

**Natural [Re]connection:  
Facilitating the Development of Preschool Children Through  
Nature Rich Environments**

by

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## **Abstract**

Humans have an instinctive attraction to the living world and growing research suggests that interactions with nature makes us healthier and happier. Early childhood development theories demonstrates that it is essential that children are in contact with nature and this, as much as possible.

This thesis addresses early childhood group age and how to appropriately implement nature rich environments into an urban kindergarten in Halifax, Nova Scotia. The thesis also advocates for a more natural way of teaching where creativity, child led play and tactile learning are at core while demonstrating the importance of nature for children and lists multiple studies researching the consequences of restrain exposure to the natural world. Through biophilic design and the natural environment studies, this thesis aims to provide a framework that can be adapted to any urban setting educational facility.

# Acknowledgements

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Un merci tout particulier à ma famille, Étienne, Lucie, Martin et mes parents, Lise et Gilbert, pour votre écoute et vos encouragements inconditionnels.

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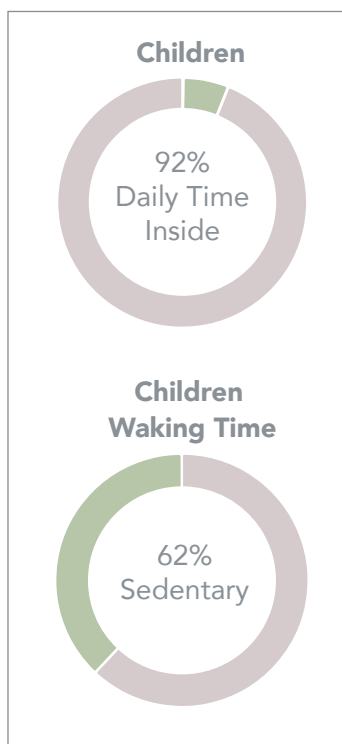
(Reddit 2016)

## Chapter 1: Introduction

Through my window, an autumn sun ray peeks and caresses my cheek as I observe this little bird, searching through my balcony garden for any left overs, “don’t eat the hot peppers” I whisper at him. (author)

Architecture can create spaces where interactions with nature becomes intertwined with our everyday routine. This thesis proposes that through proper designing of our buildings, surroundings and cities, we can create environments where a diversity of life are welcome and can thrive in our company. Furthermore, as this contributes to help the abundance and complex sets of life around us, it simultaneously benefits our mental and physical well-being. As the architect Frank Lloyd Wright expressed, “Study Nature, love nature, stay close to nature. It will never fail you” (Frank Lloyd Wright in Gray and Birrell 2014, 12205).

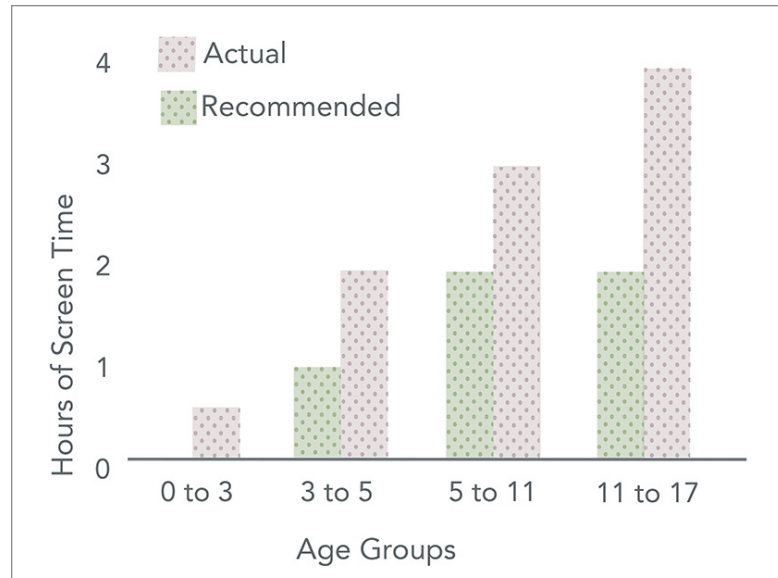
Humans evolved in a biological--not artificial or manufactured--environment and continue to depend on ongoing contact with nature for their physical and mental well-being. Sadly, however, the quality and character of the contemporary built environment has increasingly isolated people from the beneficial experience of natural systems and processes. (Kellert 2005, 123)



(Colley et al. 2011)

Spending now nearly 92% of their day inside and 50% less time outside then their parents did at their age, Canadian children are becoming more sedentary than ever before even though we know the importance of fresh air and physical activity. In average, Canadian children spend double the recommended screen time per age group and this time keeps augmenting as children grow into adolescence and adulthood.

Contact with nature is crucial to childhood development benefiting on mental well-being, stress levels, self-esteem,



Canadian children screen time per age group, recommended daily time from Canadian Society for Exercise Physiology (Colley et al. 2011, 461; Canadian Society for Exercise Physiology 2012)

motor skills and cognitive performance to name a few. Outdoors activities stimulates creative play and cooperation. As kindergarten age children are developing their language and sensory neural pathways, it is fundamental that they engage with their peers in a natural setting.

The intention of this thesis is to develop a framework to implement appropriate nature rich environments into urban kindergartens, which could be adopted across Canadian cities, and to demonstrate sets of tools that could be used singularly or in combinations. The principals and tools are tested utilizing the design of an urban kindergarten in Halifax, Nova Scotia with over 120 children.

## Chapter 2: Humans And Nature

Explanations of what is nature can vary greatly and to put it simply, can be split into two extremes. One extreme is that that all material things are considered as part of nature, which would mean, by this definition, that a machine or an oil spill is part of nature. The other extreme determines nature as the “great outdoors”, which would eliminate anything made by humans (Louv 2008, 8). For the purpose of this thesis, a definition closer to the one of biophilic design will be used.

Biophilic design is “defining nature as living organisms and non-living components of an ecosystem--inclusive of everything from sun and moon and seasonal arroyos, to managed forests and urban raingardens, to Nemo’s fishbowl habitat” (Browning, Ryan and Clancy 2014, 8).

Research continues to support the importance and power of human-nature connections. Research show that contact with nature moderates stress, enhances positive mood, improves cognitive skills, better physical well-being and even mitigate effects of ADHD, autism, and other childhood illnesses. (Zardiac and Pergams 2007, 130; Mygind et al. 2019, 17; MacKerron and Mourato 2013, 992; McCormick 2017, 3). A study from Texas A&M University studied the recovery time of patients with a view of trees compared with some with a view of a wall. The patients with a view of trees recovered faster.

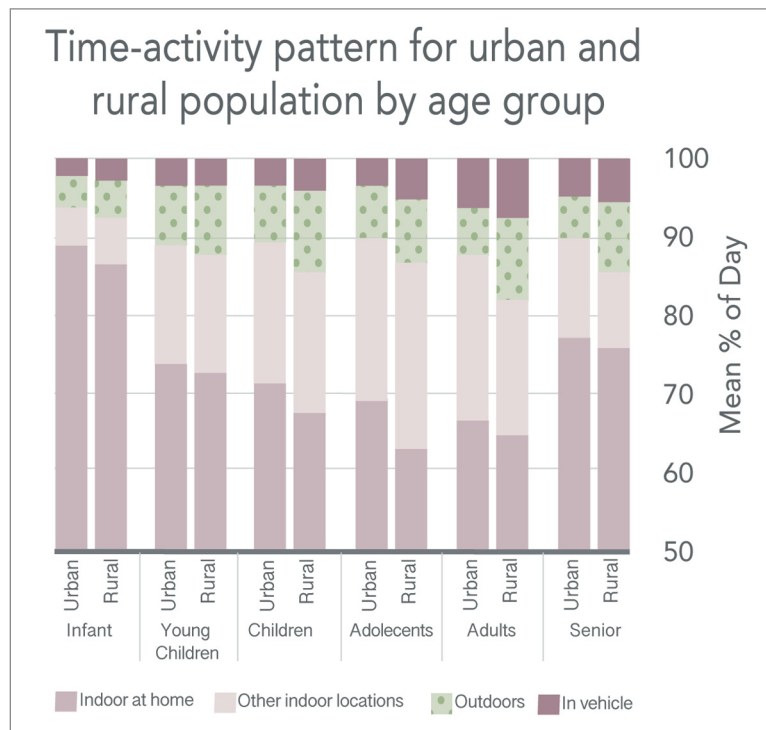
The patients with the tree view had a shorter postoperative stays, had fewer negative evaluation comments from nurses, took fewer moderate and strong analgesic doses, and had slightly lower scores for minor post-surgical complications. (Ulrich 1984, 420)





Positive effects of contact with nature. (data from Zardiac and Pergams 2007, 130; Mygind et al. 2019, 17; MacKerron and Mourato 2013, 992; McCormick 2017, 3)

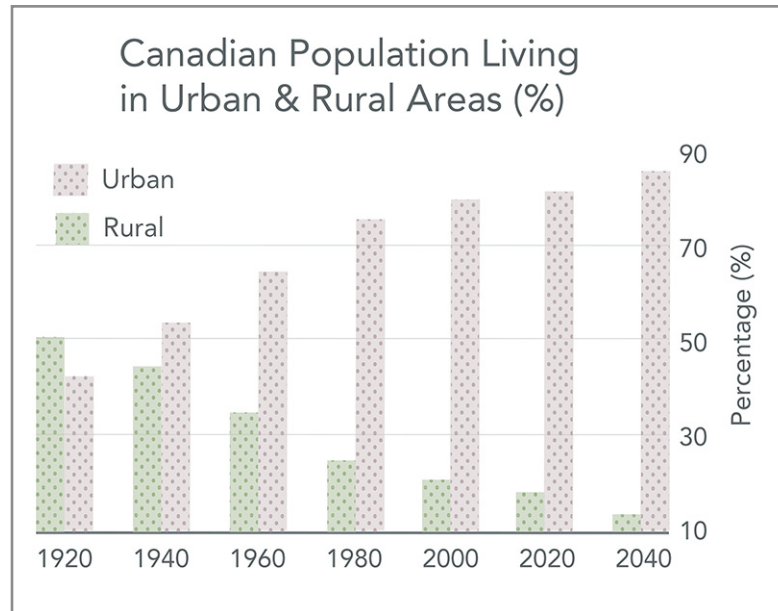
Evidence shows that people living in rural areas are happier and spend more time outside than their city counterpart (MacKerron and Mourato 2013; Adli 2011, 2; Matz, Stieb, and Brion 2015, 4).



Time-activity patterns for urban and rural population by age group (Matz, Stieb, and Brion 2015, 4)

As the global urban population continues to grow, it is crucial that cities and buildings are designed to help us stay connected with our natural environment. As Beatley explains, “we need nature in our lives; it is not optional but essential” (Beatley 2011, 3). Furthermore, research is showing that we are quickly approaching a tipping point with our ecosystems around the globe. Since children are our hope for the future, we need to teach them good habits and a respect of nature that they will practise throughout their lives.

“No one will protect what they don’t care about. And no one will care about what they have never experienced” (David Attenborough in Parks Canada Council 2014, 26).



Canadian population living in urban and rural areas (%)  
(Statistics Canada 2011)

## Biophilia

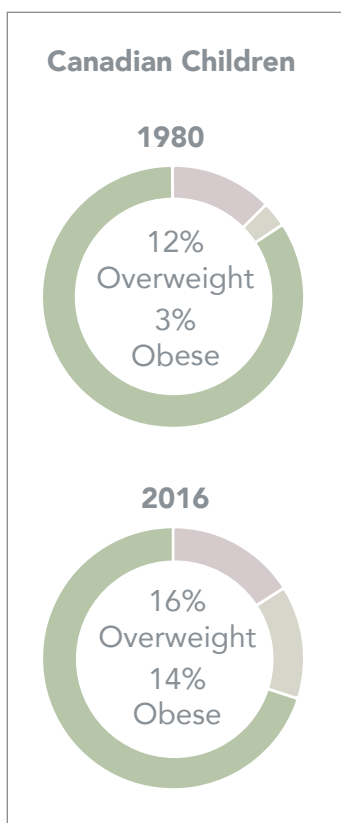
The term biophilia was first introduced by German-born American psychoanalyst Erich Fromm in 1973 and later popularized by the American biologist, Edward O. Wilson in his book, *Biophilia*, in 1984. Wilson describes biophilia as the societies “urge to affiliate with other forms of life” (Wilson 1984).

This appreciation for the colors and diversity of nature is universal and can be seen throughout cultures with their representation of natural elements in their historical traces and artifacts. The recent human disconnection with nature began in parallel with the humanity’s transition to industrialization. The last few hundred years were the most significant in the transformation of the human relation with nature (Maller et al. 2005, 46). As the urban population continues to outgrow the rural population, it seems as if we think we can live without any contact with nature (Beatley 2011, 4).

For more than 99 percent of human history people have lived in hunter-gatherer bands totally and intimately involved with other organisms. During this period of deep history, and still further back they depended on an exact learned knowledge of crucial aspects of natural history... In short, the brain evolved in a biocentric world, not a machine-regulated world. It would be therefore quite extraordinary to find that all learning rules related to that would have been erased in a few thousand years, even in the tiny minority of peoples who have existed for more than one or two generations in wholly urban environments. (Wilson and Kellert 1993, 32)

## Nature Deficit Disorder

As our lives continue to become more virtual and indoors, children are suffering the most from this shift. Doctors are reporting troubling increases in sensory and emotional disorder (Hanscom 2016, 2) and teachers report having greater difficulties with children staying attentive in class or simply sitting still (Hanscom 2018). Nature can play a great role in helping children to stay attentive and present. A study conducted by environmental psychologist, Nancy Wells, found that being close to nature in general helped children's attention span and lower their stress levels. (Wells and Evans 2003, 323).



(Colley et al. 2011)



Nature moderates effects of stressful life events on psychological distress (Wells and Evans 2003, 321)

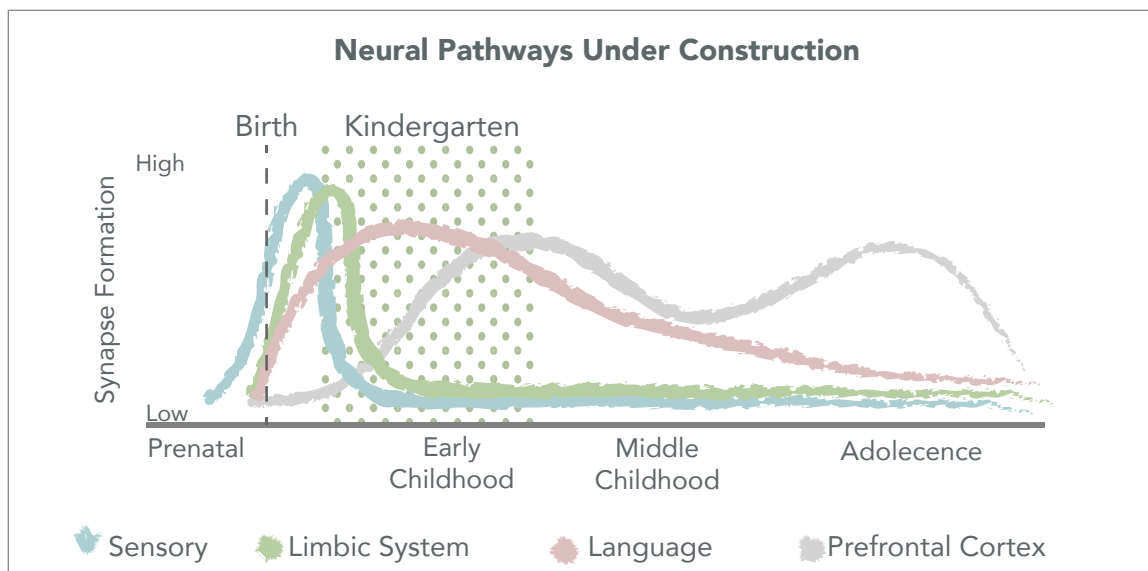
The term nature deficit disorder was introduced by Richard Louv in his 2008 book, *Last Child in the Woods--Saving our Children from Nature-Deficit Disorder*, Louv is one of the first to raise the flag about the problems of children's exposure to nature and to bring together the growing body of research to illustrate the importance of nature in childhood development.

