Design. Interface." (2022).

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A PICTORIAL ESSAY

An important design approach to biophilic design is to start with natural materials and forms that are more closely associated with nature and natural settings such as this new barn which houses the Bowers School Farm in Michigan. This 12,000 sq. ft. facility uses geothermal heating, septic fields, a bio-retention pond and a fully operational greenhouse.

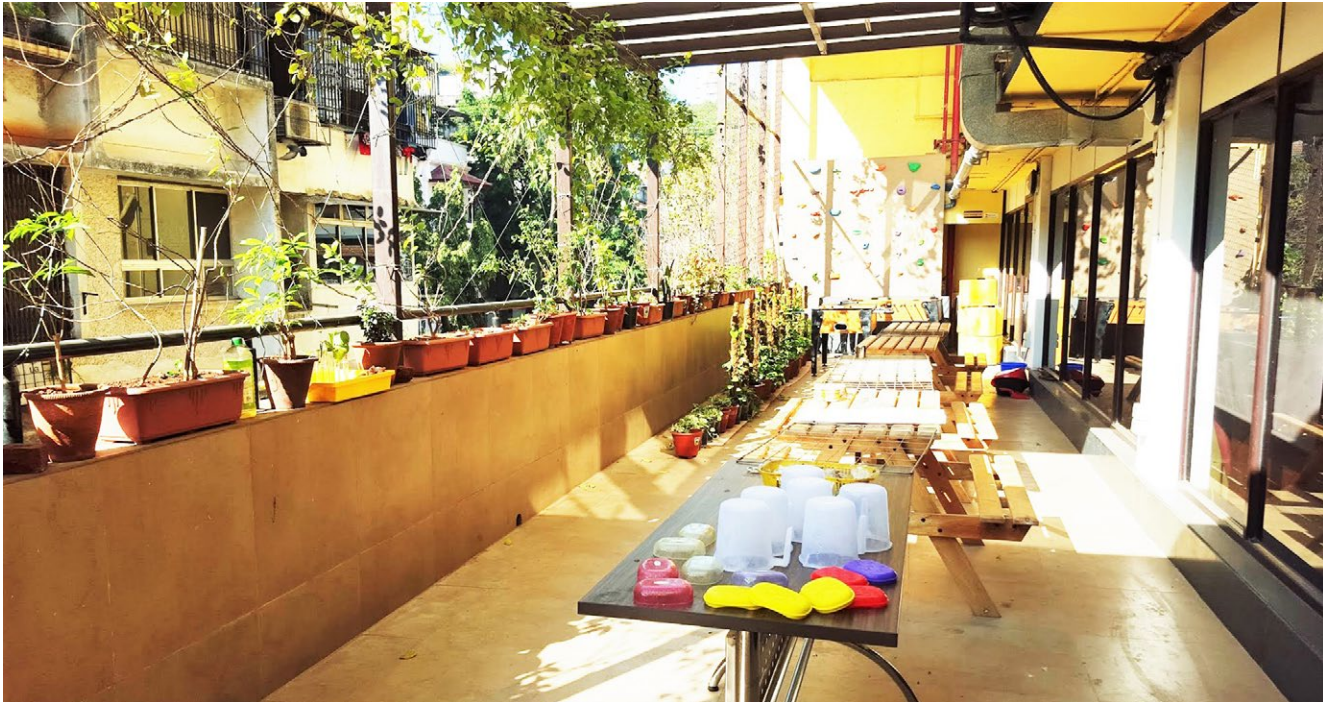
Photo by Christopher Lark.





The best way for design to express a love for nature (biophilia) is to take learning outside as with these decks at Hillel Academy, Tampa that flow naturally from indoor learning areas.





This veranda adjacent to the art room at DSB International School in Mumbai set in a dense urban area shows that biophilia can be expressed almost anywhere with some imaginative design.



In settings where the weather permits, there is almost nothing that cannot be learned better outside than in indoor settings far removed from daylight and fresh air.



Biophilic design is also a cue for simplicity—like these woven bamboo floor mats and art elements that use simple furnishings and décor in a properly daylighted space.



This treehouse at Anne Frank Inspire Academy by famed treehouse master Pete Nelson in San Antonio makes an otherwise - nondescript small school site special and has the potential to create many happy memories for the students who study at this school.



A green amphitheater like this one at Swarthmore College is an elegant way to express a biophilic design solution since it can permit social distancing and also allow for many more modes of learning such as music, dance and performance, student presentations and quiet reading. It is also a healthy, comfortable and inspiring space with lots of fresh air. Compare this to a traditional indoor classroom!
Photo: Swarthmore College.



