

Impact of Biophilic Design on Supporting Metacognitive Thinking in Early Childhood in Childcare Centers - A Multidisciplinary Study

Liza Edward William¹, Shaimaa Mohamed Kamel², Laila Mohamed Khodeir³

¹Master's Degree Student, Architecture Department, Faculty of Engineering, Ain Shams University, Egypt

^{2,3}Professor, Architecture Department, Faculty of Engineering, Ain Shams University, Egypt

Abstract

It is widely known how modern life from activities, games, and technologies has consumed children's lives and attention, distracting them from the natural environment and its benefits. Moreover, although childcare centers are nowadays considered one of the primary environments where children spend most of their time, a child-nature connection is not much considered in their designs, giving more attention to technologies and artificial life. Environmental psychology theories declare that children are greatly affected by the surrounding physical environments, emphasizing nature as the richest environment that can feed their cognition and enhance their thinking skills, creativity, and development. A wealth of research studied the effect of nature-connected environments through biophilic design on children's physical and psychological developmental aspects (226,975 articles since 2000). However, less concern is given to the cognitive development aspect (only 18.75% of the total), with a gap in terms of metacognition as a kind of high-order thinking. Metacognition enhances children's behavior and high-order thinking skills such as reflective thinking, creativity, and problem-solving. Hence, this paper aims to investigate the role of biophilic design in supporting metacognition in young children by conducting a multidisciplinary study that addresses the four theories Biophilic, Attention Restoration, Froebel's theory, and Metacognition. The aim of this paper was achieved, firstly, by conducting a structured literature review in a multidisciplinary approach in Architectural, Environmental Psychology, Educational, and Cognitive Psychology fields using academic databases such as Elsevier, Scopus, Research Gate, and Academia. Secondly, analyzing the gathered data and the interrelations between the previously mentioned four selected theories. This paper's findings show three conclusions; firstly, a restorative environment supports metacognition by stimulating reflective thinking and developing skills. Secondly, biophilic design's attributes fulfill the factors for creating a restorative environment. Thirdly, specific metacognitive skills are supported by certain biophilic attributes. This paper revisits the design criteria for childcare centers providing a framework and a guideline abstracted from the biophilic approach for supporting children's development and metacognition.

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Keywords

Childcare centers; Metacognitive development; Early Years' Children; Environmental Psychology; Biophilic design

1. Introduction

Pedagogical and educational systems have recently followed the child-centered approach considering the child as the focal point and designing the learning strategies and activities according to his needs. Children's spaces should also follow this approach by considering the factors that participate in developing children and be applied to the design criteria and vision. Children nowadays spend most of their time in childcare arrangements. The US Census Bureau mentioned that 35 hours per week is the average number of hours that 61% of children under five years spend in children's institutes (Liu, 2020). Although architects and designers work on studying the various needs of different groups of pupils and the environments they use, children's environments do not have as much attention as needed. Even more so, childcare centers nowadays are much concerned with preparing the children's environment to be fully

equipped with technological devices more than strengthening the child-nature connection (Park & Lee, 2019; Wells, 2000).

The 19th-century educator Froebel Friedrich (1830) is the first founder of an institute for children's development, which he called "kindergarten" – "children's garden" in German - as a term that declares his belief that children should be nurtured and developed in connection to nature through providing gardens and outdoor activities. Therefore, this was shown in his kindergarten design and the goals he worked to achieve through playing activities in the garden and practicing gardening. The playing tools - named "Froebel gift" - that he designed have also worked on enhancing the child-nature connection through recognizing the patterns and forms found in nature (Brosterman, 1997). Although many studies provided evidence on how nature through biophilic design has a huge role in young children's mental, physical, psychological, physiological, and cognitive development (Kellert et al., 2013), most of the studies considered the children's physical (number) and social development with less attention to the psychological aspect. Additionally, cognitive development is considered the least explored aspect, with no studies on metacognition, as shown in Figure 2 (Scopus).

Metacognition is "thinking about thinking," which refers to the mental activities in children's minds - reflective thinking, monitoring, and directing cognitive strategies (Cherry, 2019; Fisher, 1998). Educational studies support metacognition's role in academics and behavioral development in life (Fisher, 1998; Flavell, 1979; Nazarieh, 2016; Spalding, 2020; Veenman et al., 2006). It emphasizes that metacognition provides children with high-order thinking skills needed nowadays as solving problems, creativity, and imagination, all of which support their character-building and development (Cherry, 2019; Fisher, 1998; Hulbig, 2020). Gustafson & Bernet (2002) mentioned that external factors – such as the physical environment - may influence supporting reflective thinking. So, this emphasizes the need for designers and architects to evaluate the design approaches for childcare centers in supporting metacognition and high-order thinking skills in young children. Morgan et al. (2021) believe that the complexity of these internal processes makes them difficult to measure, which may be a reason for the decline of other fields in exploring them.

Environmental psychology theories can be a tool to overcome this gap and bring an initial light to this aim. This field studies the relationship between the human and the environment he occupies, whether physical – natural or built, social or virtual (Journal of Environmental Psychology, Elsevier). Attention Restoration Theory (ART) by Kaplans (1989) is considered one of the interesting theories in this field – and it is the core pillar of this study. The theory explains how the brain – in a natural environment – experiences four states to reach full attention restoration. Through the first two states, the mind in nature gets more relaxed, provided with a chance to reflect - which is the third state called the "reflection state." Finally, reaching the fourth state, "restoration," where the brain – due to some rest to its direct attention – is restored, performing better in high-order cognitive skills such as problem-solving and creativity. Kaplans (1989) also added that an environment could be restorative for human attention restoration. However, nature proved to be the most restorative environment (Liu, 2020; Wells, 2000). How considering this theory in designing childcare centers would greatly benefit young children and their metacognitive skills.

The biophilic design approach – as a child-nature connection tool - is an ideal tool for designing childcare centers to support metacognition in young children. It is a recent approach that considers the human-nature connection in built environments. It is a response to the human's need to connect with nature - whether directly or indirectly - through several attributes and elements (Browning et al., 2014). Several studies have shown the positive effects of biophilic design on adults' and children's physical, physiological, psychological, and social development. Some studies have mentioned the beneficial effects of biophilic design in children's environments in providing them with opportunities for developing their creativity. However, more studies on this approach can bring more understanding of how to use each attribute to fulfill a specific cognitive value. How can biophilic attributes be applied so that architects make the most of nature's benefit to support metacognition in children?

This paper investigates the biophilic approach's role in supporting metacognition in young children. Through conducting a literature review in four fields; Architecture, Environmental Psychology, Educational, and Cognitive Psychology, this paper studied the interrelations of four selected theories; Biophilic, Attention Restoration theory, Froebel theory, and Metacognition. It provides a theoretical framework that declares the specific natural features and biophilic design attributes that significantly contribute to supporting metacognition in terms of reflective thinking,

creativity, and problem-solving. This study is considered a key for future research exploring biophilic designs and metacognition interrelation.

2. Research Method, Scope, and Objectives:

This paper conducted a literature review on various theories in four fields as a multidisciplinary study; Architecture, Environmental Psychology, Cognitive Psychology, and Education and Pedagogy. A detailed description of the structured literature is as follows:

As shown in the diagram of Figure 1, nature, built environment, and metacognition formed the initial interrelations that directed the study to address the three theories: Biophilia hypothesis (for the effect of nature on cognition and metacognition) in the Architectural field, Attention Restoration theory (for the effect of the built environment on cognition and metacognition) in Environmental Psychology field, and finally Metacognition in Cognitive Psychology field. In addition to that, by focusing on children's environments, Froebel's theory - in the Education and Pedagogy field - is also considered in the literature.