The "term is by no means a medical diagnosis, but it does offer a way to think about the problem and the possibilities-for children, and for the rest of us as well" (Louv 2008, 10). He goes on to explain that this disorder can be found from the individual to communities and cultures (Louv 2008, 10).

As Louv advocates: "time in nature is not leisure time; it's an essential investment in our children's health (and also, by the way, in our own)" (Louv 2008, 120). With now more than 1.1 million Canadians having a Vitamine D deficiency (Parks Canada Council 2014, 3). We need to take responsibility in encouraging and emphasizing the importance of outdoor play to our children.

## **Children And Nature**

As pediatrician Dr. Laura Jane explains, the first five years of a person's life are crucial to create neural pathways since 85% of the brain growth is thought to happen before the age of three (Jana 2018). This is why "childhood is considered as the time when experiencing nature is the most essential to human physical and mental maturation, even for a species capable of life long learning" (Kellert 2005, 3). We need to change our perspective of nature time from weekend and vacation activities to a daily, fun, healthy



Notice the peek in synapse formation for the sensory and limbic system as well as language and its relation to the kindergarten time in a child's life (adapted from Nova Scotia Dept. of Education Early Childhood Development, and Canadian Electronic Library 2016, 45)

routine. Furthermore, we need to provide children with the access to green space they deserve.

Access to green space was associated with improved mental well-being, overall health and cognitive development of children. It promotes attention restoration, memory, competence, supportive social groups, self-discipline, moderates stress, improves behaviors and symptoms of ADHD and was even associated with higher standardized test scores. (McCormick 2017, 3)

## Legislation

Within the current Nova Scotia Day Care Regulations document (Day Care Regulations 2010, A58) there is no regulation stating that Nova Scotia's children get proper contact with nature other than fresh air in their outdoor space. Within this legislation, there is only "Best Practice" advice that children shouldn't be surrounded by brick walls and asphalt. Therefore, there needs to be a change in the current regulations to ensure that urban kindergartens support children's contact with nature.



Minimum space requirements as sq. ft. per child in kindergarten/preschool and childcare center (data from OECD 2011)

When comparing the interior and exterior spaces requirements for children in Nova Scotia, to other places in the world, we can notice that the minimums in Nova Scotia are lower than elsewhere.

The diagram above compares the minimum space requirements per child, in the kindergartens, of Nova Scotia, Massachusetts, Norway and the thesis.

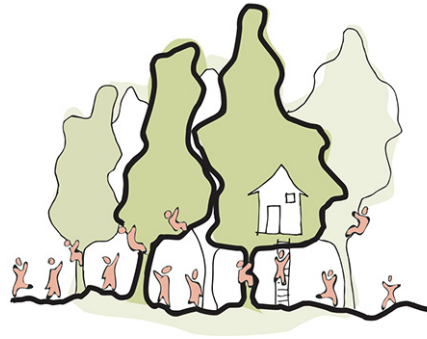
The thesis advocates to have bigger spaces for children to play and run inside as well as outside. To allow for an augmentation of space outside in an urban setting, the roof can be used as a playground and consequently augment the square footage space. For the interior space, different groups of children can cycle through the rooms, to maximize the use of the interior space.

## **Thesis Hypothesis**

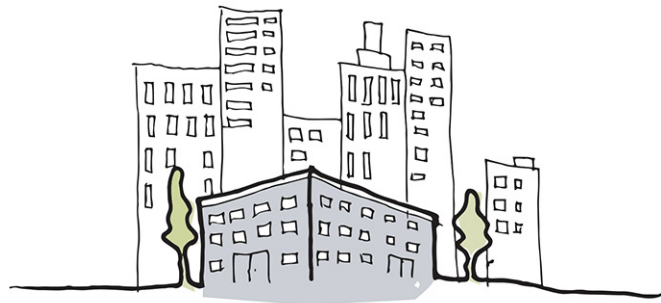
It is evident that humans are in serious need of reconnection with their natural world in their urban areas. Architecture plays an immense role in this reconnection since we spend more than 90% of our days inside. Through the design of nature rich environment, it is possible to heal the current nature deficit disorder and to advocate for the protection of our fragile planet.

Every great change happens with a new generation and what better way to start a nature revolution than to educate our children of its importance. Nature rich kindergartens find their most influential setting in urban spaces.





Natural Setting Play  
-- Children Outside --  
-- Nature Immersion --



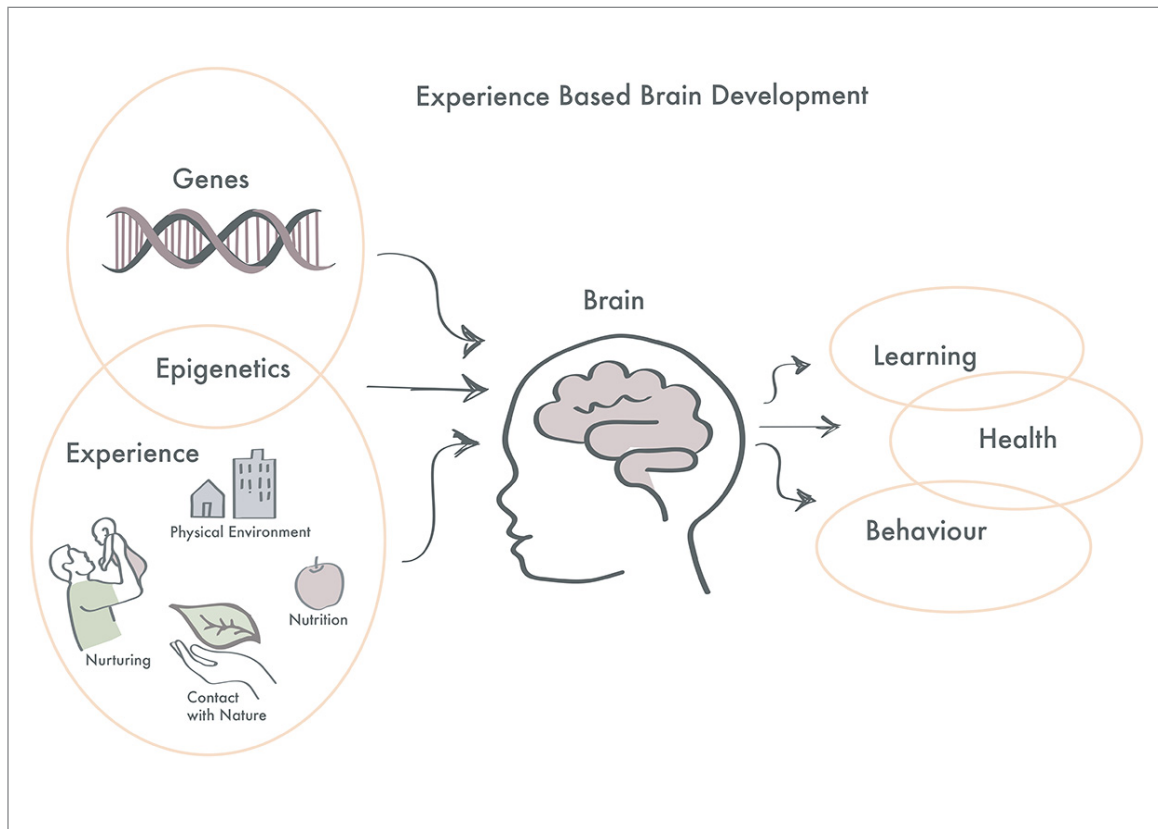
Typical City Educational Facility  
-- Children Inside --  
-- Nature Outside --



Proposed Thesis - Nature City Educational Facility  
-- Children Outside --  
-- Nature Outside & Inside --

## Chapter 3: Early Childhood Education

To create spaces for children, we first need to understand how their development and education can be addressed. This has been studied by many psychologists, sociologists, educators and theorists. For the purpose of this thesis, the educational approach will concentrate on play and contact with nature as well as Environmental Base and Place Base educational methods.

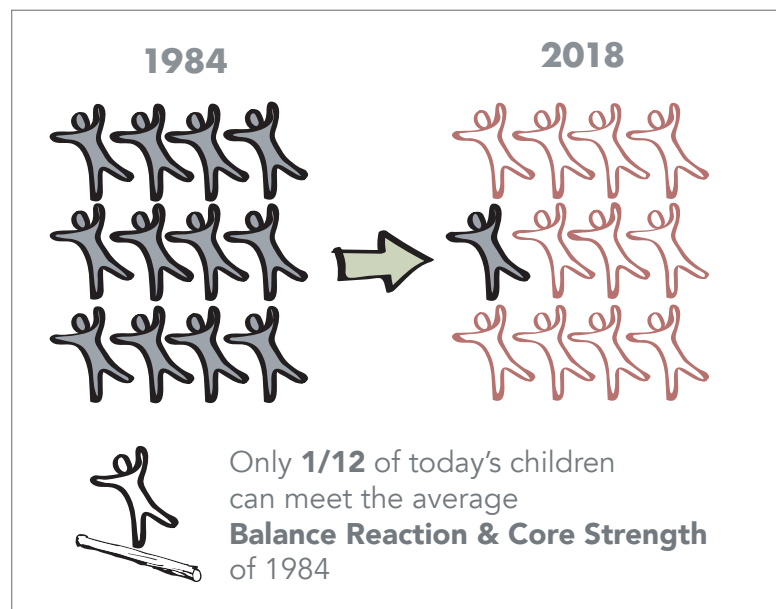


As mentioned earlier, nature plays an important role in childhood development; thus, “contact with nature” has been added as part of the “experience” elements of this diagram (adapted from Nova Scotia Dept. of Education Early Childhood Development, and Canadian Electronic Library 2016, 52)

## Play

“Play lies at the heart of childhood, limited in its boundaries only by the opportunities afforded by physical setting and by the attitudes and commitment of those whose business it is to manage them” (Robin Moore, in Stine 1997, 18).

Through his book *Free to Learn*, Gray advocates the importance of free play and explains that it is through play and physical experience that children learn the best. The lessons that children learn through tactile experiences cannot be taught verbally (Gray 2013, 24).



Comparing children's average balance reaction and core strength from 1984 to 2018 (data from Hanscom 2016, 48)

As children play, they experience everything that is crucial to their development. “Play is the highest expression of human development in childhood for it alone is the free expression of what is in a child's soul” (Friedrich Froebel in, Frost and Klein 1979, 1).

## Anji Play

Anji Play is an approach to early childhood development developed by Ms. Cheng Xueqin in Anji county, Zhejiang Province, China. The curriculum is based on “self-initiated, self-determined play, reflection and self-expression” (Coffino and Bailey 2019, 6) and was introduced without any influence of Western educational philosophy in 2001 (Coffino and Bailey 2019, 5).

Anji play believes in *True Play* which is based on children’s own needs and interests (Coffino and Bailey 2019, 4). The approach also aims to create an environment where safety and respect are at core to allow children to take “developmentally appropriate risks” (Coffino and Bailey 2019, 4). For Ms. Cheng, creator of Anji Play, play in schools is “False Play” since it is often directed and organized by adults. “True Play” comes from the child and needs to be child initiated and led. The teacher is there to observe and provide the children with the tools to freely express and reflect on their experiences.



Children playing in an Anji Play playground (base image from Anji Play 2019)

Looking at Anji Play on an architectural and design viewpoint, the most important aspects would be the materials and objects of the playground as well as the outdoor space given to play. Objects should include “ladders, barrels, planks, cubes, mats and semi-fixed play structures as well as a range of large wooden blocks” (Coffino and Bailey 2019, 6). All of those objects have a flexible function or affordance (see page 40), allowing children to create their own toys and games as well as imagining fantasy stories with the found materials.

## **Environmental Based Education**

### **Forest Schools**

Forest or Nature Schools were first introduced in Denmark as *Walking kindergarten* schools in the 1950's and were soon followed by a similar approach in Sweden called *I ur Och Skur*, “Rain or Shine”. These European educational programs have inspired similar approaches in many countries including, United Kingdom, United States and Canada, to name a few.



Children taught outside at a Forest School (base image from Forest School 2020)

One of the most important concepts of Forest Schools, which relates to Anji Play, is that play is used as a learning tool and should be child led (Knight 2013, 3). It is also founded on children using objects that can be found in their environment instead of commercial toys. The Forest School approach promotes kinesthetic learning which can therefore be beneficial to a great number of children (Turtle, Convery and Convery 2015, 3).

Even though these schools were located in the forest, there are some key components that could be brought to the design of a kindergarten in a city. These include child led play, kinesthetic learning and risky play.

### **Safety and Risk**

Letting children take risks is allowing them to learn from their experiences and respond in a safe way to their upcoming challenges. Paradoxically, it is only through letting them take risks that we can keep them safe (Andrew Barnett, Preface of Gill 2007, 7).

Self-determined risk, the natural trajectory of our growth and learning, is most often experienced as joy, and characterized by deep engagement. (Anji Play 2019)

We cannot stop parents from worrying about the safety of their child, but we can remind them of the freedom they themselves enjoyed as a child.