This is a generously sized vegetable garden at Learning Gate Community School in Lutz, Florida where students do most of the planting and tending. A substantial part of every student's day at this school is spent outdoors, and this was true even before the COVID-19 pandemic.



Biophilic design becomes the means by which school courtyards such as this one at Riverside School in Ahmedabad, India feel warm, welcoming, and home-like via the use of indigenous plantings and an abundance of greenery.



Collingwood College in Melbourne, Australia, pioneered the Stephanie Alexander Kitchen Garden Foundation project where children have the opportunity to plant, grow, harvest, cook, and eat organic foods.

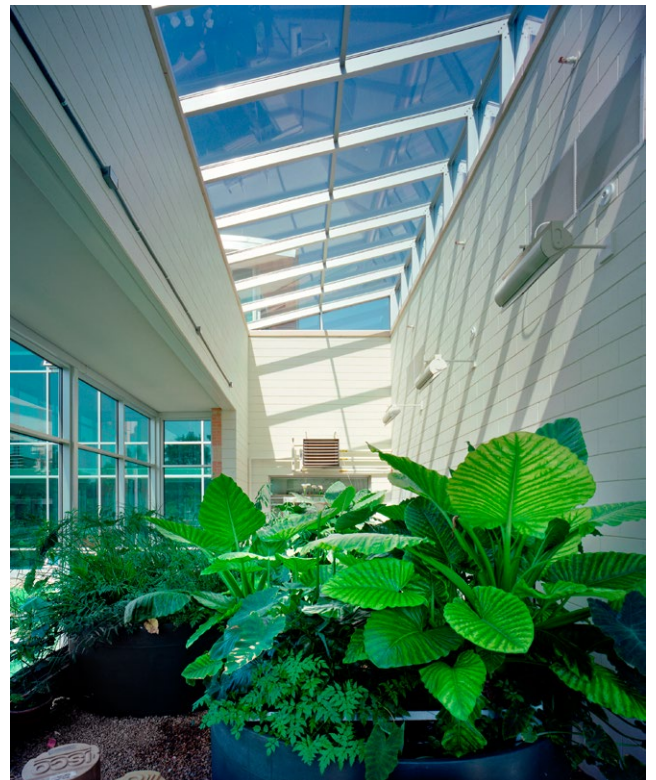


Good biophilic design does not have to be expensive as seen by this modest renovation in which a simple wood trellis provides shade and a quiet place to study between two buildings.





Play Inspired by Biophilia: An unstructured area with an assortment of natural elements such as the one featured in this photo inspires more creative play than a structured playground does.



A perfect example of biophilic design is one where water is naturally recycled as with this greenhouse with a living machine at Oberlin College, Ohio. (Photo courtesy of Barney Taxel).



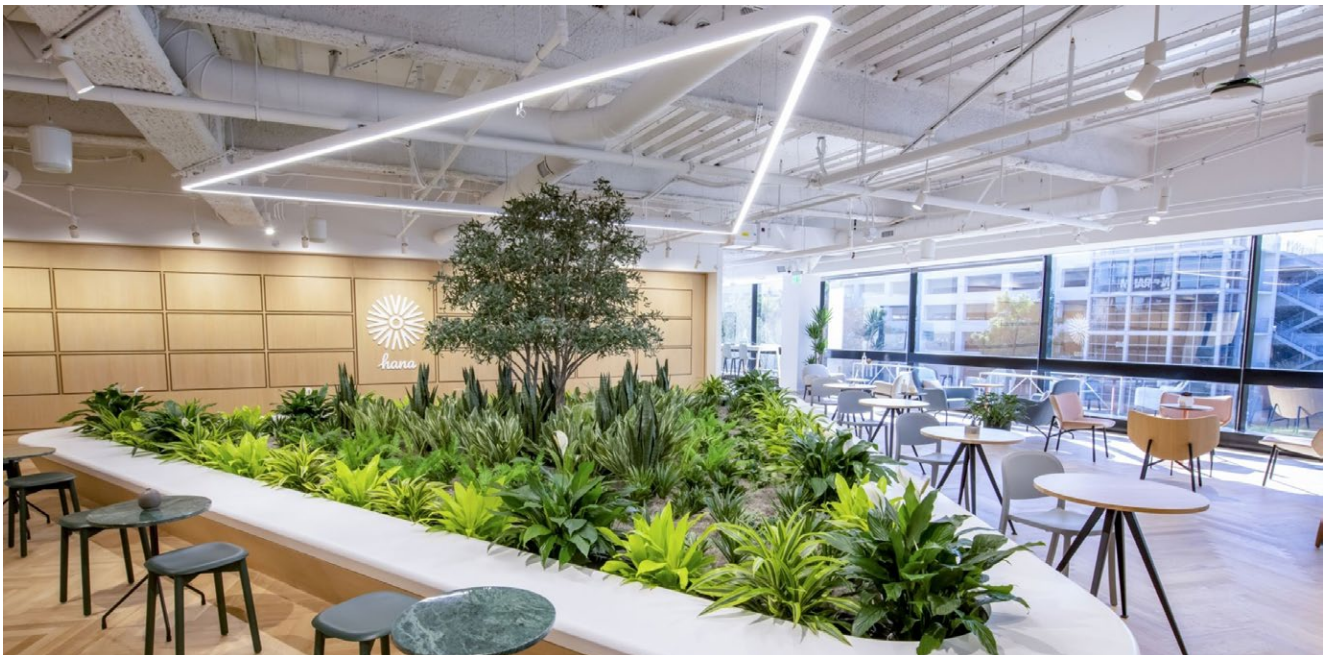
While it's easier to build on a site where all existing trees are first removed, preserving and building around a large tree can immediately introduce nature within the building in a powerful way, bringing with it all the ancillary health and learning benefits of biophilic design.