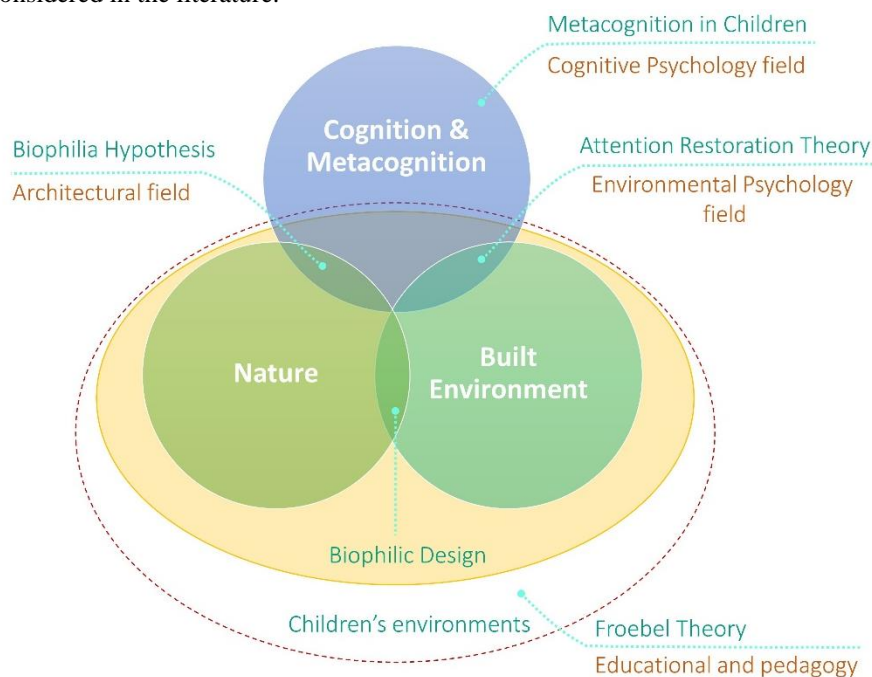


Figure 1. Literature review Keywords & Theories (Author)

By this, the five main keywords that formed the literature review structure are; Biophilic Design, Attention Restoration Theory, Metacognition, Early Childhood, and Childcare centers.

Ninety published papers and thesis were selected out of 500 papers using the following selection criteria: (a) recently published papers, thesis, books, and articles, starting from the year 2000 up till 2022, and (b) focusing on the aspect: cognition and metacognition, age: early years' children, design approach: biophilic design, institute: children's environments.

The research's aim is achieved through the following secondary objectives: (1) Identifying cognitive behavioral theory and metacognition in young children, (2) Investigating the effect of nature and physical environment on metacognition, (3) Identifying the biophilic design approach, and its attributes, examples of applying it in children's environments, and its effects on children, (4) Investigating the interrelations between a restorative environment supporting metacognition and biophilic design attributes, (5) Analyzing the vision and criteria of the first-founded kindergarten, with respect to nature, metacognitive development and biophilic approach and finally, (6) revisiting the design criteria for childcare centers by providing a proposed design guideline abstracted from the biophilic approach.

3. Literature Review:

3.1 Children's Cognition and Metacognition

A wealth of studies in the educational field took place over a vast period, all of which have emphasized the same conclusion that providing a good experience for children in their early years is necessary. The children's experiences shape their whole character, positively or negatively affecting the whole community in the long term (Kaplan, 1995; Lee & Park, 2018; Liu, 2020). Early childhood experiences are engraved in the child's personality and character, from which the psychological, mental, emotional, or cognitive attitudes are affected. That is why developmental, educational, and cognitive psychologists worked hard to study cognitive development in young children, its definitions, categories and types, and the factors that affect it. In the very beginnings of cognitive development as a science, Jean Piaget (1936) introduced the CLT (Cognitive Learning Theory), which was divided later into SCT (Social Cognitive Theory) and CBT (Cognitive Behavior Theory), where CBT mainly focuses on the behavior of the human being as a result of the inner thoughts or cognitive processes. From this point, psychologists and educators believed in the valuable effect of Metacognitive thinking – as a tool for monitoring and controlling inner processes – for better outer behaviors (Nazarieh, 2016).

Metacognition, as a recently coined term by the developmental psychologist John Flavell (1976), is an intense form of self-awareness, reflecting thinking, and self-regulating, all of which would have a significant effect on monitoring one's self-knowledge, values, or thinking process, evaluating them, directing them and re-directing them, which in turn would affect on the outer behavior on the long term, leading to more developed and thriving communities (Akturk & Sahin, 2011; Scott, 2008; Bonner, 1988; Fisher, 1998). Metacognition has a role in developing high-order cognitive skills in children, such as problem-solving, creativity, and critical thinking (Kogut, 1996; Fisher, 1998; Choy & Cheah, 2009; Jea et al., 2019; Cherry, 2019), which in turn would have a beneficial effect on their academic life (Fisher, 1998; Magno, 2010; Meijer et al., 2012) and on their behavioral attitudes on the long term (Han, 2003; Liu, 2020; Spalding, 2020).

Studies from variant resources provided some preliminary suggestions about the external factors that may affect reflection practice as time (Gustafson & Bernet, 2002), guidance, instructional methods, personal knowledge, and training dedicated to metacognition and the physical environment. It indicates that not considering factors like these may act as an obstacle to reflective thinking (Denton, 2009). Now comes the turn for architects to examine their design approaches for the physical environments, especially children's environments.

3.2 Attention Restoration Theory (ART) in Children

Environmental psychology is the science that studies the relationship between humans and the environment and how the environment would affect positively or negatively the human's physical, cognitive, and psychological development. The term "environment" in this science means the physical environment (natural or built), social, or virtual one (Journal of Environmental Psychology, Elsevier). Studies in this field declared the enormous effects of the physical environment on children's cognitive, behavioral, social, physical, and physiological aspects (Kellert, 2006; Farhanah Nik et al., 2014; Lee & Park, 2018, 2019; Moore et al., 2018). One of the environmental psychology theories adopted in this study is ART (Attention Restoration Theory), described by Stephen and Rachel Kaplan (1989) as the mechanism that occurs in our mind in which attention capabilities are restored when interacting with a restorative physical environment.

The Attention Restoration theory describes the gradual states that happen to the mind in nature – as the most restorative environment - to reach a reflective thinking state and restore attention. This restoration is witnessed especially after "mental fatigue" or "directed attention fatigue," which happens due to mentally loaded tasks or distractions around (Wells, 2000). In this theory, Kaplan (1989) mentions that this process of attention restoration includes four states called "cognitive states" or "states of attention," where the mind starts to release its tension and worries naturally, not forcedly; therefore, the mind's directed attention starts to return to normal levels, then the involuntary attention is naturally stimulated – through what is named soft fascination - which in return give time and space for the directed attention to have rest. This allowance for rest provides the mind with two main things: a chance

and ability to practice reflective thinking on life, goals, and actions; secondly, refreshing it for a new restart with a better and higher performance. This is the last state in which the mind is in its most profound restorative state, named the "Reflection and Restoration" state (Han, 2003). So, a restorative environment is an environment that can support reflective thinking in metacognition and restore the mind's attention for better performance.

Kaplan (1995) mentioned four characteristics of a restorative environment: extent, being away, soft fascination, and compatibility, as shown in **Error! Reference source not found.** They believed that nature is the most restorative environment and that the soft fascination that nature provides allows a more reflective mode for children. They added that while observing nature, children create curiosity, which drives them to ask deep questions and try to find answers while digging in the spirit of nature (Kahn, 1997; Park & Lee, 2019; Wells, 2000). Nancy M. Wells (2000) also added that nature provides play and reflection for children. This shows how nature-connected environments could strongly promote and strengthen the way of practicing metacognition in young children.

3.3 Child-nature connection

A large number of studies explored the beneficial effects of nature on human development, especially from the year 2000 to 2021, where studies reached a range of 226,975 articles on this topic. However, studies focused on nature's effect on children were only 22.42% (50,893 articles), with only (18.75% = 9,542 articles) on cognitive development, and with no studies on metacognition. As shown in the below diagram Figure 2, the cognitive aspect in these types of studies took the least place compared to other aspects such as the physical, psychological, physiological, and social (Scopus).

