Children’s Preferences for Biophilic Design In Vertical Schools

Abstract
Children’s need for contact with nature is critical to their well-being, especially in school environments where they spend the majority of their daytime. Vertical schools are increasingly built in high-density neighborhoods; however, due to their limited access to outdoor environments, they may struggle to offer children a sustained engagement with nature. This participatory study explored children’s perspectives on their preferences for biophilic design within three vertical schools in Australia. Thematic analysis of children’s narratives indicated their preferences for nature across the three categories of direct and indirect experience of nature, and in the nature of the space. The discussion argues that biophilic design can be incorporated in this school typology through the design of terraces, rooftop gardens, school grounds, windows, interior decoration and climbing play equipment. Building more vertical schools in the future seems inevitable. This paper argues that design of the vertical environment with reference to children’s observations and preferences can improve children’s contact with nature.

Keywords: Biophilic Design, Participatory Methodology, Vertical Schools, Well-Being

Introduction
A vertical school in this paper is defined as a building with six or more stories (Taylor 2020). Educational authorities have identified the need to build more vertical schools as a response to population growth and land scarcity in metropolitan areas—a trend that is common around the world (Aminpour 2020, Matthews et al. 2020). However, the literature claims that vertical schools have a poor capacity to access quality outdoor spaces, compromising children’s connection with nature (Gray et al. 2018, Truong 2018).

A growing body of literature suggests that natural settings are essential elements for children’s health and well-being, and that incorporating them in built environments can provide children with satisfying experiences (Aminpour 2021, Chawla 2015). Compared to indoor classrooms, natural settings have been found to promote concentration and relief from stress (Chawla 2014). According to Barbiero et al’s (2021) longitudinal study, learning environments with biophilic design are preferred by children and are perceived as more restorative and more effective in supporting their attentional performance than conventional learning environments. Three months after installing bio-walls in four kindergarten classrooms, Lee et al. (2021) recorded a significant improvement in children’s emotional intelligence, resilience, and eco-friendly attitudes.

This paper first draws on Browning et al’s (2014) and Keller’s (2018) biophilic design categories and attributes to identify a framework, and then reviews previous studies to identify the attributes incorporated in school design. Finally, it draws on the findings from this study on three vertical schools and identifies children’s biophilic design preferences in this school typology.

Biophilic Design Categories and Attributes
Browning et al. (2014) developed three main categories to classify various forms of nature experiences in the built environment. Kellert (2018) has expanded the attributes under each category. These include:
1. **Nature in the space**, or direct experience of nature. These include visual and non-visual connections to nature (auditory, haptic, olfactory, or gustatory stimuli); non-rhythmic sensory stimuli; thermal and airflow variability; and the presence of water, plants, or animals.

1. **Natural analogues**, or indirect experiences of nature that create symbolic and metaphorical references to nature. These include biomorphic forms, geometries and patterns that persist in nature; material and elements from nature with minimal processing; simulated natural light and airflow; and images or colors of the natural word.

1. **Nature of the space**, which refers to characteristics of spatial settings with similar experiences found in nature. These include the concept of prospect and refuge; risks and perils; mystery; complexity and order, with a spatial hierarchy similar to those encountered in nature; mobility; transitional spaces; ecological and cultural connections to place; and integrating parts to create a whole.

The next section reviews these attributes as they have been studied in school environment design.

**Biophilic Design in School Environments**

A small number of studies have investigated biophilic design applications in horizontal schools and the improvement in children’s well-being. The design attributes include access to fresh air; presence of plants, animals, and water (e.g. pond, aquarium); access to natural light and views to the outside; utilizing a mechanical ventilation system to simulate natural temperature variability and airflow; access to artificial diffuse and dynamic lighting; use of natural material; and use of natural forms, images and patterns in the interior design (e.g., curved forms and plant patterns) (Barbiero et al. 2021, Ghaziani et al. 2021).

The presence of plants, natural material and natural images are recurring attributes in buildings with biophilic design (Kellert 2018). Watchman et al.’s (2022) study extended their investigation of biophilic school design to look at the “nature of the space” within school environments and proposed a design vocabulary to communicate physical/spatial order, layout and configuration. The vocabulary has an emphasis on enclosed and “transitional” spaces that evoke juxtaposition between indoors and outdoors.