Balconies and verandas that have good nature views and that can be easily accessed from interior learning spaces are easy and relatively inexpensive examples of biophilic design.



At the AMIT GOGYA teacher training academy in Israel, architect Roni Zimmer Doctori used this warm wood-finished deck in place of the deep concrete “amphitheater” that existed here before. Human beings are naturally drawn to materials and finishes like wood and bamboo over more institutional materials like steel and concrete. biophilic design will therefore prefer natural surfaces and finishes whenever possible.



When it is not possible for students to be out in nature, then it makes sense for nature to be brought indoors as with this large green indoor planter. Such installations are even more critical in cold climates where students live are deprived of green settings in the outdoors for several months of the year.



While green amphitheatres are the most desirable, more modest ones like these paved examples can also work if they are adequately shaded. Natural stone can qualify as appropriate biophilic design and will be even more effective when used in a green setting with trees all around as with the paved amphitheater below at the American Embassy School in New Delhi, India.





Water elements inside and outside a school building are often powerful examples of good biophilic design as demonstrated by this Koi pond at Sinarmas World Academy in Jakarta, Indonesia.



For biophilic design to be effective in outdoor settings, it is important to plan properly for the kinds of activities that will happen there. Table surfaces that can be easily cleaned are more suitable for outdoor art projects such as the one from Israel shown in this photo.



An excellent approach to biophilia starts with introducing children to gardening. It connects them with nature and helps them breathe fresh air, gets them interested in fruits and vegetables making them more likely to eat them, gets them away from the computer screen, involves physical activity and makes them more environmentally conscious. This picture shows children participating in a tree-planting event sponsored by Growing Together in California.

Photo © Jason Clary. Growing Together: Mallika Nair, Founder.



At Anne Frank Inspirer Academy in San Antonio, the trees that were cut down on the site to make room for the new buildings were repurposed as part of a feature wall (background). The wood-finished ceiling, natural wood floors, and wooden cubbies are all set in a brightly daylit space with nature views. These elements combine to create an environment that is quintessential example of holistic biophilic design.

Architecture, Landscape Architecture, Education, School Reform



The application of biophilic design in hospitals, workplaces, and schools has demonstrated many positive outcomes. Biophilic environments are health-promoting and restorative. They are known to combat mental fatigue, with stress recovery leading to enhanced creativity, relaxation, and excitement. Biophilic Design is the practice of incorporating nature, natural materials, and concepts into a human-made environments, including schools, creating a closer connection to nature and the surrounding environment.

This white paper provides compelling research-backed evidence regarding the many health and learning benefits of biophilic design and includes specific strategies for incorporating it into the design of schools.

AUTHORS



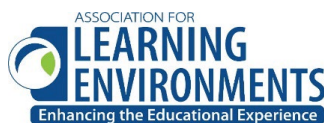
Prakash Nair, AIA is a world-renowned architect, futurist and the Founding President & CEO of Education Design International. Over the past 20 years, Prakash has helped build EDI into the global leader for school design with innovative work in 54 countries on six continents. Prakash has written dozens of articles in leading education journals, and he has written three books including *Blueprint for Tomorrow: Redesigning Schools for Student-Centered Learning* published by Harvard Education Press.



Parul Minhas is a research scholar in the Department of Architecture, Guru Nanak Dev University, Amritsar, India. Through her expertise in salutogenic design, Parul has created a series of guidelines and assessment tools that educational architects can benefit from as they develop new schools and renovate existing facilities in ways that best serve children's holistic health and well-being.



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The Association for Learning Environments is a professional non-profit association whose sole mission is improving the places where children learn.