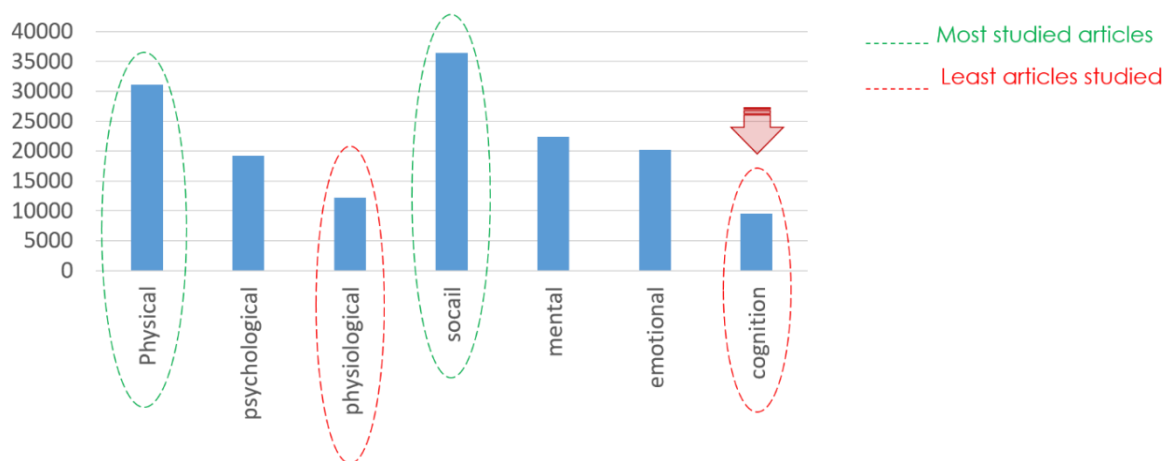


Figure 2. Studies on Child-nature connection's effects on different aspects (Scopus)

The studies that focused on the effect of nature on children's cognitive development – though their limited quantity – have agreed that nature has a role in creating better attentional capacities, cognitive restoration, and performance in children (Dadvand et al., 2015; Gillis & Gatersleben, 2015; Schertz & Berman, 2019; Schutte et al., 2015; Wells, 2000). This is compatible with what the attention restoration theory (ART) states regarding nature being the most restorative environment that helps restore attention for better performance in children (Wells, 2000). Worrall (2017) conducted a study that seeks empirical evidence on nature's effect on the brain. Researchers and scientists in this experiment used technological evidence to monitor these effects. Using portable EEG (Electroencephalogram) units, they found that the brain reacts differently to different environments. For participants who spent time in nature, their brain activities' results differed from those who spent the experiment time in an urban setting. It was shown that "alpha waves" in the brain become more active in a natural environment, where these waves indicate calmness of the mind, unlike beta brain waves that work against alpha ones, which indicate mind stress or tension. Also, in nature, the frontal lobe deactivates.

It is part of the brain that gets highly engaged when participating in modern life duties that need focus and exhausted mental activities.

These results support the attention restoration theory previously stated by Kaplans (1989) in terms of the effect of nature in relaxing the mind and releasing its stress. Nature is then proved to be a great reason for that abundance of benefits on children’s cognitive development and an essential factor for providing the mind an opportunity for reflection and restoration for better performance in high-order thinking skills. The architecture and designing field adopted the biophilic design approach as the recently developed design tool to provide nature in the designed architectural spaces.

3.4 Biophilic design in childcare centers

As a reflection of these psychological studies, the architectural design field started to follow this approach investigating the impact of nature-connected environments on adults and children. Studies from year 2000 to 2021 on biophilic design as a nature connection approach in architectural designs started to exist, although increasing over time, however, the cognitive aspect in these studies is still one of the least explored ones as shown in Figure 4 and Figure 3. Moreover, their methodological methods to examine it lack the empirical evidence on high-order cognitive skills as those in metacognition. This is considered an unexplored area, yet needs to be studied in the field of cognitive psychology in synergy with architecture and spatial design. Thus, this research works on studying this approach addressing this gap in the literature, and investigating the impact of biophilic design in childcare centers – as a nature connectedness approach - on enhancing metacognitive skills and reflective thinking in young children.

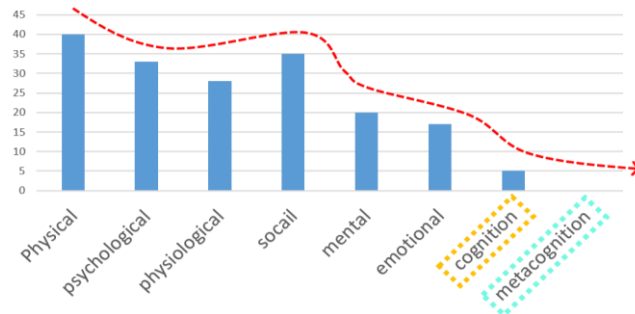


Figure 4: Studies on Biophilic design’s effect on different aspects (Scopus)

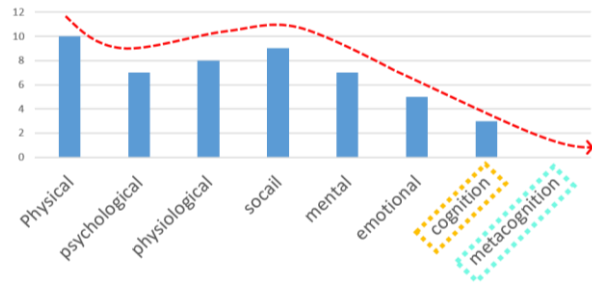


Figure 3: Studies on Biophilic design in children's environments and its effects on different aspects (Scopus)

3.4.1 Concept and patterns of Biophilic design

Biophilic design is the approach that supports human-nature connection through several elements and attributes designed to connect humans with nature, directly or indirectly (Browning et al., 2014). Kellert et al. (2013) defined the biophilic approach through two basic dimensions; the Naturalistic dimension and the place-based dimension, which contains six elements; each element contains several attributes, as per **Error! Reference source not found..** More than 70 attributes are in the biophilic approach; however, this number and classification are still in progress, whereas modifications may occur over time as knowledge about this approach increases.

Table 1: Biophilic Design Elements and Attributes (Kellert et al., 2013)

Environmental features	Natural shapes and forms	Natural patterns and processes
<ul style="list-style-type: none"> • Color • Water • Air • Sunlight • Plants • Animals 	<ul style="list-style-type: none"> • Botanical motifs • Trees & columnar supports • Animal & motifs • Shells & spirals • Egg, oval, & tubular forms • Arches, vaults, domes 	<ul style="list-style-type: none"> • Sensory variability • Information richness • Age, change, & the patina of time • Growth & efflorescence • Central focal point • Patterned wholes

<ul style="list-style-type: none"> • Natural materials • Views & vistas • Façade greening • Geology & Landscape • Habitats & ecosystems • fire 	<ul style="list-style-type: none"> • Shapes resisting straight lines & right angles • Simulation of natural features • Biomorphy • Geomorphology • Biomimicry 	<ul style="list-style-type: none"> • Bounded spaces • Transitional spaces • Linked series & chains • Integration of parts to wholes • Complementary contrasts • Dynamic balance & tension • Fractals • Hierarchy organized ratios & scales
Light and space	Place-based relationship	Evolved human-nature relationships
<ul style="list-style-type: none"> • Natural light • Filtered & diffused light • Light & shadow • Reflected light • Light pools • Warm light • Light as shape & form • Spaciousness • Spatial variability • Space as shape & form • Spatial harmony 	<ul style="list-style-type: none"> • Geographic connection to place • Historic connection to place • Ecological connection to place • Cultural connection to place • Indigenous materials • Landscape orientation • Landscape features that define building form • Landscape ecology • Integration of culture & ecology • Spirit of place 	<ul style="list-style-type: none"> • Prospect & refuge • Order & complexity • Curiosity & enticement • Change & metamorphosis • Security & protection • Mastery & control • Affection & attachment • Attraction & beauty • Exploration & discovery • Information & cognition • Fear & awe
Inside-outside spaces	Avoiding placelessness	Reverence & spirituality