The review of the literature shows that application of biophilic design in schools tends to be adult-directed. We do not know enough about children’s perspective of biophilic attributes, and no other projects have focused on children’s experience of biophilia in vertical schools. This study acknowledges this knowledge gap and aims to find the biophilic design attributes that children identify and value in vertical schools.

**Methodology and Method**

This project used a qualitative, child-centred participatory methodology to understand children’s biophilic design preferences in vertical schools. Qualitative methodology enabled the in-depth study of the topic and the multiple dimensions involved (Corbin and Strauss 2008).

**School Settings**

This study surveyed three vertical schools located in two Australian capital cities, Brisbane and Melbourne. These two cities have contrasting weather conditions, and so provide environmental variation for this study. Melbourne has a cooler climate on average than the other major coastal cities in Australia, whereas Brisbane has a subtropical climate, with warm or hot weather for the majority of the year. Fieldwork was completed from 10 November through 25 November 2022, with 36°C the highest temperature in Brisbane and 12°C the lowest in Melbourne.

School 1 is a public primary school, has six stories and serves Kindergarten to Year 6. School 2 is a public high school, features seven stories and serves years 7–12. School 3 is a private school of 10 stories, serving Kindergarten to Year 12. They all feature terraces and rooftop gardens intended for specific year groups. A particular element between two sets of terraces in School 1 are climbing play structures called “The Treehouse,” which allows vertical connection between the terraces on levels 2 and 3; however, during the researchers’ visit, it was out-of-bounds due to an incident. School 1 and School 2 have school grounds, and School 1 and School 3 have regular access to a public park located across the street. School 3 staggered recess and lunch breaks to maximize use of the two terraces and the park. Across the three schools, children were not allowed outside on rainy days, and the cohorts participating in this research were not allowed to use the elevators.

**Participants**

The participants were selected from students studying in years 3 to 7. The participants’

“Learning environments with biophilic design are preferred by children, and are perceived as more restorative and more effective in supporting their attentional performance than conventional learning environments.”
average age was 10, and they ranged in age from 8 to 13 years old. Consent forms were sent to the parents of these year groups in the selected schools, and all the volunteered children were interviewed with parental consent. Overall, 24 walking tours of 1–3 children each were completed, with a total number of 35 children.

Method: Walking Tour
Walking tours were used as a child-centred participatory research method. This method has been demonstrated to be powerful for revealing children’s perspectives on multiple aspects of their school environments (Aminpour 2020, Clark 2012). The walking tours were completed face-to-face, and they were audio-recorded using a digital recorder. Children were asked to show their preferred places during a tour guided by them around the school (see Figure 1). As they were explaining how they typically used their preferred spaces around the school, they were asked questions to understand the reasons behind their choices and how their school environments impeded or supported their activities. Photographs of their favorite spaces were taken to better understand the physical characteristics of children’s chosen spaces.

Each walking tour took about 30 minutes and was completed during school recess and lunch breaks. The research obtained the required institutional ethics approvals—from both the university and the relevant Department of Education of the participating schools.

Data Analysis
The audio-recorded narratives from the walking tours were transcribed for thematic analysis (Leech and Onwuegbuzie 2008). The development of themes was guided by the biophilic design framework used by this study (Browning et al. 2014, Kellert 2018). The themes were identified and organized to indicate the different biophilic design attributes preferred by the children across the three vertical schools. The next section will discuss the predominant themes indicated by the narratives, common to the three schools.

Results
The results from the walking tour interviews reveal that children referred to all three biophilic design categories; however, only a selection of biophilic design attributes in vertical schools are preferred. The main themes show that the children value direct experience of nature (visual, thermal and air flow, sunlight, and natural systems) and indirect experience of nature (images and patterns of nature, play equipment), as well as nature of the space (prospect and refuge, risk and peril) (see Table 1). However, the children indicate the vertical school typology has impeded their overall mobility, and that the site is over-exposed to urban noise.