Activities and experiences that previous generations of children enjoyed without a second thought have been relabelled as troubling or dangerous, while the adults who still permit them are branded as irresponsible. (Gill 2007, 11)

As Louv explains: "Fear is the emotion that separates a developing child from the full, *essential* benefits of nature. Fear of traffic, of crime, of stranger-danger--and of nature itself." (Louv 2008, 123)

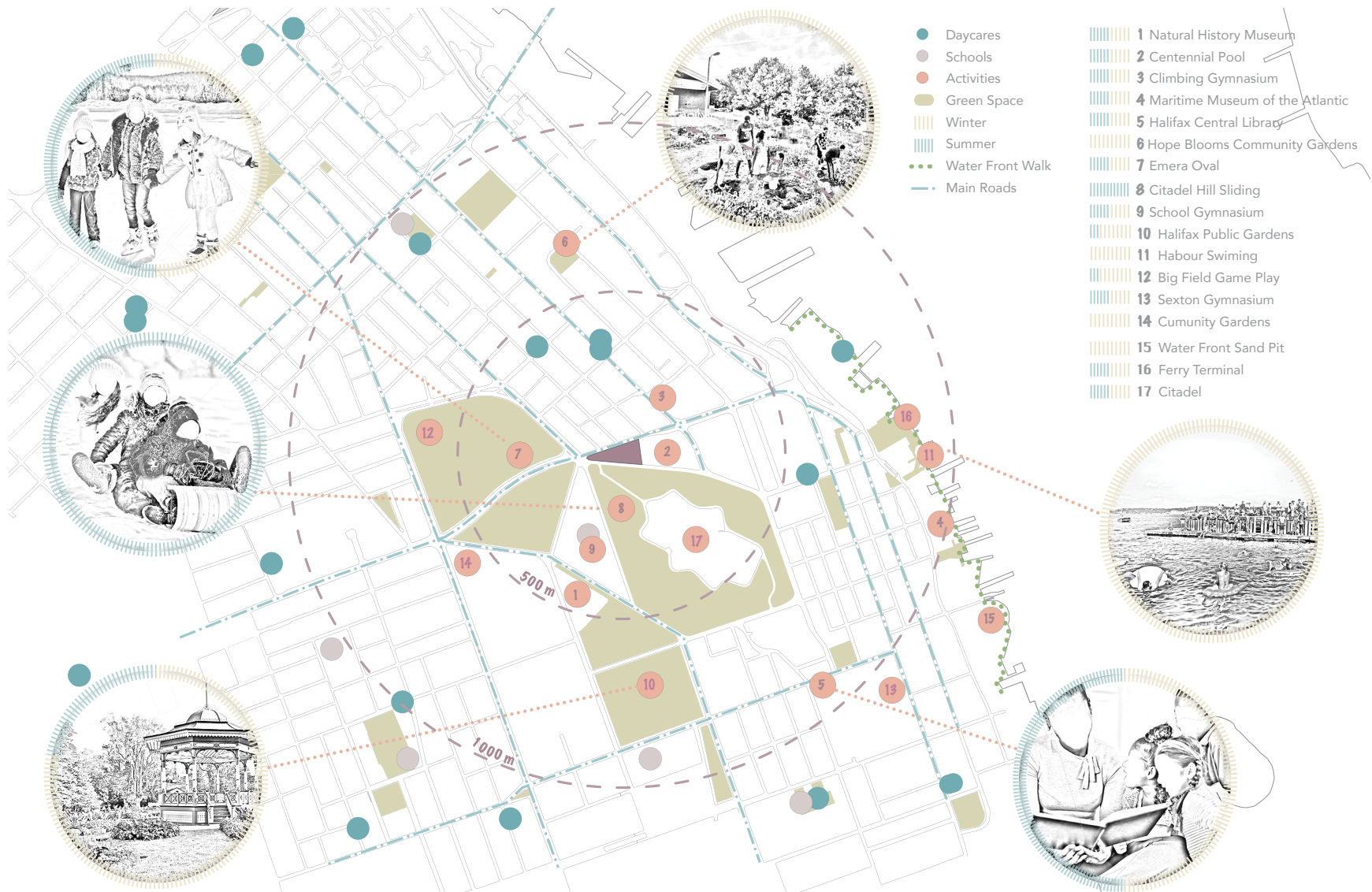


“Each prohibition on this sign may be defensible, however, the broader message is hard to avoid – as the graffiti addition makes clear” (Gill 2007, 11)

## Place Based Education

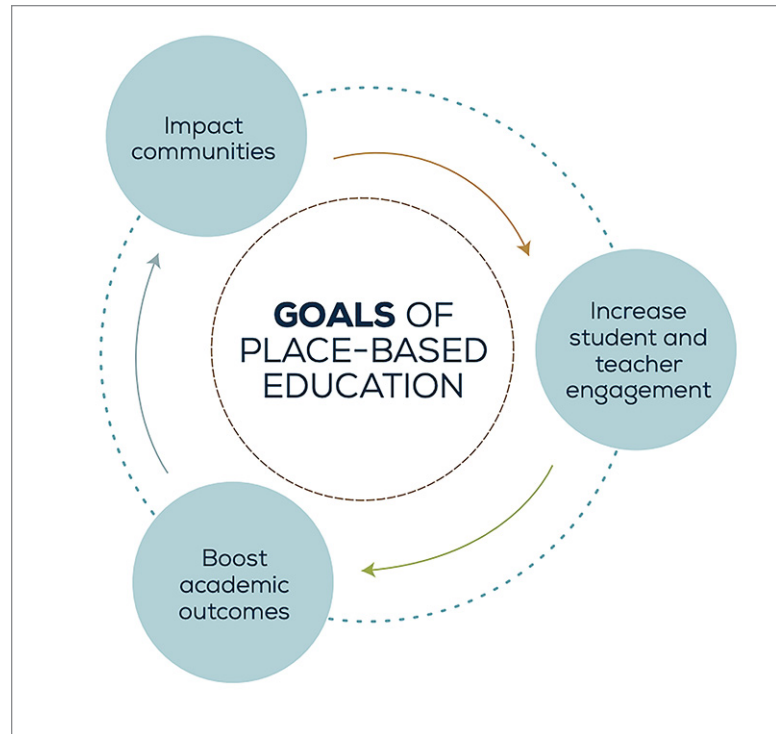
Place Based Education is an approach that aims to connect the education of children with their surrounding community. Main goals include, increasing students and teacher’s engagement, boosting the academic outcomes and positively impacting the communities to promote understanding on the world around us (Getting Smart Staff 2017, 5).

The method can be developed anywhere including an urban setting. Simply, Place-Based Education is about using the immediate environment of an educational facility to create learning opportunity and community connections. As the next page map shows, the Halifax site allows for a wide range of learning experiences, example: the views of harbor and city from the Citadel, The Oval (rollerblading and winter skating), Hope Blooms’ community garden, the Museum of Natural History, to name a few.



Activities within walkable distance of the site





Place-Based Education goals (Getting Smart Staff 2017, 5)

### Open Air Schools

The open air movement was a reaction to the spread of tuberculosis in children occurring in the period leading up to the Second World War. The ideas were constructed on the concept that fresh air, good ventilation and contact with the outdoors would improve the children's health. The institutions were established by doctors and educators interested in a new open air educational experience.

The first school was implemented in Berlin, Germany and supported by the International Congress of Hygiene, which shortly after, opened more schools around Europe and North America. They often reused old structures or set up tents in proximity to a city but far enough to allow the children to be away from the pollution of the cities industries.



Children dressed up for the winter weather in an open-air school in the Netherlands (Spaarnestad Photo 2015b).



Children taught outside in the Netherlands (Spaarnestad Photo 2015a).

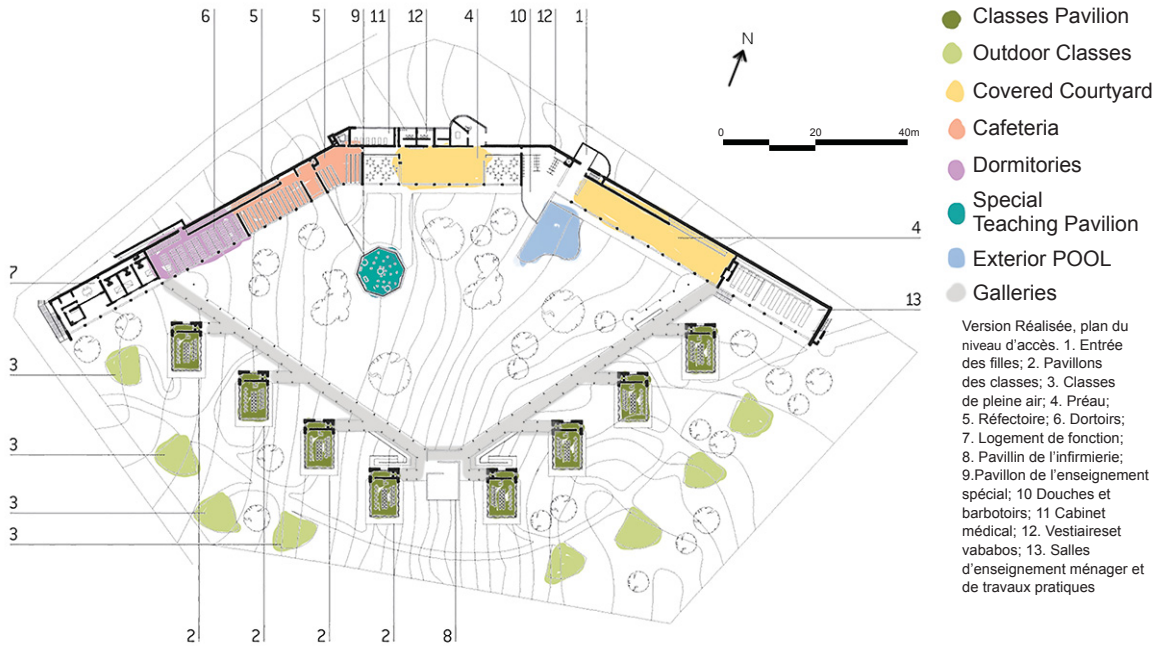
Architects specified that the open air schools were to have large windows to be operable and a heating system that could work with opened windows. Although the movement influenced some aspects of the evolution of education and hygiene, it was quickly dismissed after World War II with the introduction of antibiotics to cure tuberculosis.



A set of columns allow the walls to be open to the exterior in an open air school in New York, 1910. (Riis 1910)

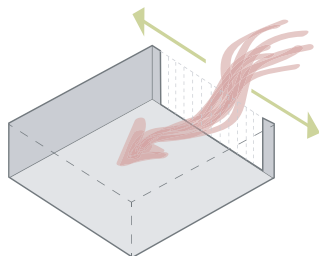
### ***L'École de Plein Air, Suresnes, France***

Located in Suresnes, France, l'École de Plein Air was designed by Eugène Beaudouin (1898-1983) and Marcel Lods (1891-1978) and considered one of the most important Open Air Schools. The school was built in the early 1930s and consisted of eight class pavilions dispersed in a park connected through a circulating series of galleries. Each classroom was also combined with an outdoor classroom which allowed for a specific learning environment that encouraged observation skills. The school is also known for its giant outdoor globe (see page 27) where children could tactilely learn the world's geography.



Floor plan of L'École de Pleine Air showing the classes pavilions and the outdoor classes.

The building is specifically oriented to allow maximum exposure to the sun. Each class pavilion consists of three complete glass sliding panels. This provides for a deep connection with nature allowing fresh air, views of nature as well as the sounds of wind and birds to enter the classroom.



Openable walls



Class pavilion in L'École de Pleine Air with three opened walls (Lods 1936)

The building also has a very specific relationship with its site and surrounding nature creating a safe inner courtyard for the children to play. This strategy could easily be used for a kindergarten considering that the outdoor play space would otherwise have to be fenced.

## Montessori Approach

The Montessori approach and philosophy developed by Maria Montessori in the early 1900s focuses on promoting creativity, curiosity and encouraging children to investigate and explore for themselves. The environment is divided by age groups, for a kindergarten there would be a group of under three years old and an other of three to six years old. The classrooms are organized by themed areas which consist of materials of all kinds organized in open shelves to invite children to explore individually or with peers.

In the Montessori curriculum, children under three years of age are encouraged to develop concentration, speech and coordinated movements, allowing the child to gain



Exterior playground in a Montessori school (Natural Playground Ideas 2019)

confidence and discover her/his potential and place in the community. For the three to six year old, the curriculum is devised into four working areas: practical life, sensorial, language and mathematics (Fundación Argentina Maria Montessori 2018).

A more just and charitable attitude would create an environment in which children were free from the oppression of adults, where they could really prepare for life. The school should feel like a shelter from the storm or an oasis in the middle of a desert, a safe haven for the child's spirit (Maria Montessori in Migliani 2019)

## Chapter 4: Design Principals

### Sensory

Before any kind of listing of design principals is introduced, a better understanding of the way children experience the space around them is necessary. Childhood is the time in our life where one is the most receptive to it's senses.

Because Children are highly motivated to learn about everything, effective teachers of the very young manipulate environments, not children. Designers and teachers set the stage for children's learning about their bodies and what they can do, their relationships with other people, and all the wonders of the world. (Elizabeth Jones in Stine 1997, 14)

Our senses help us process important information throughout the day. The sound of children playing, the rise of humidity before a storm, the smell of baked cookies, all these little clues allow us to make decisions about our surroundings. For children, who are experiencing new things everyday, it is essential that they are given an environment which allows for a range of sensory stimulus, "children need nature for healthy development of their senses" (Louv 2008, 55).

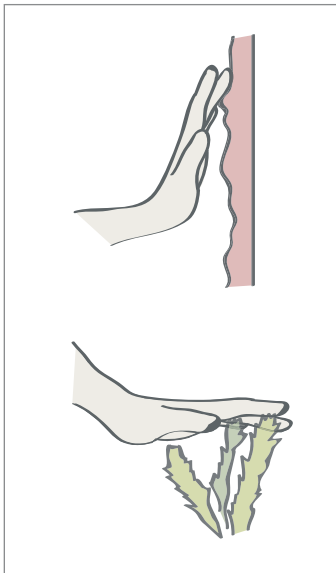
Juhani Pallasmaa emphasizes: "Every touching experience of architecture is multi-sensory; qualities of space, matter and scale are measured equally by the eye, ear, nose, skin, tongue, skeleton and muscle" (Pallasmaa 2012, 45).

### Touch and Kinesthetic Learning

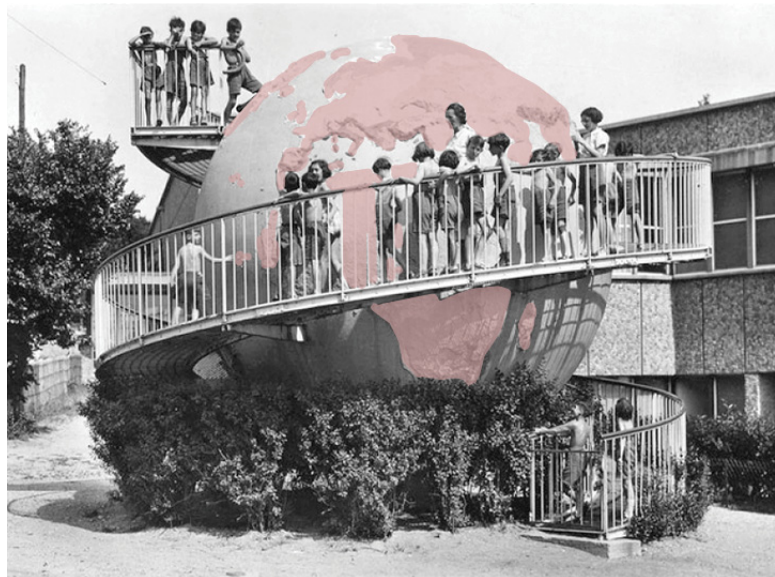
The sense of touch starts its development in the womb and our skin is the largest organ of the human body (Biel and Peskev 2009, 28). The sense of touch gives us the information needed to "feel" the environment around us and at every given moment we are passively or actively touching something, (Hanscom 2016, 45). We sense what

temperature it is outside, wet grass under our feet, the heat of the sun on our skin or simply a cold tiled floor.

It is important to allow children to experience these physical changes in their environment and give them tactile opportunities to learn. A great example of this is in L'École de Pleine Air in Suresnes where a textured 3D globe was constructed to allow children to feel the differences between land, water and mountain as they are learning geography.



Tactile learning



A ramp running around the globe allowed children to feel the changes in land around the world at L'École de Pleine Air, Suresnes activating their tactile learning capacities. (Le Parisien 2015)

### **Vesibular Sense**

The vestibular sense is arguably the most important sense for children since it's malfunction affects the auditory senses as well as the balance and body awareness. This sense, which is also known as the balance sense, is responsible for the understanding of one's body in space, coordination, skillful balance and body awareness (Hanscom 2016, 48). An American study compared core strength and balance reaction of elementary school children from 1984 to 2018.