3.4.2 Effects of biophilic design on cognition and metacognition

Many studies on biophilic design have mentioned its beneficial effect on humans in several aspects. Ulrich (1993) as an architect had performed a lot of studies on nature connection effects. One of the general responses to nature that he mentioned is the “restoration responses (stress recovery)”. Empirical evidence has shown that natural elements like water, open spaces (such as grassy meadows and valleys), and trees greatly help in recovering from mental fatigue and stress compared to the restorative experience that a human can try to have when not connected to nature in an urban context, measured through verbal and physiological tests (Ulrich et al., 1991). Ulrich (1993) also mentioned another response in which connecting with nature enhances high-order cognitive functioning as long-term memory, problem-solving, and creativity (Atchley, 2012). This is also approved by Kaplan’s (1989) attention restoration theory in which the last stage for reaching a restorative state was mentioned to be a way for reflective thinking (Kaplan, 1995). Park and Lee (2019) have gathered in a study of the effects of nature on children. They mentioned that outdoor spaces in nature make children feel free and relaxed, adding that interacting with living things in nature fills them with a sense of amazement and mystery. They also highlighted the great effect of nature on children in stimulating their in-depth questions and curiosity when observing it.

A recent study by Park & Lee (2019) shows the biological responses for biophilic design patterns gathered from different studies as shown in below **Error! Reference source not found.** In their study, they show how certain biophilic attributes can engage in stress relief through lowering blood pressure, decreasing heart rate, increasing comfort, and therefore happiness and productivity. Also, material connection with nature promotes relaxed feelings. They added that biophilic attributes have positive effects on cognitive skills. This research by Park & Lee (2019) also shows that advanced studies in the biophilic approach can lead to knowing the specific biophilic attributes that the designers can use to target some specific benefits. As for Kellert (2001), the best biophilic design is the one that

creates a natural connection that helps in decreasing anxiety and stress and provides physical, mental, and behavioral benefits (Kellert 2015). Browning et al. (2014) mentioned health, culture, social background, and people's experiences as conditions for a good biophilic design, and to form a kind of nature-based place that helps in restoration and inspiration (Browning et al., 2014).

Table 2: Biophilic design patterns and biological responses (Park & Lee, 2019)

Biophilic Design pattern	Stress relief	Cognitive skills
Visual connection with nature	Lowering blood pressure and decreasing heart rate	Increasing work engagement and concentration
Non-visual connection with nature	Lowering systolic blood pressure and relieving stress	Positive effects on cognitive skills
Dynamic and diffuse light	Increasing comfort, happiness, and productivity	Positive effects on increased concentration
Connection with natural systems	Relieving stress	-
Biomorphic forms and patterns	-	-
Material connection with nature	-	Lowering diastolic pressure
Complexity and order	Relieving psychological stress	-
Prospect	Relieving stress	Reducing boredom and fatigue
refuge	-	Improving concentration

Childcare centers that have biophilic playgrounds provide their children with opportunities for natural play and its benefits. Fjortoft and Segeie (2000) in their study emphasized that children playing in biophilic playgrounds have better motor skills, balance, and coordination than children playing in traditional playgrounds. Also, the various materials, textures, and spatial characteristics of biophilic playgrounds compared to those of traditional ones entuse different skills in children that lead to fewer behavioral problems and positive impacts on children's evaluation skills (Cengiz & Ozge, 2019). Moreover, due to the transformability and convertibility of natural materials, children develop their creativity and imagination skills. This is clear in the idea that the children can form shapes from rocks, pebbles, sand, leaves, and many more materials provided by nature. Froebel in his kindergarten has provided this activity for the children believing in its role in developing their imagination and creativity as well as strengthening their bond with nature (Tovey, 2017, 2022). In another study, researchers found that the participants had lower levels of psychological stress and higher creativity scores when they were in biophilic spaces of different levels compared to their base case (Yin et al., 2019).

Biophilic design brings benefits to adults and children as improvements in their self-esteem level, and increase in cognitive functioning and attention capacity (Wells et al., 2003). One study was carried out to measure the biophilic design in childcare centers as related to the developmental outcomes of children aged 34 to 38 months, this study came out with a conclusion that children in childcare centers with high application to the biophilic approach had significantly better outcomes in a creativity assessment. Though it showed a correlation between applying biophilic design and achieving great scores in health, cognitive, social, and physical outcomes, moreover, the creativity outcomes surpassed the threshold of statistical significance (Cerezo, 2013).

3.4.3 Biophilic elements in childcare centers' design

As per a study by Park and Lee (2019) which was built on a literature review and case study of 20 childcare centers in Japan, they determined the biophilic elements and patterns applied in the selected facilities as per the following: (1) providing sandbox indoor, using natural materials in indoor spaces' finishing to stimulate tactile nature connection; (2) using natural forms and shapes as trees, mountains, waves, and caves; (3) many nurseries had considered incorporating daylight and its dynamicity in their spaces; (4) providing a sandbox in the outdoor area; (5)

providing waterway around playing area or water bodies of gravel for stimulating tactile and auditory nature connection; (6) providing an outdoor natural environment that can be viewed from inside the childcare center, this help children to observe the changes in the ecosystem during the day.

For (NFB Nursery and KM Kindergarten and Nursery), they worked to provide this in the cafeteria and study room since they are the most spaces the children spend time in. However, in (TAKENO Nursery) they were able to the courtyard design in the center of the childcare center to provide visual access to the outdoor view from anywhere in the building. Widely opening the exterior space of the playroom to allow as much possible view of the outdoors was applied by (Hanazono Kindergarten) (Park & Lee, 2019).

Park and Lee (2019) in their study also came up with some conclusions depending on the results of the case study and survey conducted with caregivers. They mentioned that childcare facilities should have a view from the inside to the natural environment outside which mainly provides them with the chance to observe the seasonal and various daytime changes in a natural ecosystem. This was the most important factor to be applied in childcare centers from guardians' point of view measured through a questionnaire conducted by them. Regarding this element, they recommended that architects and designers can early plan for this in the childcare centers' planning phase. They also mentioned the importance of considering using natural elements and providing the children with the various sensory experiences needed relating to nature as the visual, auditory, olfactory, and tactile ones, adding to that, nature is the element where designers can find its way to serve the various senses of children. In this point, they mentioned using water bodies made up of water and gravel and building green pedestrian paths. Also, open spaces should be considered in childcare centers since they are a source of relaxation and free movement. Finally, incorporating hiding places for children with respect to their stage of development. They added that further research should be conducted in which children's satisfaction shall be measured (Park & Lee, 2019).

3.5 Early Foundations of Children's Institutes

Believing in nature to be a rich environment for children's development has been raised since the early foundation of children's institutes. Even more so, children's institutes were founded based on the idea that nature is the teacher of children's creativity, playing, imagination, and reflective thinking.

3.5.1 Froebel Kindergarten & Nature connection

The foundation of childcare centers refers to the year 1830 when a French educator called Froebel Friedrich was the first to create an institute for children's development. He named it "Kindergarten," a German-driven name for the meaning "Children's garden." Froebel believed that nature is the mother and teacher for developing children's knowledge and creativity, and for that, they should be nurtured in gardens. Through the activities and the playing items - "Froebel gift" - that he designed, he introduced nature into the children's lives, drawing their attention to its patterns and forms (Brosterman, 1997).

3.5.2 Froebel Kindergarten supports children's metacognition in nature

Designs and art before and after Froebel's kindergarten have changed due to including a child-nature connection in its approach. This first childcare center is considered a world-changing educational institute that supported creativity, reflective thinking, and imagination in young children through providing nature connection. Many of those who attended kindergarten have grown as adults impacting the world with their creativity, imagination, and thinking skills. As said by Brosterman: "Frank Lloyd Wright, the American architect, is the great child of the kindergarten. You can see the kindergarten in everything Wright ever did." Wright has mentioned that in his early childhood, his mother brought him a set of Froebel's Gifts. She also used to attend classes for kindergarten education (Brosterman, 1997).