Direct Experience of Nature
Children valued access to terraces and rooftop gardens located at classroom doorsteps, or the local parks located in close proximity to the school. Elevated building levels also provided children the opportunity to have a “great view” of the

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<td>Visual access to nature</td>
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<td>Thermal and airflow</td>
<td>Terraces, open atriums</td>
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<td>Availability of play equipment</td>
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<td>Prospect and refuge</td>
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Table 1. The main themes and subthemes associated with vertical school spaces.
surrounding natural settings and their neighborhood park. Warmth, air flow and access to sunlight were other benefits of terraces mentioned by children.

From children’s perspectives, the plants made the terraces “feel lively,” “very beautiful,” and “relaxing” (see Figure 2). They adored the garden beds and the vegetables they were growing for their environmental education and cooking classes, and valued their access to nature in the urban context overall: “It’s nice to have a bit of greenery around because you’re in the middle of the city”—a 13-year-old student in School 2.

While the green terraces offered quiet and relaxing environments, they could be limited in the variety they offered; thus, their trip to the neighborhood park was described as “adventurous.”

“The plants here are really lovely… like we are in a forest full of nature… I like that there are different bugs that we can see. We went for a plant hunt… and there is all the different kinds of trees and all the different kinds of flowers in here”—an eight-year-old girl in School 1 (see Figure 3).

They valued having the choice of using the terraces, school ground and the neighborhood park, depending on their mood, and the opportunities they present.

Children preferred the terraces that were fully covered, as they were “shaded and cool” on hot, sunny days, but received some sunlight and had a “good breeze”: “It’s like we’re outside, except we’re not in the rain. We’re under cover… you can run around… instead of [being] stuck in a room with no refreshment”—Nine-year-old students in School 1. Terraces were children’s first choice when the school grounds were “boiling hot,” “quite sunny,” and “always flooding,” making its use “inconvenient.”

While a breeze was favored, a “wind tunnel” in the corridor could be “freezing” in winter, as claimed by a 13-year-old student in School 2. In this school, the terraces on the southern side were open to the atrium and to openings on the northern side of the school building, creating a wind tunnel in the corridors throughout all levels (see Figure 4).

The vertical schools visited featured expansive windows, which let in a lot of sunlight, benefiting the learning spaces (see Figure 5). This notion was voiced by a nine-year-old student in School 1 who believed access to sunlight benefited her learning and concentration: “I like how many windows there are, and so much light is coming in, because in my old school, there wasn’t many windows and I found it hard to concentrate because there wasn’t much light coming in; and here, there’s giant windows so we’re getting lots of light.”
Preference for access to sunlight on the terraces was also evident. A nine-year-old girl compared two different terraces in School 1 and signified her preference for the one with the higher ceiling that allowed the sunshine in: “I prefer the higher [ceiling] because… this one is too low, and it doesn’t give you much sun…. and sun is very important for people…. it gives us more nutrients.”

Children enjoyed using terraces for outdoor learning activities such as painting and cooking classes, as well as environmental education. They believed that being outdoors enabled them to experiment with hands, even if it was “all liquidy.” They also found the ability to grow vegetables and herbs a privilege in the city: “You can have a look at all the stuff you’re growing here, because a lot of people live in apartments, and you don’t have that”—a 13-year-old student in School 2.

Being located in busy urban districts, the schools’ auditory connection with nature was compromised. The outdoor school environments were exposed to the noise pollution originating from the nearby railroad and vehicular traffic. Moreover, noise echoed inside the building and transferred through the stairs was found by students to be “disturbing.” Children could mitigate the negative impact of noise by using “quiet” breakout rooms and enclosed spaces. However, this experience could not be found in the outdoor settings if the school was close to major transport infrastructure.

Indirect Experience of Nature
Patterns and images of nature that simulate experience in natural settings were two main biophilic attributes valued by the children in the vertical schools.

Images of nature were mostly displayed in common areas such as corridors (see Figure 6), “Hellerup” staircases—a wide stair named...
after the open-plan design of the Hellerup School in Denmark (see Figure 7)—and stair landings. Children in School 1 found this initiative “cool,” “relaxing,” and “nice to look at.” In the same school, one wall of the main common area on each level was painted with a different nature element, a feature which children adored: “I also like that each level has a different name. There is Alpine, Sunshine, River, Rainforest… and it goes from the lowest thing on the earth to the highest thing. The top one is Sunshine.” In contrast, School 2 lacked a differentiated approach, making children feel the rooms looked “all the same,” as they were “pretty empty,” “very modern,” and “lame.”