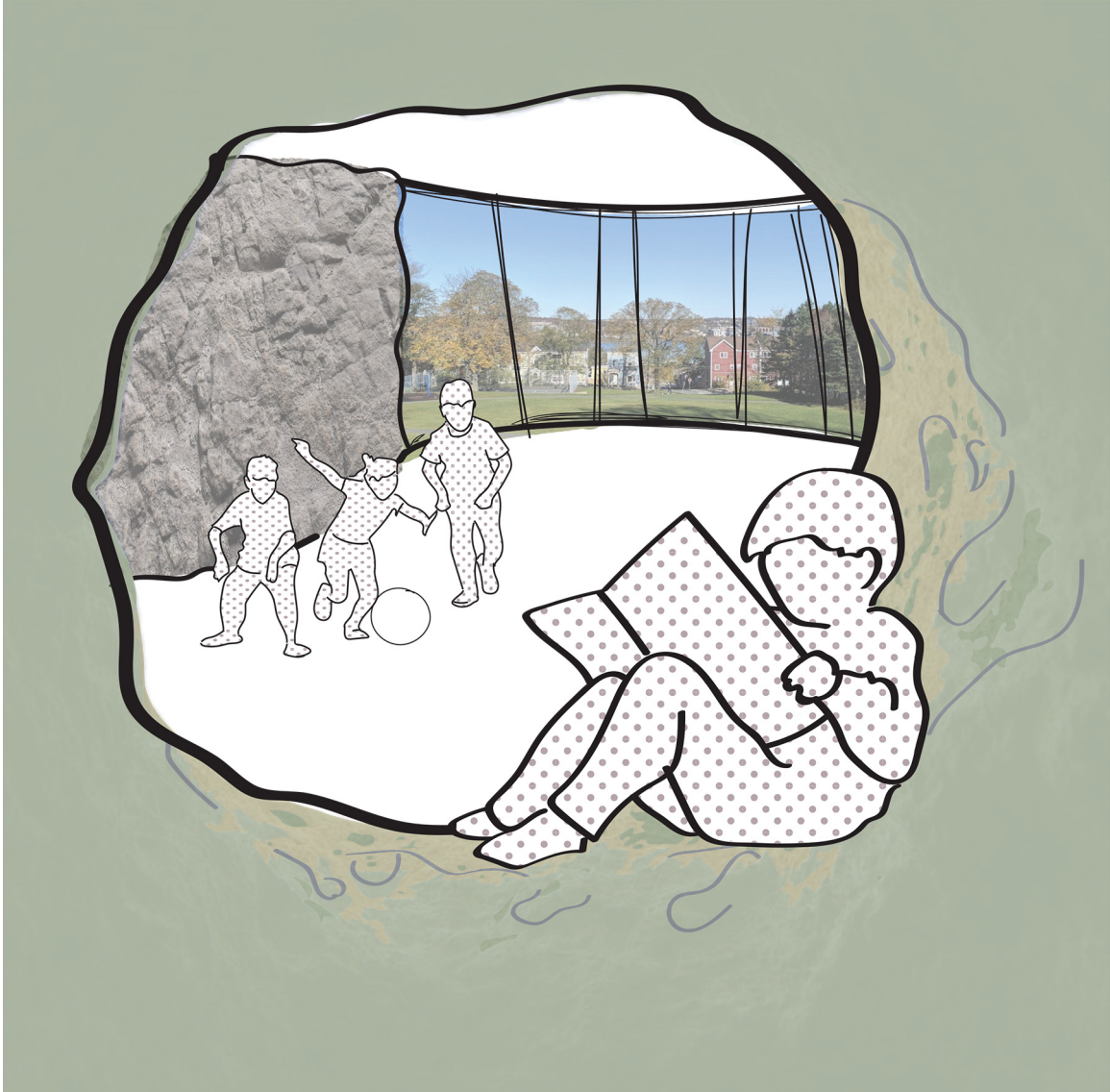


They found that only 1 out of 12 children could meet the average of 1984 (see page 14). This is because we need to allow children to run, get upside down and spin in circles as much as possible to move the fluids in the inner ears to further develop their vestibular system (Hanscom 2016, 48).

It is important in the design of children spaces to create many opportunities for children to climb, jump and balance on things. Incorporating trees, logs and rocks in a play space would inspire children's play. Like a study from University of Tennessee at Knoxville explains, natural setting increases



“Wish image” of a space allowing for the stimulation of the vestibular sense.



“Wish image” of an important time out or retreat space for children to take a break.

creative play among children (University of Tennessee at Knoxville 2012).

### **Sight**

Sight often comes in combination with other senses to reinforce a learned lesson. For instance, when a child hears the sound of a bird and looks up in the tree to discover the bird’s size and color. Sight is one of the most important senses for safety, it is through sight that a child will determine,

for example, if he is at a fair height to jump down from a rock (Hanscom 2016, 50).

Too often, when it comes to the design of children spaces and toys, too much emphasis is put on the visual. As a result, bright colors and patterns are often the indication that the space or object is created for children, but it can overstimulate children's visual sense.

Observing nature, the differences in colors and patterns are more subtle, for instance, the change in color through the bark of a tree or the difference in greens from one leaf to another. This could be used to create a space where children learn to see small changes in colors and lights.

### **Smell and Taste**

These two senses often work together, as we know, sometime it can be difficult to taste your food when you have a stuffy nose. Smellscapes help us navigate through our environment and recognize our surroundings. Children can smell the changes in their surroundings and understand the cycle of life with the smell of each season. The Reggio Emilia preschools create smellscapes in the children's environment by adding plants as well as building and furnishing materials that raises children's awareness (Day and Midbjer 2007, 84).

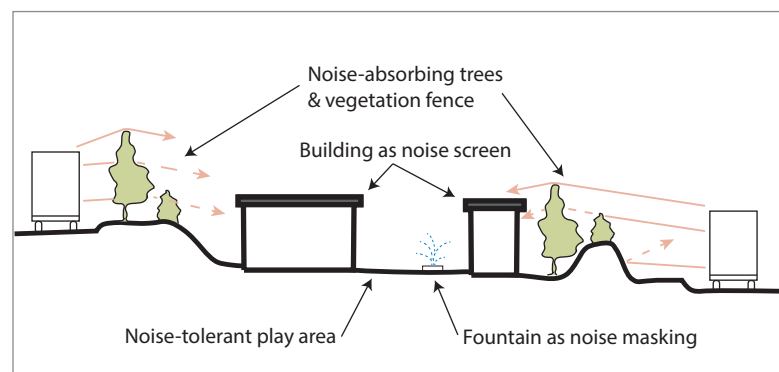
What better way to connect with nature as well as our senses but to grow a garden. At King Middle School in Berkeley, California, children learn to farm, cook and teach in their *Edible Schoolyard*. Constructing and taking care of a garden engages children's curiosity, dignity, abilities to work in teams, respect of their environment and others as well as

understanding the relationship between their engagement and the food we eat.

## Hearing

Sound of birds or wind in the trees gives us an awareness of the space around us. The sound of the waves on a beach or a running creek is often used in meditation music to help us relax. Furthermore, children enjoy spaces with different sounds, like caves, tunnels, echoing walls; they also are captivated by silent spaces or speaking in a cone to amplify the sound. Even with your eyes closed, you can hear and imagine the size of the space you are in.

The sounds that are unwanted we call noise and too much exposure to it can cause us stress and increase errors. In schools, it lowers reading skills, concentration and attention span and can lead to depression (Jarvie 2003). This is why mitigating the exposure to excessive noise is crucial in cities. Strategies that can be used include: traffic sound-barriers such as mound walls, vegetation like trees and climbing plants. Sometimes the placement of the building on its site can create a quieter inner courtyard. Ambient noises can also be camouflaged by having the sound of running water or rustling leaves.

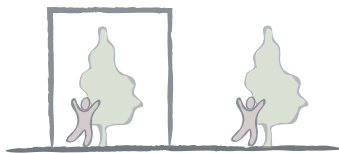


Possible approach to noise control on the site

Sounds can also be a great opportunity for children to understand materials around them such as, knocking on a tree, like a wood pecker, to hear the different sounds of empty or full. Creating a space where the sound of the rain is amplified and can be enjoyed as a reminder of the power of nature.

### Tangible Nature Inside

Many studies have demonstrated that interior plants may have air cleaning properties. A research done by the National Aeronautics Space Administration (NASA) tried to determine if potted plants could potentially reduce the pollutants found in indoor air. They found that plants, in combination with



Physical contact with nature inside and outside

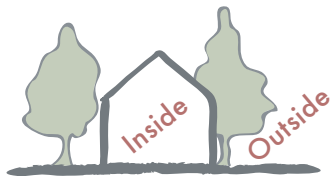


A tree incorporated into the interior of the building in the Fuji kindergarten, Japan, is a great example of physical contact with nature inside. (Tezuka Architects 2007)



Google Dublin office (Dunne 2014)

the potting soil microorganisms, can improve the indoor air quality (McDonald, Wolverton and Watkins 1984, 224). The department of Environment of the University of Aveiro, Portugal, conducted a similar experiment comparing the air quality of classrooms with and without potted plants. Respectively, the results also supported the hypothesis that indoor plants create a healthier air quality (Pegas et al. 2012, 1371). The air quality in schools or early childhood development facilities is of utmost importance since children breathe more air than adults “relatively to their body weight” (Pegas et al. 2012, 1372).



Typical approach to nature and architecture



Thesis approach to nature and architecture

The benefits of indoor plants have also shown to enhance well-being and attendance of building occupants (Bergs 2002; Fjeld 2002). Moreover, companies such as Google, Amazon and Apple recognize the direct link between well-being and the boost in productivity that nature rich working environments can bring and have invested large amount of money in improving their offices (Nelson 2018).

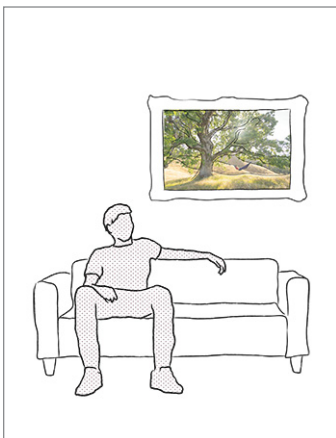
Furthermore, green foliage in children’s environment has shown to improve their attention and feelings of comfort



*Direct exposure to nature*



*Indirect exposure to nature*



*Symbolic exposure to nature*

(Oh, Kim, and Park 2019, 9; Han 2009, 687). Incorporating vertical gardens inside a kindergarten or other buildings would also be useful for insulation of walls both for winter cold and summer heat (Blanc 2017).

## Biophilic Design

The most basic objective of biophilic design is to create “a positive, valued experience of nature in the human built environment” (Kellert 2005, 124). The design practice uses strategies of different exposure to nature like; direct, indirect and symbolic.

### Direct

Direct interaction with nature is explained by the physical contact with nature where elements have not been planned by humans. These features are self-sufficient and function without human support and control, for examples: trees, daylight, animals, and all ecosystems. Even in a city, direct contact is possible such as children spontaneously playing in a backyard or city park.

### Indirect

Indirect exposure to nature represent a more restricted physical contact with nature. These elements which require a constant human input to survive include examples like: potted plants, community garden, aquarium.

### Symbolic

Symbolic exposure to nature happens in the absence of physical contact with nature but where elements are simply representations of nature. Examples would include: pictures, patterns, images, video, metaphor.



Typical approach to cold winter weather



Thesis approach to cold winter weather



Microclimate - Sun shade oasis



Microclimate - Wind protection



Microclimate - Sun trap

## Permability

### Interior and Exterior

As the image on the left shows, the common way of dealing with interior and exterior space is to simply put a wall to keep the hot or cold air inside. The shades of grey do not represent inside nor outside but the “in between” space, and can be used to connect us with the exterior temperature and environment.

### Microclimate

Imagine, that just like we add a layer of coat in the winter, we added a layer to our buildings in the colder months. Like an onion, layers of varied enclosures can create seasonal microclimate.

The slope of a hill that faces the sun or is sheltered from a cold wind will be warmer than the opposite slope. Indeed this variation in microclimate can be so significant that entirely different communities of plants will grow on the opposite sides of a hill, each community thriving in the climate to which it is best adapted. An animal, on the other hand, can select among the various microclimates according to its needs. (Heschong 1979, 3)

Following Heschong ideas about microclimates, humans are yet to take more advantage of the natural and human made microclimates around us. Just like in the Open Air Movement schools, where children had to put on a coat to learn outside, we should be more acceptant and ready to put an extra layer of clothing on during colder months, or to change rooms depending on the rooms temperatures. This would allow us to be more conscious of the fluctuating temperatures outside.



### ***Walls And Structure***

A strategy that can be used to blur the line between inside and outside is to have the walls of a building completely or partially openable. To do so, the structure of the building would have to rely on columns instead of walls for support. This strategy was used in the l'École de Pleine Air (see page 23), where a distinct set of columns make up the four corners of each pavilion allowing the sliding walls/doors to open. The same structural strategy is used on the south part of the northern building to let the south walls open completely. This strategy is very successful since rooms can therefore be multi-purposed or joined with an exterior space to become a bigger room.

### ***Roof***

As cities are getting denser and every meter becomes more and more valuable, the roof space of our buildings consequently becomes substantial functional space.

A successful use of the roof for an urban kindergarten is the Fiji Kindergarten in Japan where the roof is used as a running track or play space. It comes to no surprise that the children from this kindergarten have the highest athletic abilities compared with many other kindergarten of the region (Tezuka 2015).

The roof of an urban building is also a great opportunity for a green space or even gardens. The Fifth Street Farm, in New York, is an example of using the roof to create a natural classroom creating a learning environment stressing the importance and role of plants in the environment and food system.



Fifth Street Farm, children's roof top garden, New York. (Fifth Street Farm 2016)

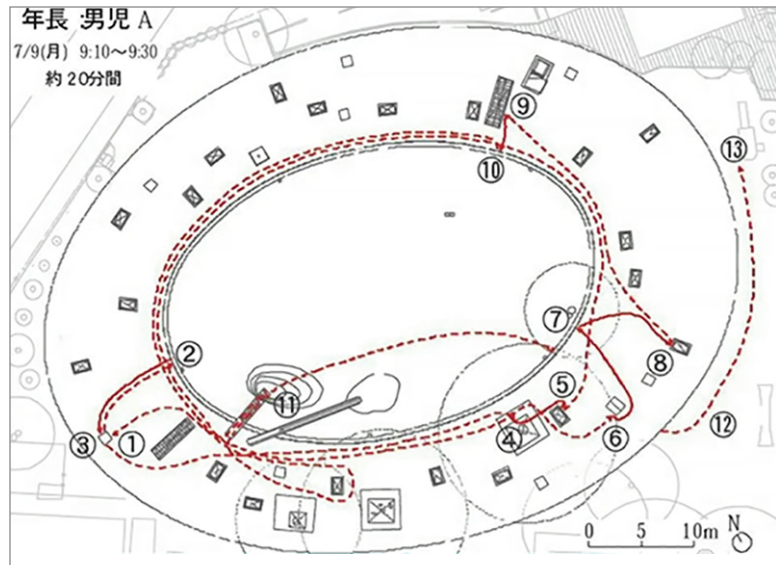
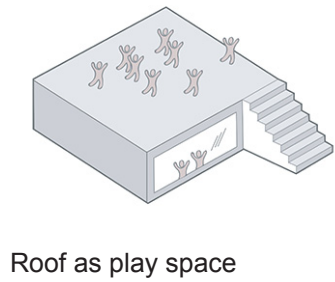
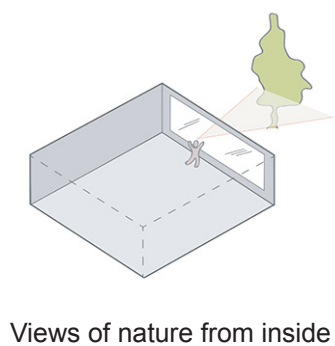


Image showing the roof of Fuji Kindergarten and the distance covered by a child running on the roof of from 9:10 to 9:30 (Tezuka 2015).