4. Discussion

This paper reached its aim by studying the interrelations between selected theories in different fields, as shown in the below diagram Figure 5. The selected theories are Metacognitive development theory, Biophilia Hypothesis,

Attention Restoration Theory, and Froebel theory in the different fields: Cognitive Psychology, Architecture, Environmental Psychology, and Education field.

Nature, reflective thinking, and high-order thinking skills in children are the common keywords between theories, which were the reason behind the interrelations between them, which led to the research’s hypothesis about the relation between metacognition (represented in reflection and high-order thinking skills) and Biophilic design (represented in nature-connected spaces).

Field	1. Cognitive Psychology	2.Environmental Psychology	3. Pedagogy and Educational	4. Architecture	“Research Hypothesis”
Theory	Metacognitive development theory	Attention restoration theory (ART)	Froebel kindergarten approach	Biophilia hypothesis & Biophilic approach	Supporting metacognition through biophilic design
Keywords	<ul style="list-style-type: none"> • Reflective thinking 	<ul style="list-style-type: none"> • Nature • Children • Reflection & restoration state 	<ul style="list-style-type: none"> • Nature • Children • Reflective thinking & high-order thinking skills 	<ul style="list-style-type: none"> • Nature • Children • Development 	<ul style="list-style-type: none"> • Biophilic design • Young children • Metacognition • Childcare centers • Environmental psychology

Figure 5: Literature review theories and keywords diagram (Author)

4.1 The Restorative Environment Supports Metacognition

As mentioned in Attention Restoration Theory (ART) in section 0, the child in nature reaches four attention states the final one is the state of reaching the most restoration of his mind, and therefore, being able to reflect and perform better in high-order thinking skills. Metacognition is reflective thinking and it is responsible for developing high-order thinking skills such as problem-solving, creativity, and evaluating. Therefore, providing nature as the richest restorative environment leads to enthusing metacognition in young children. Therefore, this paper concludes its first conclusion: A restorative environment supports metacognition in young children. The below diagram Figure 6 shows the effect of nature – as the most restorative environment - on children according to Attention Restoration Theory (ART). From this, the question is: Does the biophilic approach – as a nature connection approach – create a restorative environment?

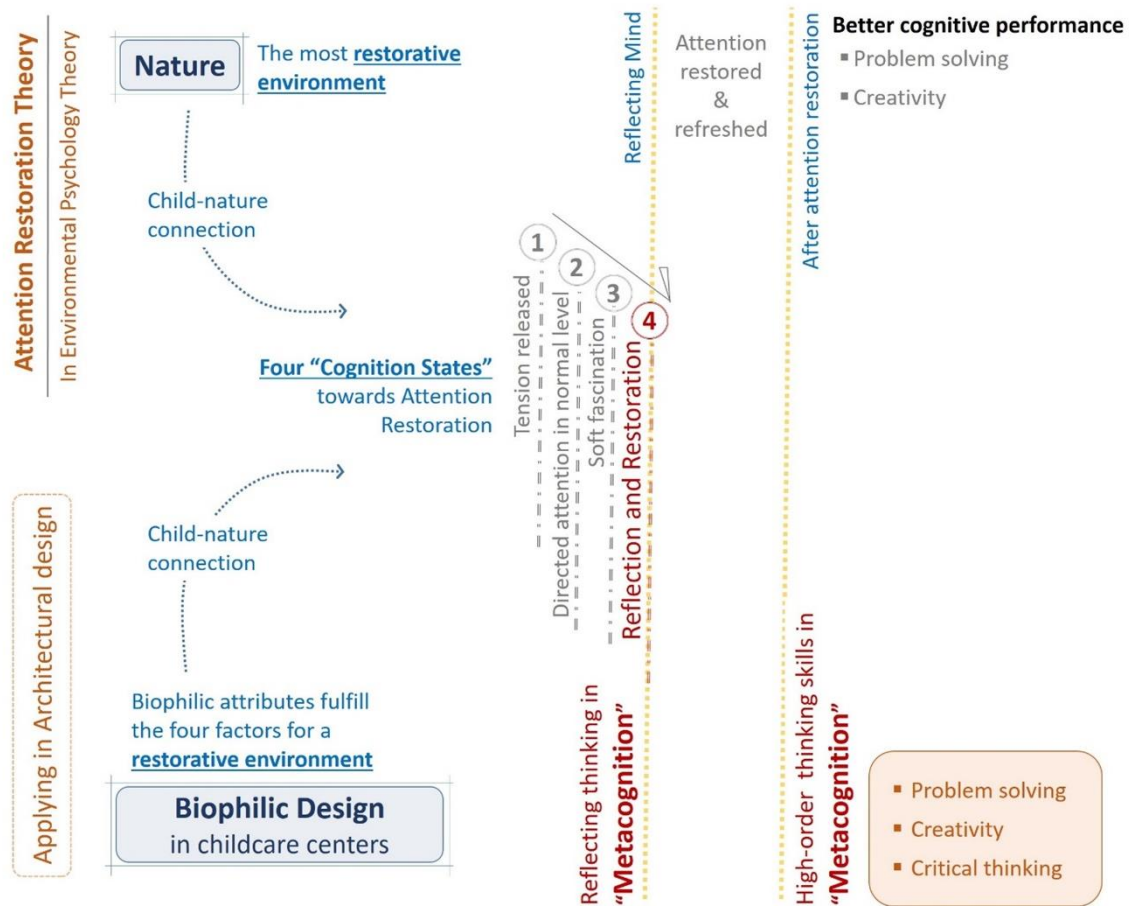


Figure 6: Attention Restoration Theory in Environmental Psychology and Architecture field (Author)

4.2 Biophilic Design: A way for a restorative environment

By studying the ART theory and biophilic approach, this paper shows the interrelations between the characteristics of a restorative environment and biophilic design attributes, emphasizing the ability of a biophilic designed space to meet the restorative environment's criteria, and therefore, enhance metacognitive skills in children.

Firstly, and most importantly, the biophilic approach, through its attributes, supports the human-nature connection, and according to Kaplan et al. (1989) and Nancy M. Wells (2000), nature is considered the most restorative environment. Therefore, the vision of a biophilic approach to connect humans with nature is the main reason biophilic design supports metacognition in children. Most clear through the "Environmental features element" in the biophilic approach, as shown in **Error! Reference source not found.**, in which all of its attributes provide a human-nature connection through natural features such as; water, air, sunlight, plants, animals, and natural materials. Therefore, a direct connection with nature takes the first position in this interrelation list, as it is the authentic and deepest form of connection with nature through its features and processes. Following this, the outdoor areas in children's environments and providing natural views and elements in their indoor spaces also take place in first positions. Below **Error! Reference source not found.** shows the interrelations between the four characteristics of a restorative environment provided by Kaplans (1995) and the biophilic design attributes, showing the capability of a biophilic designed space to be a restorative environment that supports metacognition in children.