Play equipment that imitated the mobility challenges usually found in natural settings were children’s preferred play opportunities on the terraces, rooftop gardens and in school grounds. An artificial mount covered with artificial grass and surrounded by some stepping tires was one of children’s favorite places on the rooftop garden in School 1 (see Figure 8): “On a nice sunny day, playing out here was really fun… With the climbing thing and the tires which you can hop in and out of… I like this mountain thing and grass… it’s fun to play on it and climb up… it’s steep… it’s kind of different than just a flat surface… and for young kids it would be like an adventure,” described two nine-year-old girls. As they had to keep their balance on these structures, the play equipment highly engaged their vestibular sensation and challenged their motor systems, including proprioceptive sensory responses.

Nature of the Space
Prospect and refuge, and risk and peril were two main concepts evident in vertical school space design. Prospect and refuge were created by stair landings (see Figure 9) and terraces (see Figure 10), places they were interested to sit to watch their friends interacting on the lower levels. Children described the experience as “calming” and “relaxing.” The view from the rooftop gardens and terraces offered

“Feelings of ‘prospect and refuge’ and ‘risk and peril,’ created by stair landings and terraces, were two main responses elicited by vertical school space design.”
This study indicates children’s preferences for the physical environment of vertical schools that correlate with the principles of biophilic design. Examples of opportunities in vertical schools that provide children with direct experience of nature include large windows with green outlooks, covered green roofs or terraces with access to sunlight, gardening and outdoor learning activities. These features correlate with the biophilic design attributes of visual and nonvisual connections with nature, dynamic and diffused light, thermal and air flow, and connections with natural systems (Kellert et al. 2011). Compared to conventional learning environments, these features have been proven to support children’s concentration, attention restoration and relief from stress (Barbiero et al. 2021, Chawla 2014 & 2015).

Aside from direct contact, indirect contact with nature can be established by offering images of nature within the interior design of the common areas. Due to their vertical typology, these schools are more likely to feature common areas such as atriums and stair landings, spaces with high visibility which may not occur in the linear horizontal buildings (Swinburn 2017). Presenting images of nature in these common areas, in the form of posters, artworks and decoration, can attract children and create a loving, caring environment. A lack of these images and artworks, on the other hand, was not welcomed by the children in this study, with this type of interior design interpreted as characterless.

Another indirect experience of nature which has been less discussed in the literature is physical connection through vestibular and proprioceptive systems. These two systems use sensory input to connect the body to the brain to balance and coordinate movement. While vertical circulation via stairs can be tiring and overcrowded, innovative design can encourage adventurous and child-preferred movement patterns in the vertical structure to challenge their gross motor skills. Research shows that vestibular and proprioceptive stimulation risks and peril, a similar experience to those found in climbing and open outlooks (see Figure 11). A nine-year-old girl who visited the rooftop garden in School 1 expressed her excitement: “I love the view [from Level 6], I can see everything from here and it’s still safe… It’s scary… I like it.”

Mobility was often lacking in the vertical schools. Children had to travel between the levels using the stairs, which they found “too many” and “tiring to walk up.” From their perspective, the stairs were “the most noticeable” problem, especially if they were not “personally fit.” In addition, they encountered a large crowd while traveling on the stairs during the peak break times, which further hampered their mobility: “Stairs can be very crowded and there is a traffic jam could happen,” an eight-year-old student in School 1 complained.
Vertical schools are located in busy local districts, so are likely to be exposed to the hustle and bustle of urban life. Thus, auditory connection to nature may not be possible in outdoor school settings close to highways and rail lines. However, children can experience a more immersive sensory connection with nature in neighborhood parks, if a shared-use agreement is in place between the school and the local council. The large scale of an urban park can disperse sensory pollution from loud urban surroundings.

Finally, children favored spaces that incorporated a sense of prospect, refuge, or risk, all experiences to be found in nature. Rooftop gardens, terraces and expansive windows on higher levels offer elevated vantage points with unimpeded views to the surrounding landscape. These features can be incorporated into the design of vertical schools to promote a greater exposure to nature, either directly or indirectly.

This research project was limited to the study of biophilic design in three Australian schools. Future research may include more schools to allow broader implications for future biophilic school design.

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References