### **Window**

Windows are the frame in which we can see the exterior world. A study from Cornell University reported that children which have a view of nature from their window are less stressed (Louv 2008, 50). A view of nature from a window



L'École de Pleine Air in Suresnes was surrounded by trees and greenery and each classroom had big class doors allowing views of nature from inside (Wikimedia Commons 2015).

also accelerates the healing of patients (Ulrich 1984, 420). Having these studies as guides and references, we can advocate for the importance of the presence of nature through a window.

Windows are also extremely important for the natural light that they allow into a building. In her TED talk, architect Amanda Sturgeon explains: “We feel better when we can place ourselves in time and understand what time of day and year it is” (Sturgeon 2018). We have all experienced being inside for part of the day and finally getting outside only to find, to your surprise, that the weather had changed.

The arrival of electric light and air conditioning has led our building designs to lessen the need of windows. Being able to build buildings with a bigger footprint and less peripheral surface, natural light and ventilation from a window becomes an after thought.

## **Outdoor Space**

“The freedom to flip over rocks looking for bugs or dip one’s feet in local streams, in endless and slow time, is important for getting to know, in a very hands-on way, the nature around us” (Beatley 2011, 12).

According to a study from University of Tennessee at Knoxville, children who play in playgrounds with natural elements like logs and flowers, are more active than children who would play in a more conventional playground. The study also supports that children are more imaginative in their games when playing in natural settings (University of Tennessee at Knoxville 2012).

Keeping this in mind, it is important that the exterior space of a kindergarten promotes contact with natural elements



Wish image of outdoor space

and takes advantage of existing trees, landscape features or any other humble natural details of the site.

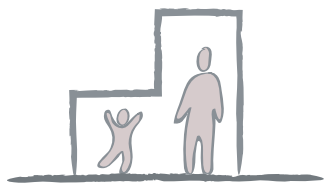
By allowing the natural dynamic shapes of the playground to emerge, we can challenge the children's motor activity (Fjortoft 2001, 111). In the context of this thesis, the Halifax site has a strong slope and takes advantage of this by allowing the roof to meet the landscape to provide the children with a bigger outdoor playspace on the roof.

### **Affordance and Irregularity**

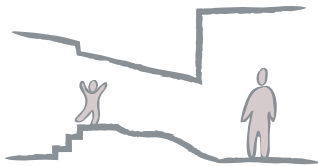
It is important that a playground allows freedom of imagination for children, and an effective way to achieve this is to allow affordance of the objects and environments of a playground. The term affordance, developed by James J. Gibson in 1979, describes "an awareness of the environments and their functional significance, or their functional meaning" (Fjortoft 2001, 111). By example, an object having multiple possibilities of functions like a rock that could fit in the hand could become an object to grasp or throw. Natural environments provide constant potential and affordance (Fjortoft 2001, 111).

The irregularity in a playground is also very important since it stimulates a constant need for reevaluation of the situation and risk in which children play. Imagine the difference in the concentration needed to balance on an uneven log compared with a smooth equal surface. Or the judgement and skills necessary to climb a tree versus a set of matching parallel monkey bars.

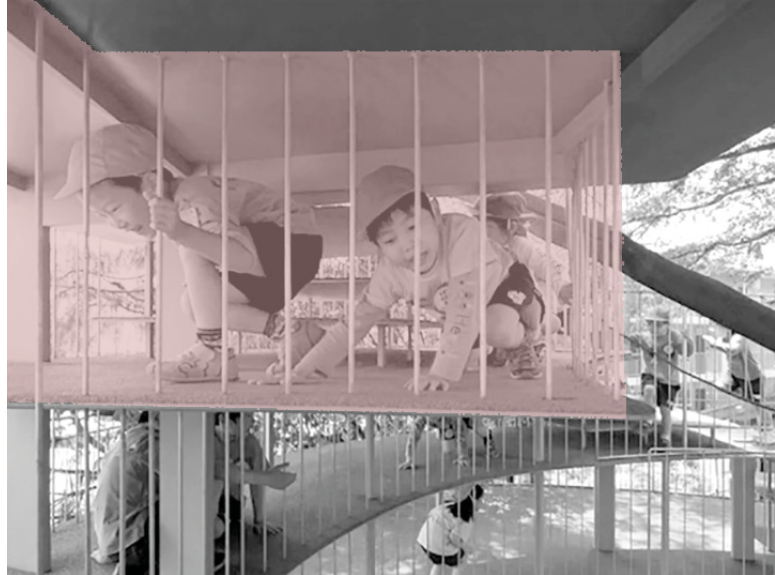
Irregularity can also be used in the floor to ceiling height. Children love to climb and crawl into small spaces and this allows them to practice their motor skills.



Spaces scaled for children



Varied floor and ceiling height



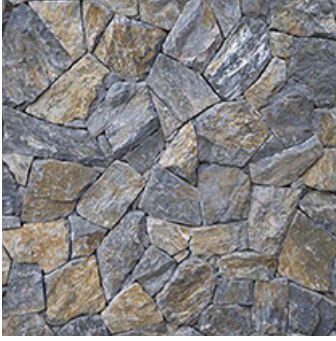
A great example of varied floor to ceiling height in the Fuji Kindergarten in Japan. (Tezuka Architects. 2007)

## Materials

Materials are greatly important when designing a nature rich environment for children as these are the surfaces that they will be in direct contact and touch everyday.

As the playgrounds take an enormous abuse, and need constant maintenance, it is important that the materials used are sturdy, resilient, age well and allow easy maintenance. Natural materials like vegetation, logs and boulders come in all sizes and shapes and can easily be replaced if need be. Also, all of these materials ignite children's imagination, a log can become a balancing object, a horse, a bus, a canoe and endless other ideas.

For the thesis proposal, natural materials were used at every opportunity on the exterior as well as interior of the building. The exterior cladding is mostly composed of wood, offering a warm touch for children. The vertical wooden siding extends pass the roof to create a railing around the

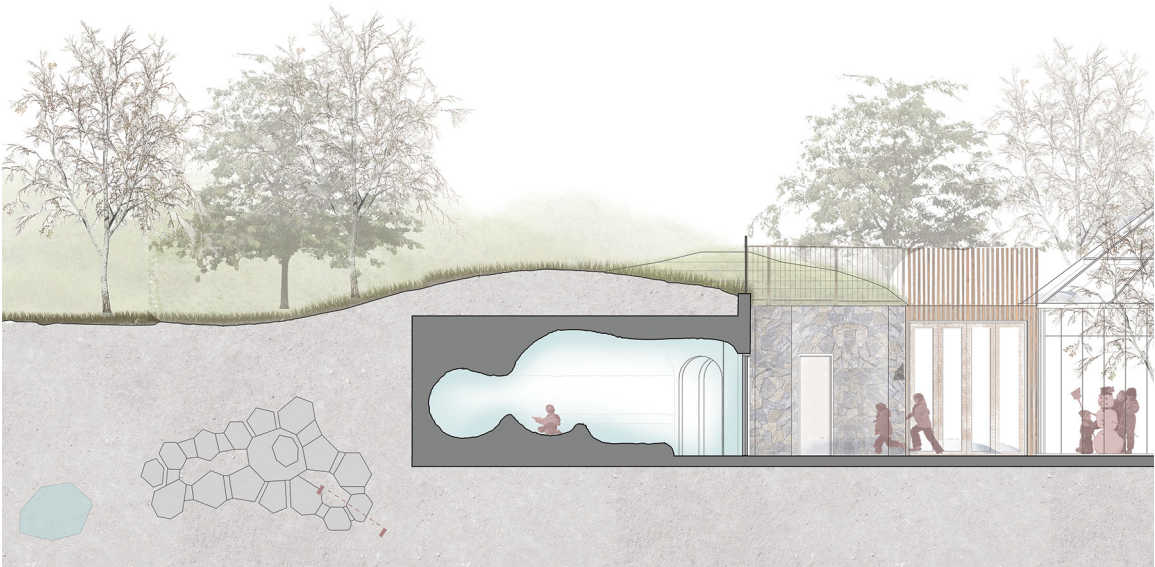


Exterior cladding for the  
Retreat room (Square  
Texture 2020)



Exterior cladding (Square  
Texture 2020)

usable roof areas (see vignettes on page 49 and 70). In the two areas of the building which connect with the landscape, the Retreat rooms, the exterior cladding is made of a stone veneer speaking to the nature of the earth's composition and representing a boulder in the landscape, adding to this, the grass from the landscape continues to the roof of the these rooms (see critical section enlargement below).



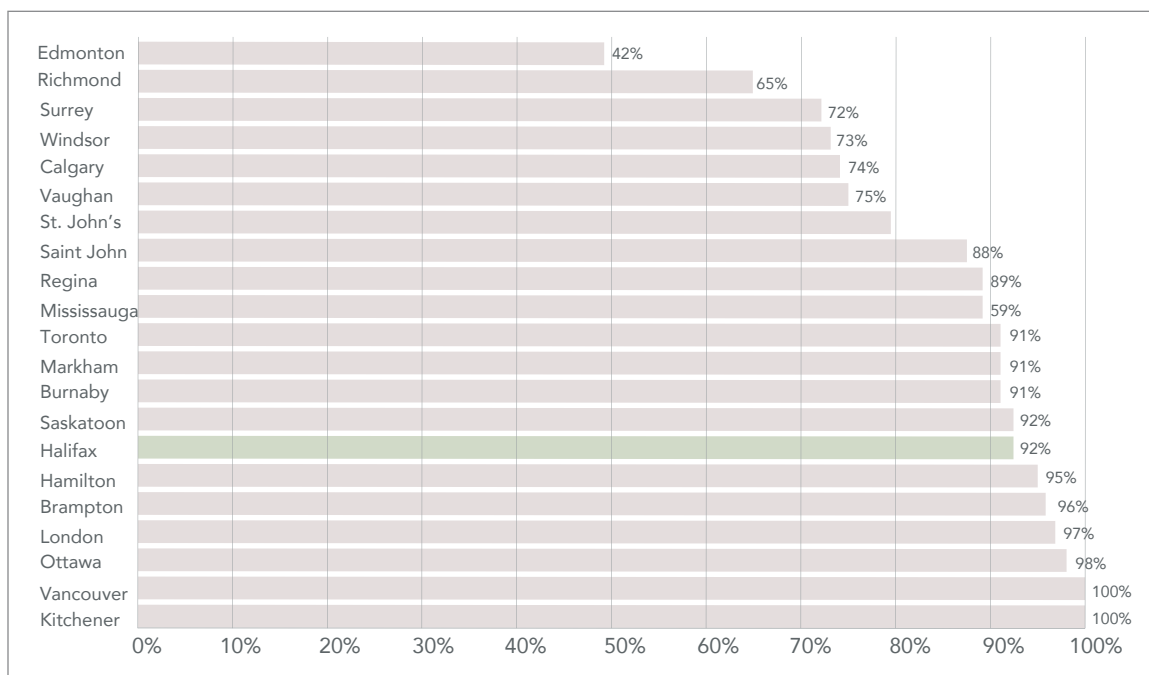
Critical section enlargement - Notice the grass from the landscape extending to the room of the Retreat room and the vertical cladding extending passed the roof to become a railing (full section on page 65-66) .

## Chapter 5: Site and Program

### Site

In order to test the thesis hypothesis (see page 11), it is important that the site is located in an urban area where the density of children is high. Another factor to determine a potential site, is the type of housing surrounding the location, people that are living in high-rise, mid-rise or houses without a back yard, have less access to green spaces. The North End of Halifax, Nova Scotia, meets these three criteria, as well as having a need for more daycares in the region.

This site is also located in a section of the city that is surrounded by many nature engaging, summer and winter activities. A large number of these can be found within a child's walkable distance (see map on page 19). For example, Emera Oval, allows rollerblading in the summer, fall and spring as well as ice skating during the winter. The

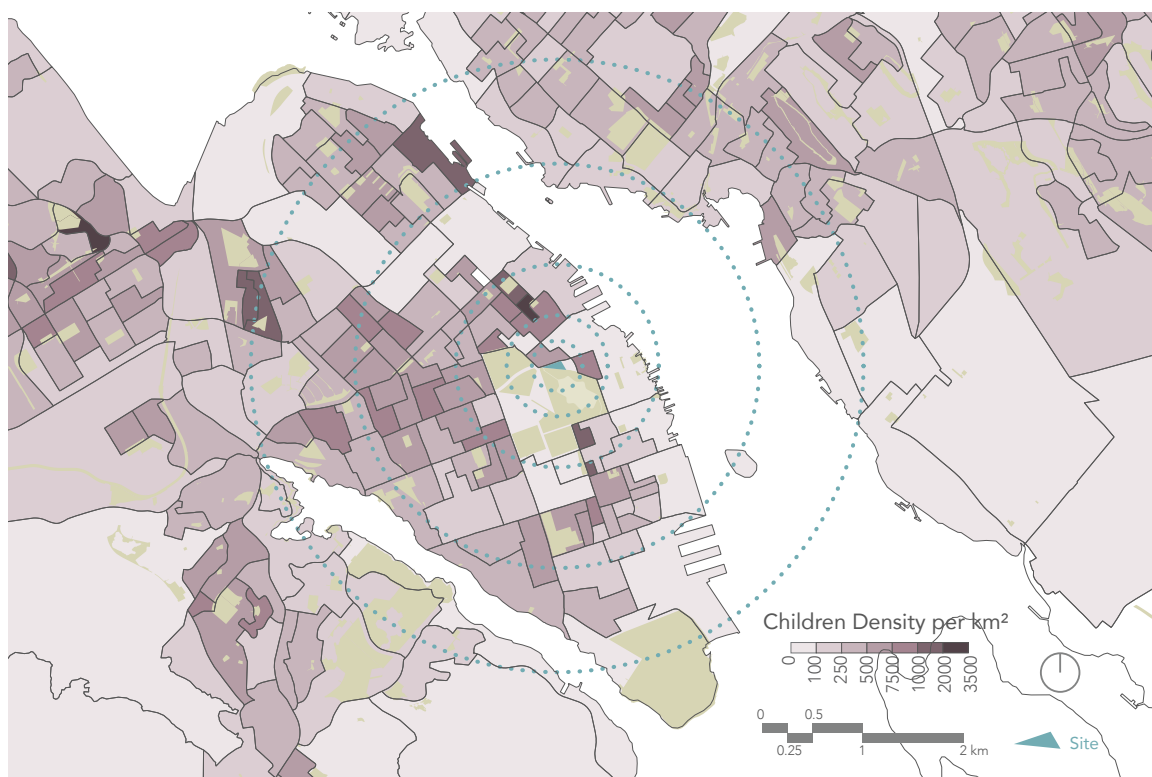


Proportion of childcare centers maintaining a waiting list in different cities around Canada, note that 92% of Halifax's childcare centers have a waiting list. (Macdonald and Friendly 2019)