Table 3: Restorative environment and biophilic design. Source: Author based on (Kaplan, 1995; Kellert et al., 2013)

A Restorative environment's characteristics (Kaplan, 1995)	An explanation for the characteristic (as per Kaplan, 1995)	Terms concerning a physical environment (by the Author)	Biophilic Design approach (as nature-connected spaces) (Kellert et al., 2013)	
			Attribute	Element
Extent	<ul style="list-style-type: none"> ▪ Feel immersed in the environment ▪ Large environment to be explored ▪ Depth of the experience 	<u>An environment of:</u> <ul style="list-style-type: none"> ▪ Attentive area ▪ Rich area ▪ Variable experiences 	<ul style="list-style-type: none"> ▪ Information richness ▪ Order and complexity ▪ Exploration and discovery ▪ Sensory variability 	<ul style="list-style-type: none"> ▪ Natural patterns and processes ▪ Evolved human-nature relationship ▪ Evolved human-nature relationship ▪ Natural patterns and processes
Being away	<p>Away from habitual activities and daily concerns</p> <p><i>Example:</i> a look of a window to the outdoor natural element or setting, having a walk</p>	An environment for relaxing the state of mind	<ul style="list-style-type: none"> ▪ View and Vistas ▪ Geology and Landscape 	<ul style="list-style-type: none"> ▪ Environmental features
Soft fascination	<p>Capturing the mind effortlessly through the environment's elements</p> <p><i>Example:</i> The sound of birds, the movement of leaves with the wind</p>	An environment of attractive, enchantment, and adoration elements (smoothly effortlessly)	<ul style="list-style-type: none"> ▪ Natural features ▪ Mimicking natural features ▪ Fractals ▪ Dynamicity, complexity, and stimulation of nature (Schutte et al., 2015) 	<ul style="list-style-type: none"> ▪ Environmental features ▪ Natural shapes and forms ▪ Natural patterns and processes
Compatibility	The desire of users to interact with it and appreciate it	Harmonic relation with the environment	<ul style="list-style-type: none"> ▪ Avoiding placelessness ▪ Affection and attachment ▪ Attraction and beauty ▪ Curiosity and enticement 	<ul style="list-style-type: none"> ▪ Place-based relationships ▪ Evolved human-nature relationship ▪ Evolved human-nature relationship ▪ Evolved human-nature relationship

Error! Reference source not found. shows the four characteristics of a restorative environment with the corresponding biophilic attribute. On the one hand, for an environment to be restorative, the first factor is its “extent,” which means that the environment is much bigger than the user, far from the user’s ability to contain or realize its limits. It also means that the user would always need to re-discover; however, the environment still holds information to be yet explored. On the other hand, the biophilic design approach believes in creating a space that is rich in information (Information richness), a space of a complexity that stimulates the viewer (order and complexity), and rich enough in its design and zones that enthralls the user to explore and discover it more (Exploration and discovery). Also, a space that stimulates more than one or two of the human senses, providing richness to the variable senses (Sensor variability). Biophilic attributes strongly stimulate the human senses visually by light, colors, proportions, sizes, shapes, and patterns of natural elements; and acoustically by the sounds of natural features such as water flows, birds singing, wind, leaves, trees, and movement of pets. Also, the odors in nature as the flowers' fragrance and the smell of leaves, wind, and water, stimulate the sense of smell, and the different textures in natural materials stimulate the touch sense.

The second factor for an environment to be restorative is its ability to help the user “get away” from stressful and noisy environments. The biophilic approach achieves this by providing physical or visual access to natural areas (Vistas and views, Landscape and geology). The third factor is the ability of the environment to stimulate the user’s “soft fascination.” Soft fascination occurs when involuntary attention is attracted by soft stimulators, giving the mind’s directed attention a chance to rest. A lot of things in nature stimulate soft fascination in the mind, such as the sounds of birds, water, soft movements of green leaves, flowers and trees, curvy lines, patterns, and the variety of colors in nature (element: Environmental features). Even using shapes, patterns, and fractals from nature to include in the design of the space can softly enthrall the mind to meditate in it, and thus the soft fascination is stimulated (element: Natural shapes and forms, Natural patterns and processes).

Lastly, a restorative environment is an environment that the user can have “compatibility” with, which means having harmony with, appreciating it, wanting to interact with and it is not repulsive to him. As the biophilic approach values the human-nature connection, it also assures the necessity to have harmony between the human and the environment (Place-based relationships), avoid placelessness, and have a space that attracts the user to enjoy its beauty and interact with (Avoiding placelessness, Attraction and beauty, Affection and attachment, and Curiosity and enticement) (Kellert et al., 2013).

The previous **Error! Reference source not found.** shows that the biophilic approach fulfills the four factors for having a restorative environment, which means that children's environments if applied these biophilic attributes in their designs, would create an environment suitable for supporting metacognition in young children. Biophilic attributes mentioned in this table represent almost 50% of the total attributes in biophilic design (37 attributes out of a total of 72 attributes). As this study focuses on supporting metacognition through biophilic design in childcare centers, it is necessary to look back to the origins of early childhood institutes and nature's position in them and their vision towards developing high-order thinking skills, reflective thinking, and creativity.

4.3 Metacognition, Nature, and Biophilic design are in Froebel's Kindergarten approach

Froebel’s kindergarten –the first childcare center founded- has gathered the three factors (children’s institutes, child-nature connection, and metacognitive skills). He believed that nature should be provided in children's environments and that a child's interaction with nature enthralls his reflecting and thinking skills. Regarding reflective thinking in metacognition, Froebel also cited in Herford (1916) saying “It is first and weighted point of education is to lead children early to reflect”. He added that outdoor nature offers endless opportunities for symbolic and reflective thinking. Therefore, Froebel believes in developing high-order thinking skills in young children, which he believes to happen most through gardening (physical interaction with nature) (Lilley, 1967; Tovey, 2022). Below,

Table 4 shows the interrelations between Metacognition models and Froebel's kindergarten approach for developing children's thinking skills through interacting with nature.

Table 4: The Interrelation between the Froebel kindergarten approach and metacognition. Source: (Lilley, 1967; Fisher, 1998; Whitebread et al., 2007; Robson, 2010; Magno, 2010; Nazarieh, 2016; Spalding, 2020; Tovey, 2022) modified by the author.

Thinking process	Froebel kindergarten approach (Thinking skills develop through child-nature connection)	Metacognition
Questioning	Through observing the plants growing, they develop a sense of wonder, <u>asking questions</u> about how? Why? When? And what for? (Lilley, 1967).	Curiosity brings children to explore and <u>ask more questions</u> , which motivates problem-solving techniques and develops them (Spalding, 2020).
Evaluating	Each child has his own plot of land to plant, water, and harvest, which brings up a sense of responsibility and <u>learning from mistakes</u> (Tovey, 2022).	<u>Reflecting on the previous</u> tasks and <u>evaluating</u> them is a part of metacognitive thinking (Fisher, 1998; Spalding, 2020).
Discussing and reflecting	Besides gardening the child's own plot, he also shares in caring for the communal garden working with other adults, and interacting with them through <u>talking, discussing, and reflecting</u> (Tovey, 2022).	Metacognitive thinking is better developed in a social context and through peer <u>discussions</u> and adults' guidance. Social interaction is a good environment for developing metacognition (Whitebread et al., 2007; Robson, 2010).
Building knowledge	Froebel's approach assured the benefits of connecting children's <u>previous knowledge</u> to new ones, as the new <u>connection</u> they create when seeing natural elements such as leaves, worms, and soil (Tovey, 2022).	Knowledge about cognition is one of the two models for metacognition, where the child is aware of his <u>knowledge</u> and can <u>reflect and build on it</u> (Magno, 2010; Nazarieh, 2016).

This shows that Froebel in his first founded childcare center has greatly intended to enrich the children's high-order thinking skills in his institute through their interaction with nature. Direct interaction with nature through observing its growth, and its life process, and having a sense of responsibility for a living organism brings development to a child's thinking skills in metacognition as questioning, evaluating, and reflecting. Froebel supported children's direct interaction with nature in his institute through its vision, architectural zones and designs, activities, and more. Digging deeper into this, Froebel was able to define specific characteristics in nature and the corresponding beneficial effect it has on children's high-order thinking skills. From this, researchers, educators, and caregivers can easily investigate how biophilic design – as a child-nature approach in architecture – when applied, would greatly support the children's metacognition. Furthermore, this information provided by Froebel could be a way for them to identify the specific elements and attributes in the biophilic approach that they may include in their childcare centers' design to support their children's metacognition and thinking skills. The below Table 5 shows the specific characteristics in nature described by Froebel, their effect on a child's thinking skills, and the biophilic attributes that interrelate with them.

Table 5: Froebel and biophilic design approach to nature. Source: (Kellert et al., 2013; Tovey, 2017, 2022; d'Ascoli and Hunter, 2022) modified by author.

Nature in Froebel's approach	Child's thinking skill development	Biophilic Design Approach (Kellert et al., 2013)	
		Attribute	Element
Ever-changing environment	- Connecting children's previous knowledge to new ones (<i>Observing the growth of plants, animals, and different seasons</i>) (Tovey, 2017, 2022).	Age, change, and the patina of time	Natural patterns and processes
Rich sensory environment	- Learning about their senses experiencing new colors, smells, shapes, substances, and energies which tickle their creativity. - Gaining knowledge and synthesizing it into their understanding of their world (<i>Observing</i>) (d'Ascoli & Hunter, 2022).	Sensory variability	Natural patterns and processes
		Information richness	Natural patterns and processes
		Information and cognition	Evolved human-nature relationships
Full of exciting features	- Stimulate exploration <i>through active learning, play, and talk (interaction)</i> . 1. (Tovey, 2022)	Curiosity and enticement	Evolved human-nature relationships
		Exploration and discovery	Evolved human-nature relationships
Open-ended (transformational) materials	- Increase imaginative skills in play - Creativity (<i>endless opportunities to form shapes and patterns</i>) (Tovey, 2017, 2022)	Change and metamorphosis	Evolved human-nature relationships
Wild areas	- Provide an opportunity for exploration and imagination (Tovey, 2017)	Exploration and discovery	Evolved human-nature relationships
Places to hide in	- Creating their small world or kingdom by themselves (Tovey, 2017)	Mastery and control	Evolved human-nature relationships

4.4 Biophilic Design Attributes for Metacognition's Support

As previously mentioned, the previously shown tables (**Error! Reference source not found.**) and (Table 5: Froebel and biophilic design approach to nature) show certain characteristics in nature, and therefore, the corresponding biophilic attributes that stimulate reflective thinking and high-order thinking skills in metacognition. The below Table 6 is a guideline reference for all the biophilic attributes gathered in this study that showed an interrelation in supporting metacognition.

Table 6: Biophilic Design Attributes for Metacognition Support (Author)

Element	Attributes
Environmental Features	All attributes
Natural shapes and forms	All attributes

Natural patterns and processes	Sensory variability/information richness/age, change, and the patina of time /fractals
Light and space	All light attributes
Place-based relationship	Spirit of place / avoid placelessness
Evolved human-nature relationships	Order and complexity/curiosity and enticement/change and metamorphosis/ mastery and control/affection and attachment/attraction and beauty/exploration and discovery/information and cognition

The interrelations between Froebel theory, metacognition, and biophilic design discussed in Table 5 reveal some preliminary insights about certain characteristics in nature and the corresponding biophilic attributes that stimulate specific thinking skills in children. The below Table 7 below shows children’s thinking skills and the biophilic attribute that stimulates each.

Table 7: Biophilic design attributes and metacognitive skills (Multiple documents modified by author).

Biophilic Design Approach		Child’s thinking skill development
Element	Attribute	
Environmental features	<i>* Direct connection with a purely natural environment allows the child to be exposed to nature’s several characteristics affecting “several aspects in child’s thinking skills and development”</i>	
Natural shapes and forms	<i>* Stimulating and mimicking natural features considering their curvature and softness, saturation degree of colors, and variability can be a source for a soft fascination state, providing “some rest and relaxation, refreshment and restoration for child’s mind.”</i>	
Natural patterns and processes	- Age, change, and the patina of time	Connecting children’s previous knowledge to new ones (Tovey, 2017, 2022).
	- Sensory variability	Tickling their creative side (d’Ascoli & Hunter, 2022).
	- Information richness	Gaining more knowledge and synthesizing it to their own understanding of the world (d’Ascoli & Hunter, 2022).
- Information & cognition		
Evolved human-nature relationships	- Curiosity & enticement	Stimulate exploration (Tovey, 2022)
	- Change & metamorphosis	- Increase imaginative skills (<i>symbolic play</i>) - Creativity (Tovey, 2017, 2022)
	- Exploration & discovery	Provide an opportunity for exploration and imagination (Tovey, 2017)
	- Mastery & control	Creating their own small world or kingdom by themselves (Tovey, 2017)

4.5 Design Guideline for Childcare Centers – DGCC (extracted from Biophilic Design elements)

Designing children’s centers should not be limited to designing the building that the children occupy and just having an outdoor area with artificial playing instruments. As it happens in many cases, the childcare center starts from a villa that is no longer used as a residential building. Instead, it is transformed to use the building for the children’s academic lessons and the villa’s garden as the outdoor area, without much studying the site’s aspects and re-plan it to satisfy the new usage.

The childcare center's design should start outside to the inside. Children’s outdoor natural area is considered the direct form of connection with nature, which carries the depth of nature's benefits. Therefore, providing an outdoor area with natural features for children is on top of the design criteria for their physical environments. These concerns raise the question of whether there is a need to revisit the design criteria of childcare centers, considering planning the site area from the beginning up to the details of the interior furniture and materials. Biophilic design attributes have triggered all the design phases of physical environments, considering the relation between nature, space, and user from the very early designing phase (place-based relationship) until the details of the interior materials, patterns, shapes, and light.

As shown in the below diagram Figure 7, the proposed "Design Guideline for Childcare **Error! Reference source not found.**Centers - DGCC" is inspired by biophilic design attributes that triggered several aspects in the design phases. It includes four phases for designing children's environments that start from the theme phase, pass by the planning and design phases, and end with the quality phase.

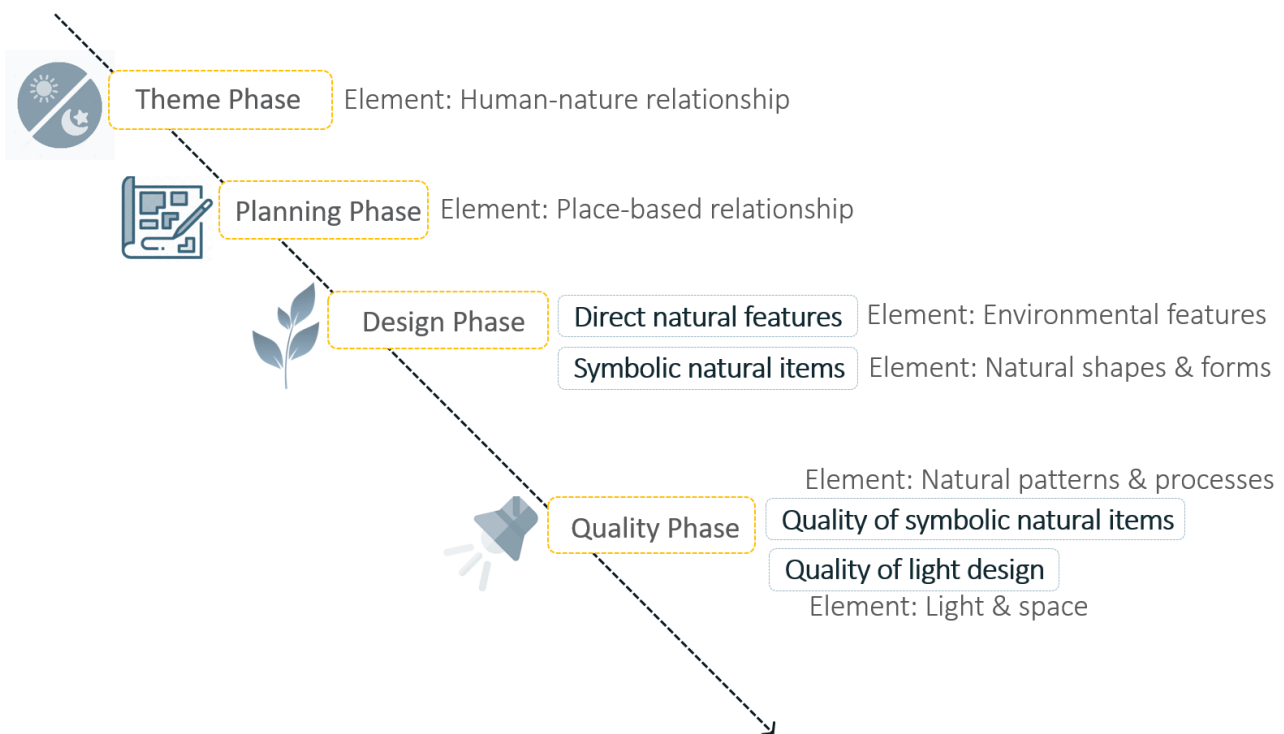


Figure 7: Proposed Design Guideline for Childcare Centers - DGCC (Author)

The "Design Guideline for Childcare Centers - DGCC" starts with the "Theme Phase" for the childcare center, where the designers, in collaboration with the educational leaders and decision-makers, design the environmental experience for the children. Children should be provided with a positive environmental experience. Besides that, designers can provide ideas for a specific theme (e.g., jungle theme, aquarium theme, desert theme, space theme) or variable themes (e.g., weather seasons themes) for the design theme of the environment. This phase is inspired by the (Human-nature relationship element) in the biophilic approach.