Halifax's total Population density, per km<sup>2</sup> (data from Statistics Canada 2017)



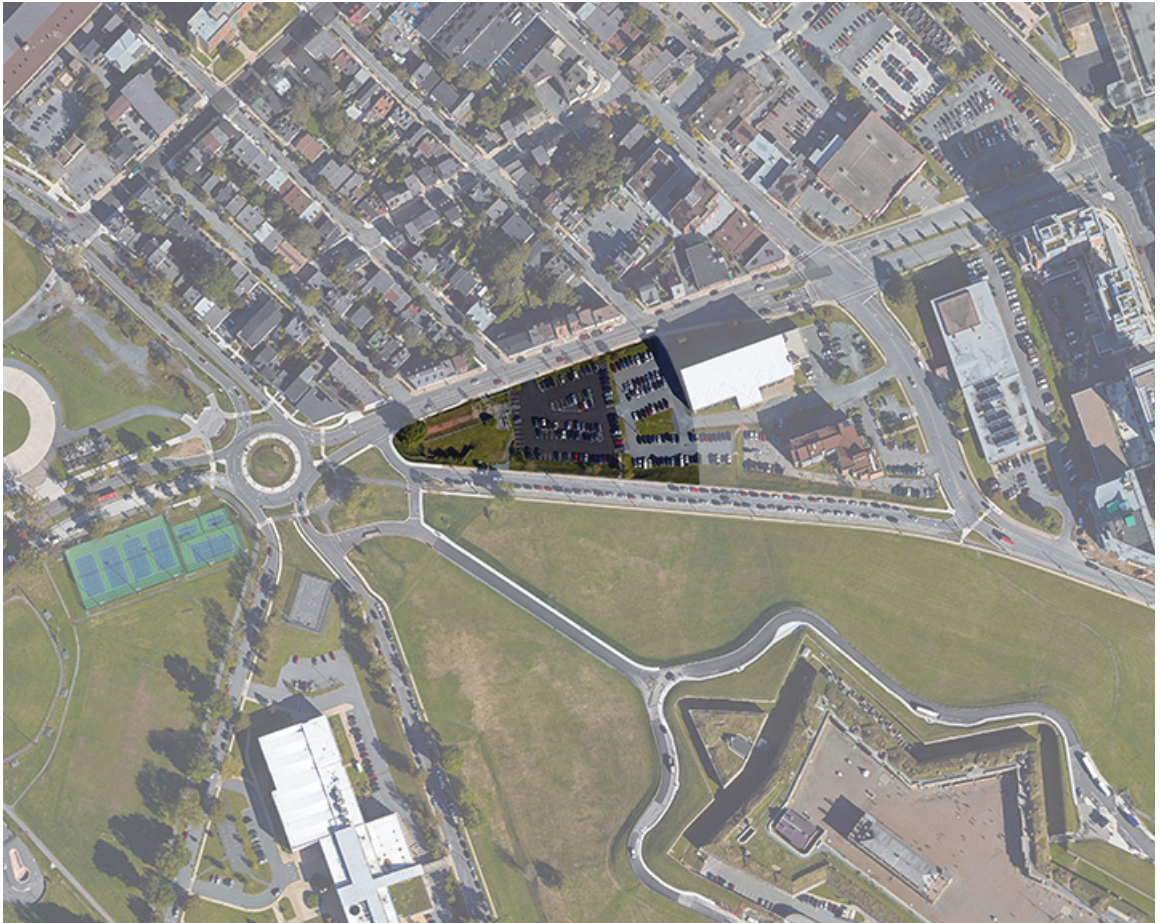
Halifax's children density, per km<sup>2</sup> (data from Statistics Canada 2017)



Halifax's employment density, jobs per km<sup>2</sup> (data from Statistics Canada 2017)



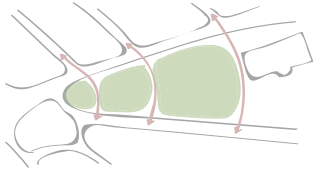
Halifax's housing types (data from Statistics Canada 2017)



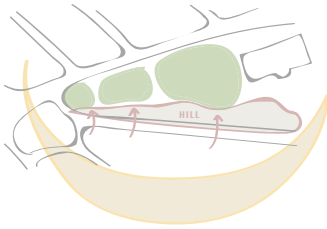
Satellite image of the site's surroundings (Google Maps 2020)



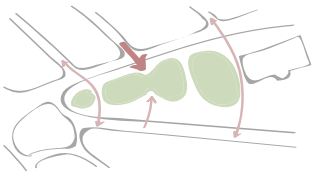
Satellite image of existing site conditions (Google Maps 2020)



Urban integration - Visual and physical connections



Site Strategy--Sun path and hill.



Site Strategy--Site circulation and entrance.

Halifax Citadel is a great place for running games or sliding during the winter. A neighboring building off the site is the Centennial Pool which has lots of open hours for children's swimming. Another great excursion around the site is the Halifax Public Gardens, where an incredible variety of flowers, plants and trees can be found during the summer, fall and spring months.

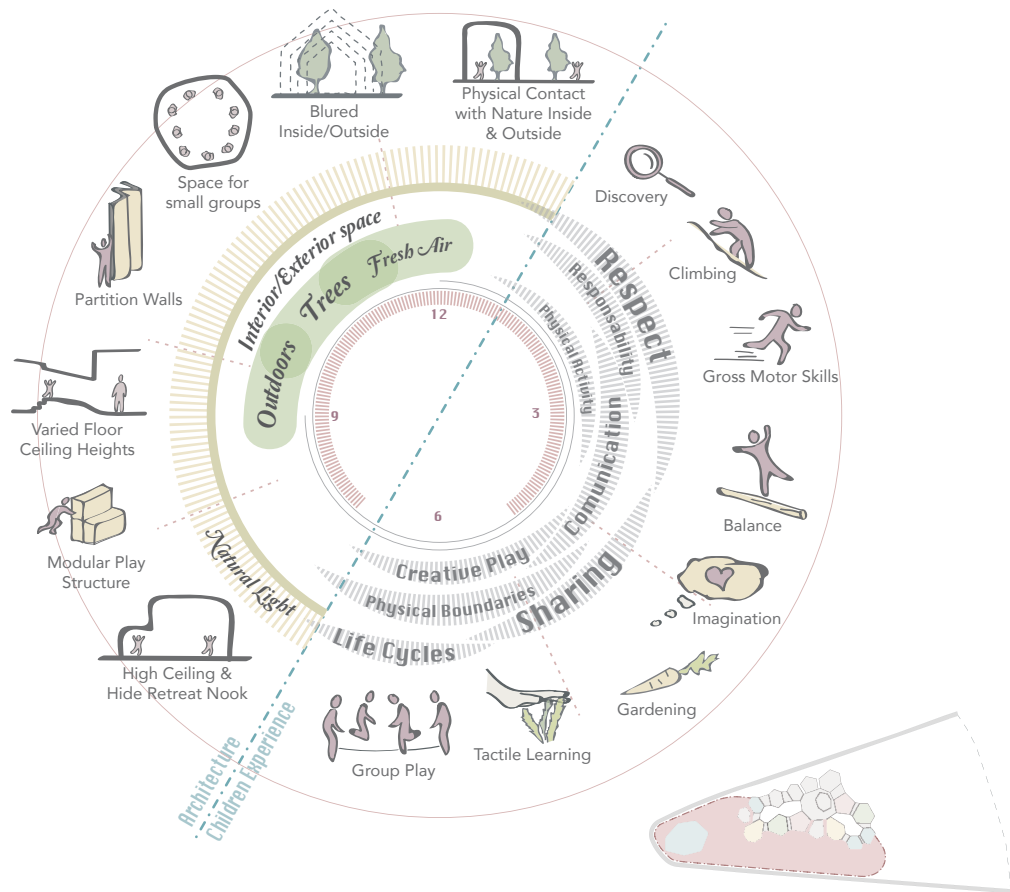
The site strategy allows for three circulation paths following the existing perpendicular city streets. The building's location on the north portion of the site, allows for great sun exposure. The programs requiring the most sun, like the greenhouses, are situated on the south of the building. The west side has a lake that can be accessed by the community. The east portion of the site maintains portion of the existing centennial pool's parking lot but transforms it into a green parking by adding a great number of trees.

## Program

The program is concentrated on preschool children, age one to five and aims to create a kindergarten where nature and play are at the core. The program is divided into five distinct rooms, each with their specific architectural principals and qualities of experiences: the exterior room, the physical activity room, the transformation room, the retreat room and the educational room. Each room is explained in more details through page 49 to 57.



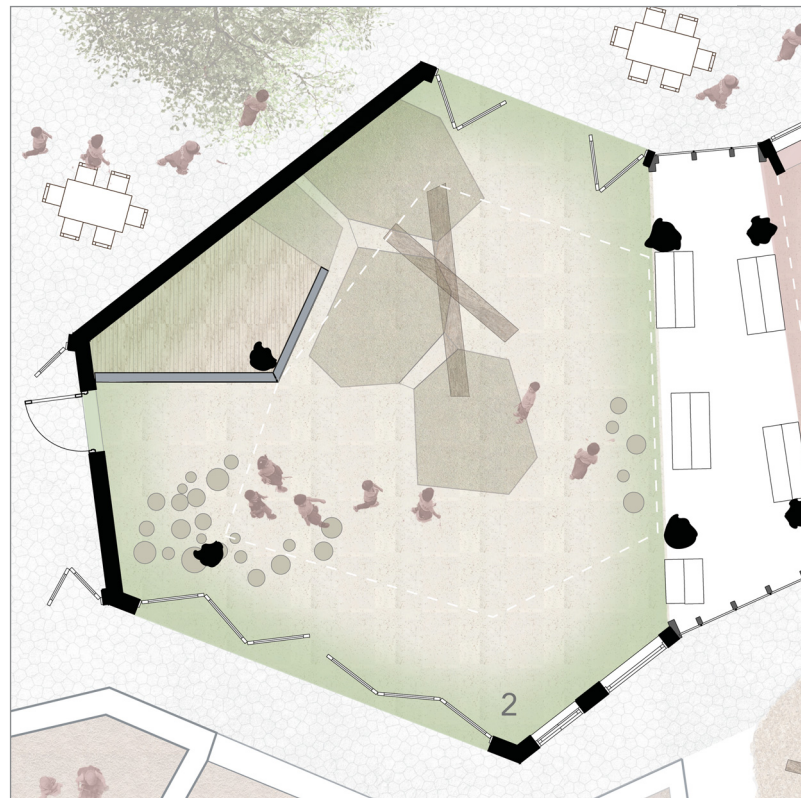
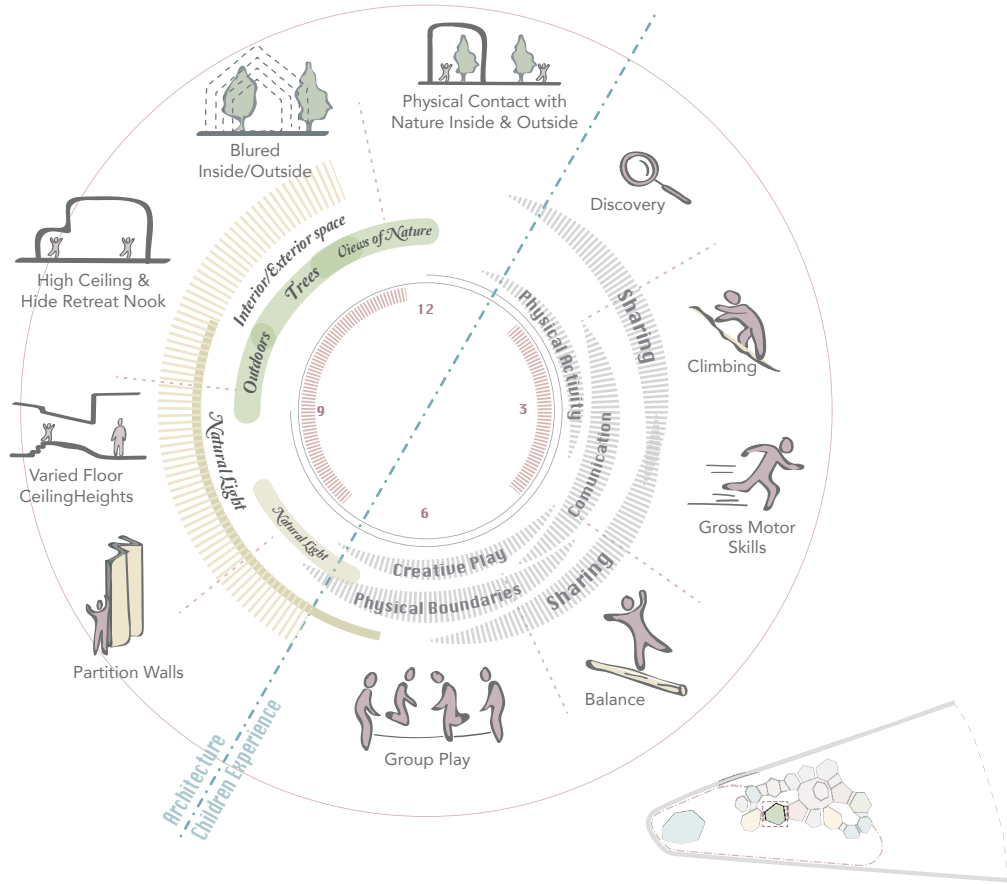
Site plan



1. Outdoor room, is the most representative of the program since it contains all of the tools from the project. It is designed to be enjoyed in all seasons and allow children to be in direct, indirect and symbolic contact with nature. Children can discover, Climb and play in Groups.



2. Physical Activity room, represented in green, allows children to run, climb and challenge their physical abilities. Children also learn to help each other and communicate through play while practicing their gross motor skills. Big tree trunks acting as columns create a tactile connection to nature.