The second phase is the "Planning phase", where the land's zones and areas are considered in functionality and placement, as well as considering other perspectives regarding the relationship with the surrounding places as in privacy, safety, and noise. The planning phase is inspired by the (place-based relationship element) in the biophilic approach, considering its attributes (as the cultural, historical, and ecological connection to the place / landscape orientation / spirit of place / avoiding placelessness) would add more strength to the relation of the childcare center site to the environment's context. The following diagram Figure 8 introduces more factors that specifically target the needs of childhood environments in this "planning phase."

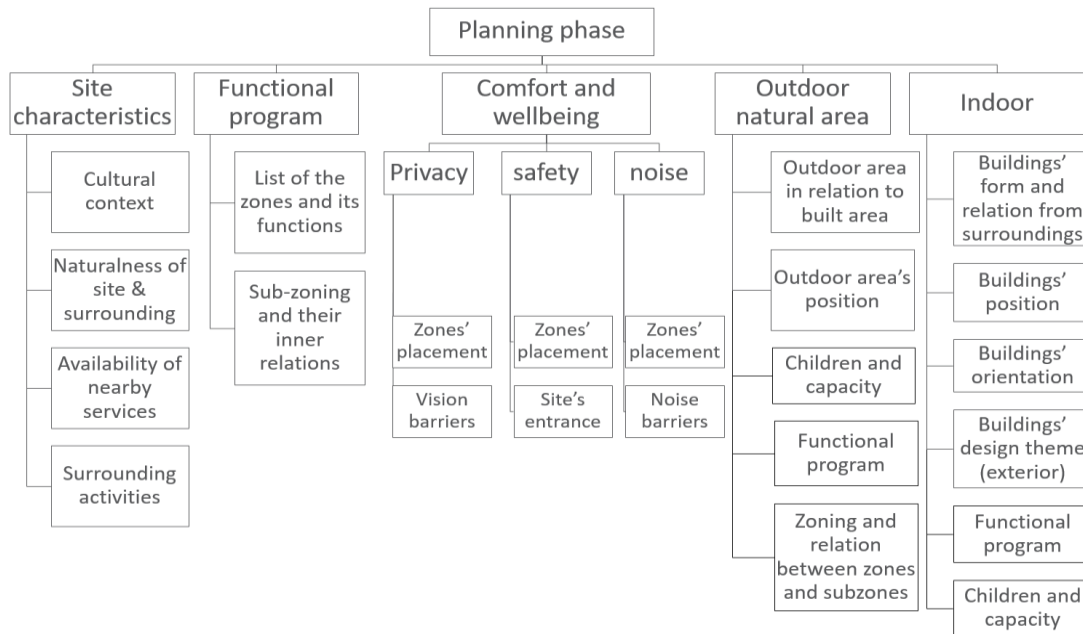


Figure 8: Factors in the planning phase for children's environments (Author)

The planning phase starts with site characteristics, and this factor, should be considered the type of environment in which the childcare center will be placed; this varies between urban and rural contexts. However, in both types, the quality of the environment should be well selected for the providence of an ideal environment for the children to be raised in. Also, the context's naturalness will affect the quantity of nature we provide for children. Nature should be considered either way; however, in urban contexts – where hardscape is widely used - it is more necessary that the childcare center's site provides a more richly natural environment for the children. Another factor is the availability of services, considering the emergent services availability in case of an emergency need for any injury or health conditions. Also, the availability of natural sites and places for activities around the site would add more livability, such as parks, science theaters, and educational gardens. The second factor in the planning phase is the functional program, where zones and subzones are listed according to the activities and services needed, considering the relation between zones and subzones. Thirdly, the comfort and well-being of the site, this is regarding the site's privacy, safety, and noise. Things like these should be studied from the early stages of design and considering the alternatives in case of lacking, such as vision and noise barriers and locating the children's entrance regarding their safety and security. Fourthly, studying the needed area for outdoor space, its orientation, and location in the site area, its functional program, its zoning and sub-zoning, and the relation between subzones, children, and capacity. A well-studied outdoor area should contain all the children's needs for exploring, movement, gardening, playing, and security. The last factor in the planning phase is studying the children's indoor area and this includes the indoor area concerning children and capacity, functional program, the position and orientation of the building would affect the quality of the indoor environment for children and could create the most child-nature connection possible in the site. Adding to that, considering the outdoor and indoor connection by providing the indoor a view to the outside as a visual access and designing physical access to the outdoor.

Following this is the "Design phase," where the applications for the selected theme take place, and the ideas to reach that theme develop into practical ones. In this phase, the ideas for nature-connection can be applied using the (Environmental Features element) for actual natural features and the natural shapes and forms element) for the symbolic natural ones. Finally, the "Quality phase" is the fourth phase, which assures achieving the desired aim in the design theme line. For example, not every pattern taken from nature and repeated can resonate with the real one, nor can copying a shape from nature mimic the same real one. Colors, patterns, shapes, and light in nature have variable equations in patterns' rhythms, proportions, richness, and saturation degrees of colors that need more study. Not every lightening can be considered close to the natural light properties. Fortunately, some institutes have already begun to explore this approach, especially in terms of light. Some electric light institutes mention the beneficial effect

of daylight on humans and therefore try to get closer to its properties in manufacturing artificial lamps. (Natural patterns and processes element), (Light and space elements) in the biophilic approach are used in this phase.

5. Conclusion

This study aimed to investigate the biophilic approach in supporting children's metacognition in childcare institutes. Results show that biophilic attributes create a restorative environment that supports metacognition. Based on a multidisciplinary literature review, this paper studied the interrelations between: (1) Restorative environment & metacognition, (2) Restorative environment & biophilic approach, and (3) Nature-connected environments & children's metacognition in Froebel's approach. This paper's findings show three conclusions: firstly, a restorative environment supports reflective thinking and high-order thinking skills in metacognition; secondly, a restorative environment's criteria are fulfilled in biophilic design attributes; and thirdly, specific metacognitive skills are supported by certain biophilic attributes. The interrelations analyzed and the concluded findings in this study provide a proposed design guideline for childcare centers, that is abstracted from the biophilic elements and their attributes. Finally, this study helps to better understand how to use a biophilic design approach in childcare centers' design to support children's metacognition through natural connection.

6. Recommendations

Additional key stakeholders, including government bodies, community groups, and organizations, should actively implement the child-nature connection approach by incorporating biophilic elements. They can develop nature grounds in childcare centers and school districts beside the park systems. The growing body of studies consistently highlights the significant negative impacts of children's disconnection from nature, underscoring the need for government intervention. Consequently, there is a compelling case for authorities to establish minimum standards for nature-connection in childcare centers through licensing regulations.

Recognizing the characteristics of children's physical environment and their effects on children could provide more insights to decision-makers from educators, architects, and planners to participate in developing better environments for them. This collaboration can lead to developing better environments for children that prioritize and enhance the child-nature connection.

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