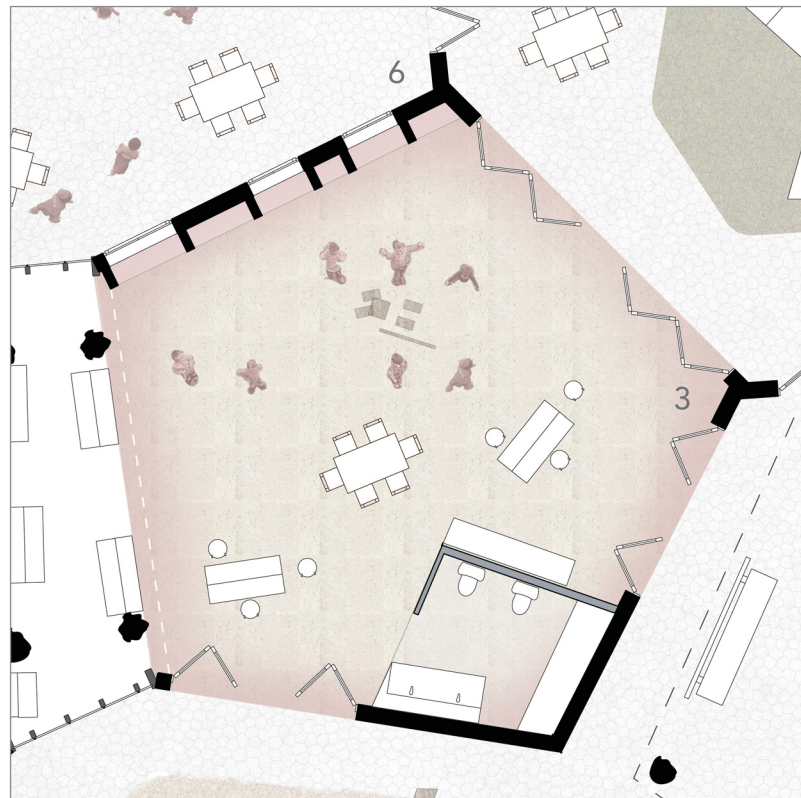
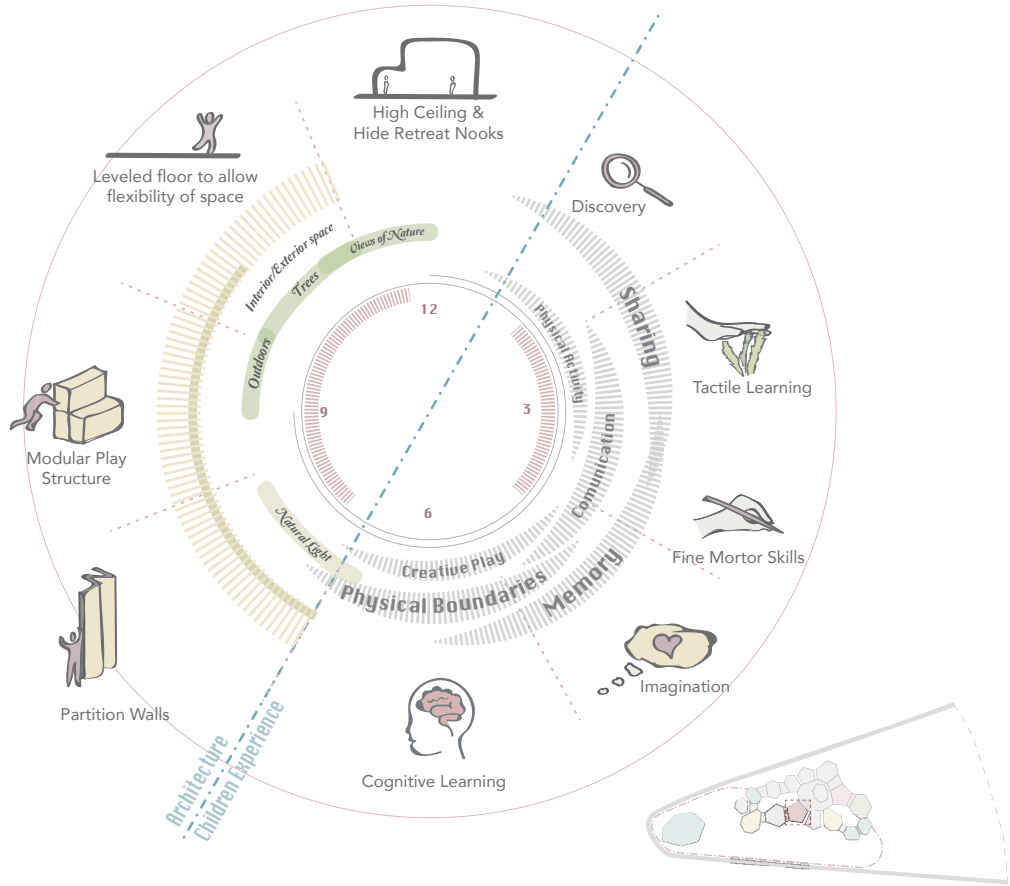


2. Physical Activity room diagram and floor plan.





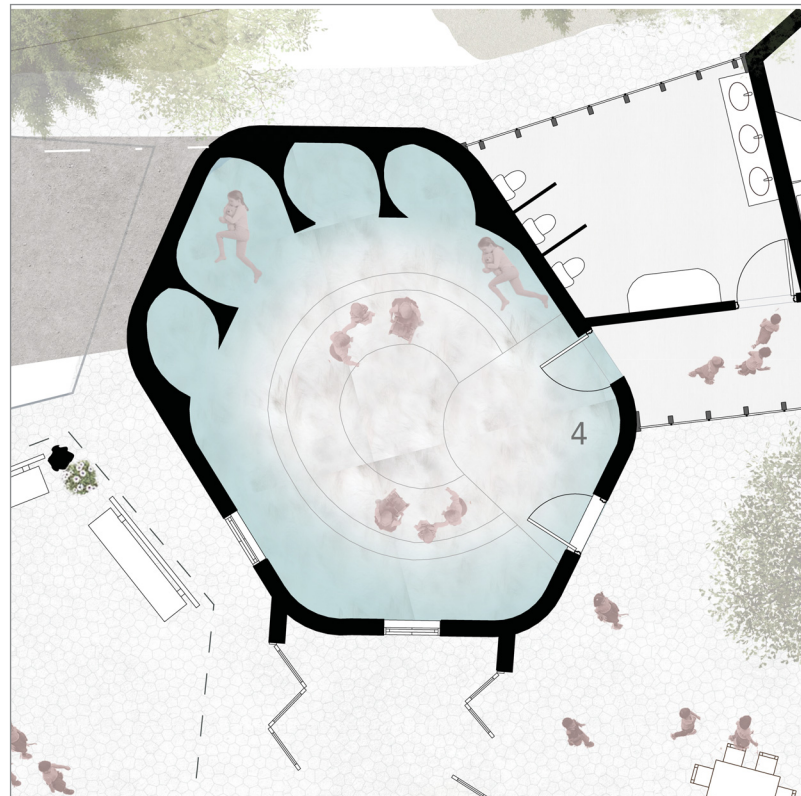
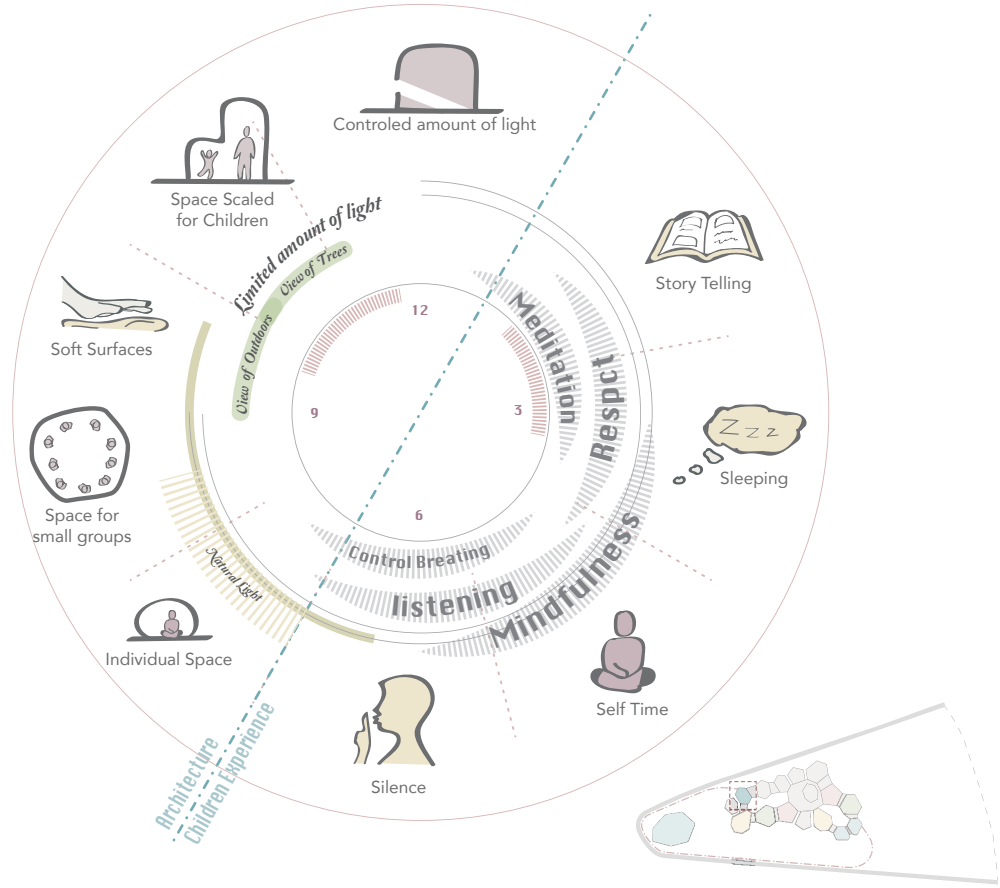
3. Transformation room, represented in pink, allows children to comprehend the geometry of nature and work with their hands to imagine and create. In this room, children also learn tactile skills and develop their memory. Further more, they can experiment with big objects and toys to create their own games and shelters.



3. Transformation room diagram and floor plan.



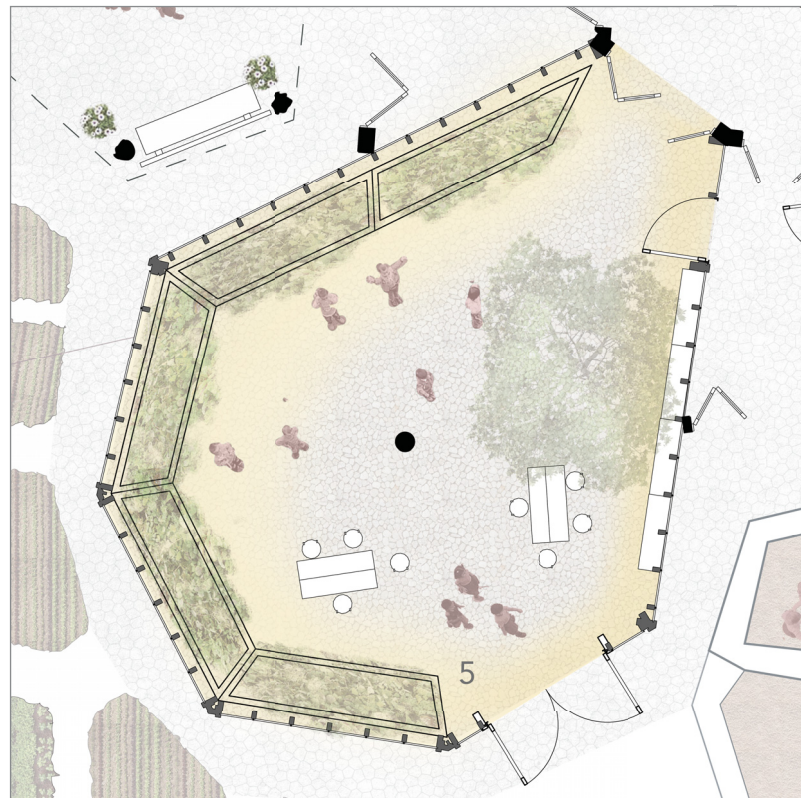
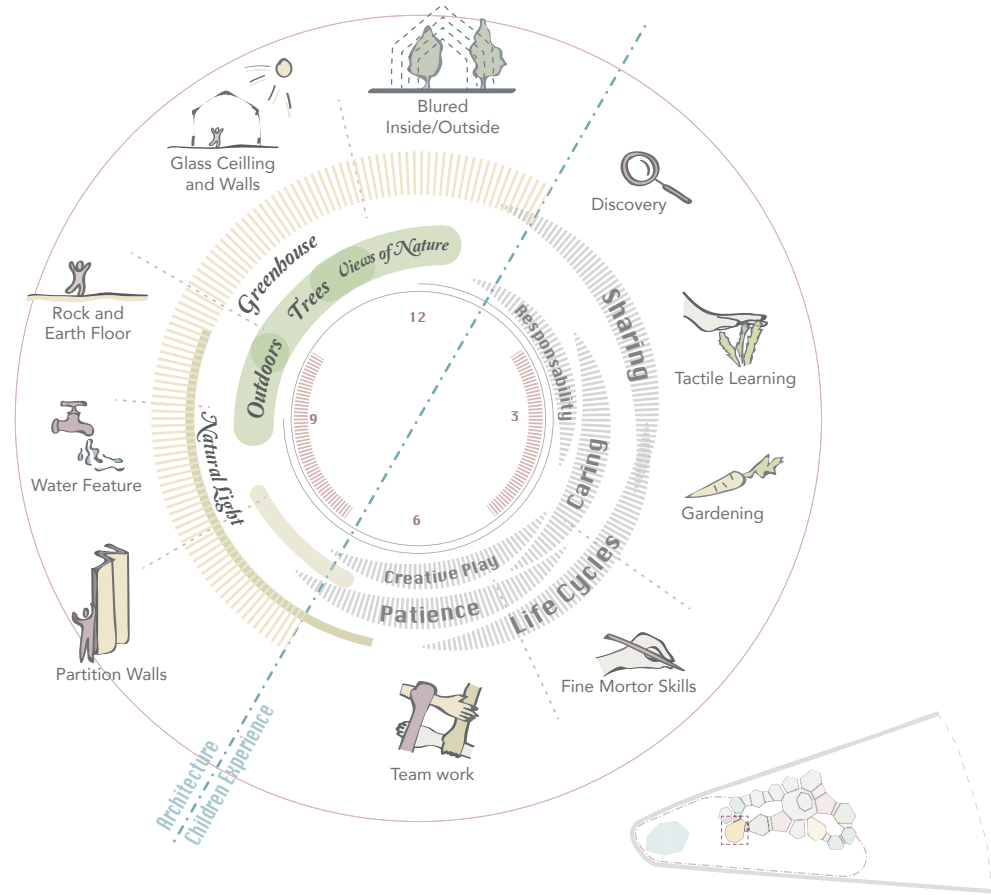
4. Retreat room, represented in blue, allows children to relax, sleep and take self time. With its low ceiling and smooth curved surfaces, it creates a quiet and welcoming cocoon for story times and personal moments. The controlled amount of natural light calms down the children to help them unwind and soft comfortable materials, pillows and blankets help children to prepare for a nap.



4. Retreat room diagram and floor plan.



5. Educational room, represented in yellow allows children to experiment and learn through exposure to life cycles and gardening. With its all-seasons gardens and water feature, the room supports children's tactile learning. Further more, the room is fully glass to allow maximum natural light and views to the sky.



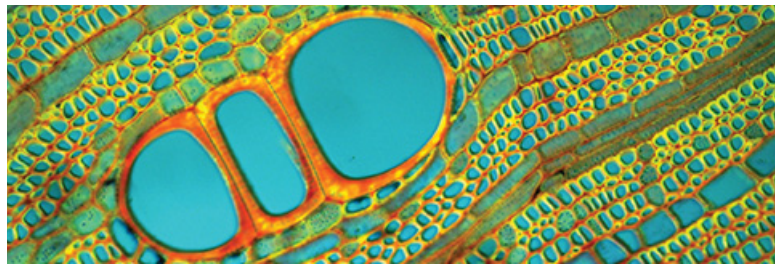
5. Educational room diagram and floor plan.

## Design Method

### Voronoi Pattern

The Voronoi pattern is a geometry which is fundamental to nature and is found all around us, from a microscopic plant cell to the cracking of dried earth.

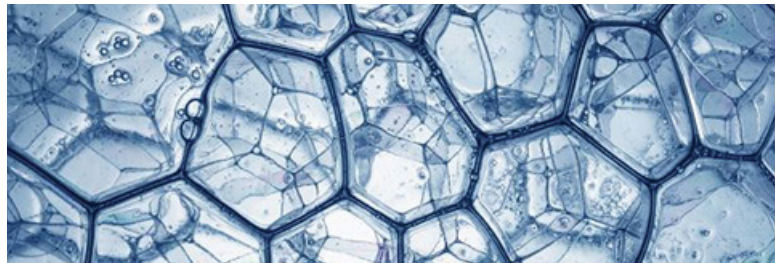
A great example of the formation of this natural geometry is the bubbles on the surface of water. The lines that are created between adjacent bubbles follow this Voronoi pattern.



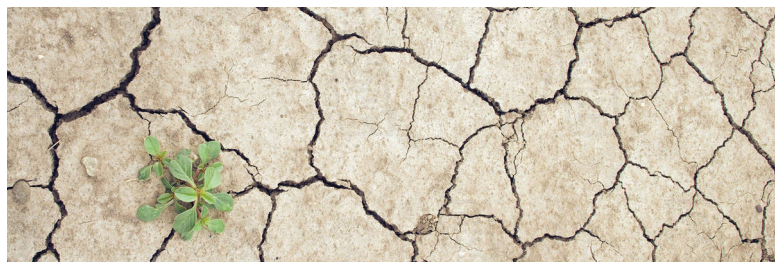
Voronoi pattern--plant cell (Federici 2012)



Voronoi pattern--honeycombs (Duffy 2014)

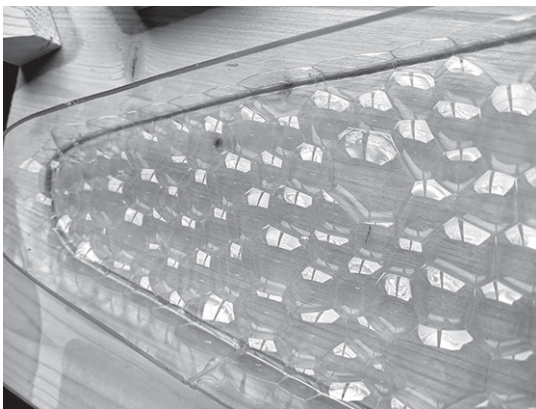
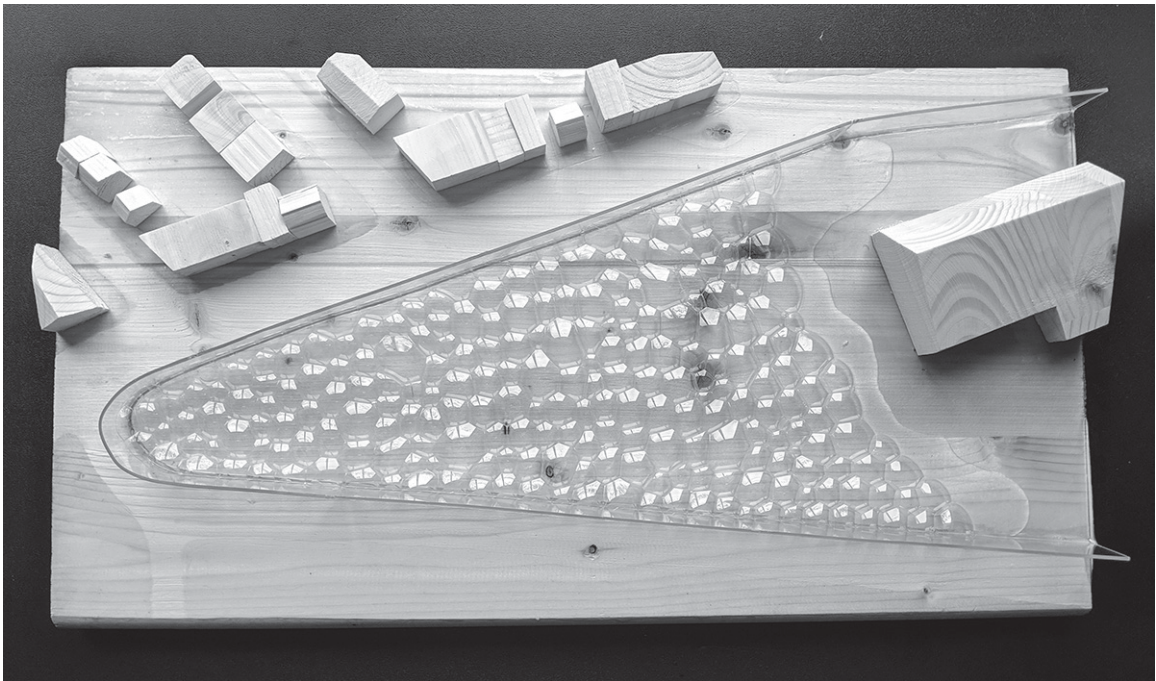


Voronoi pattern--bubbles (Davidhazy 2014)



Voronoi pattern--dry earth (Design Pics 2020)

Using bubbles as a toy, I created a site plan model which could hold soapy water, and like a child having fun with bubbles, I started playing with bubbles myself. Through this game-like method, I was able to study and understand the qualities and behavior of this natural geometry. Then, I used this knowledge to create Voronoi shapes and relationships between them to create varied qualities of spaces.



Experimentation with bubbles and the Voronoi pattern on a site model.





Experimentation with 2D Voronoi shapes.



Experimentation with 3D Voronoi shapes.

## Building and Landscape Strategy

The Voronoi shapes of the building extends to the space surrounding the building and becomes a playground of winter and summer activities in direct contact with nature. Children can get their hands dirty by taking care of the vegetables and flower gardens or play in the sand pit. They can feed the chickens and see the chicks grow or run around the lake to chase frogs and bugs. The floor and landscape plan on the next pages shows the division of the site's exterior space into the Voronoi shapes activities, refer to the legend below.

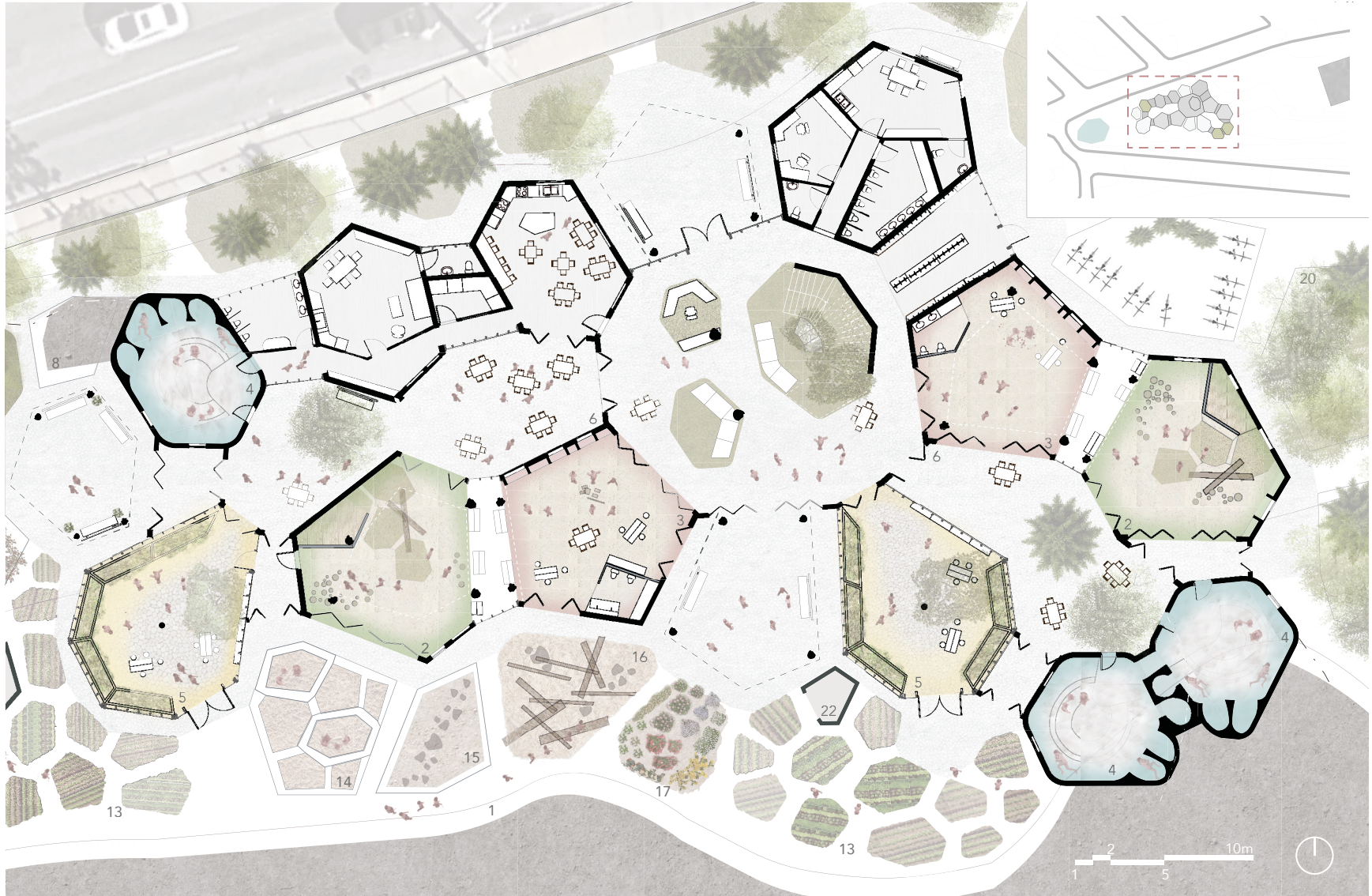
A legend for the floor plan, consisting of a list of 22 numbered items arranged in two columns. The items are: 1. Exterior Room, 2. Physical Activity Room, 3. Transformation Room, 4. Retreat Room, 5. Education Room, 6. Interior Courtyard, 7. Hills, 8. Climbing, 9. Fruit Trees, 10. Duck Coop, 11. Lake, 12. Chicken Coop, 13. Vegetable Gardens, 14. Sand Area, 15. Mud Area, 16. Balancing Area, 17. Scent Garden, 18. Community Grass, 19. Bicycle Parking, 20. Forest, 21. Car Parking, 22. Tool Shed.

1. Exterior Room	12. Chicken Coop
2. Physical Activity Room	13. Vegetable Gardens
3. Transformation Room	14. Sand Area
4. Retreat Room	15. Mud Area
5. Education Room	16. Balancing Area
6. Interior Courtyard	17. Scent Garden
7. Hills	18. Community Grass
8. Climbing	19. Bicycle Parking
9. Fruit Trees	20. Forest
10. Duck Coop	21. Car Parking
11. Lake	22. Tool Shed

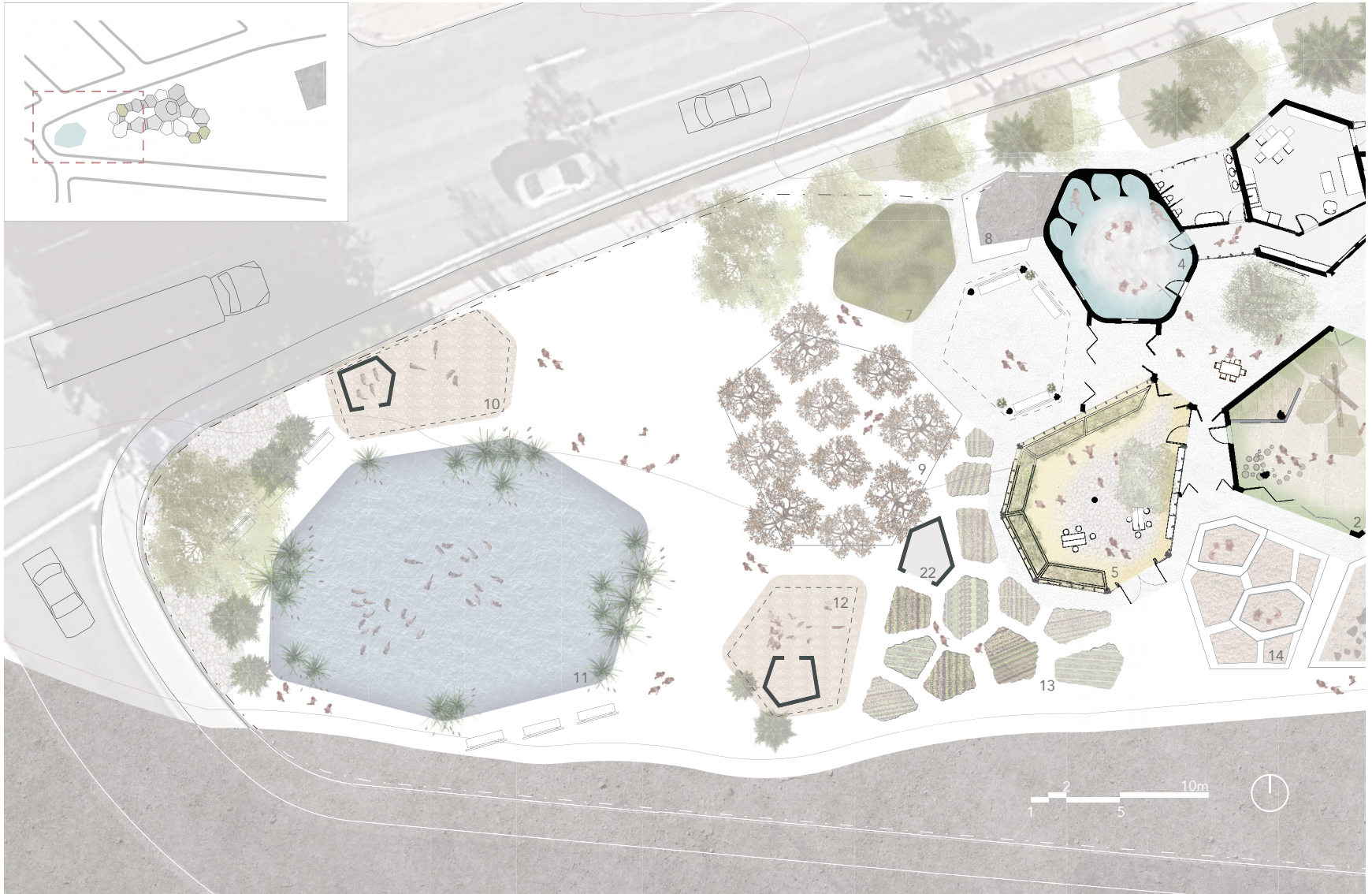
Floor plan legend



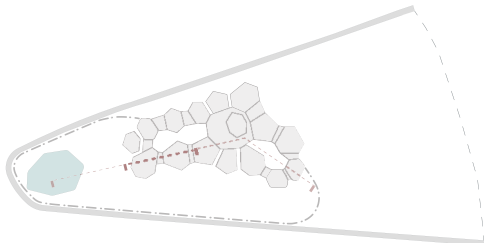
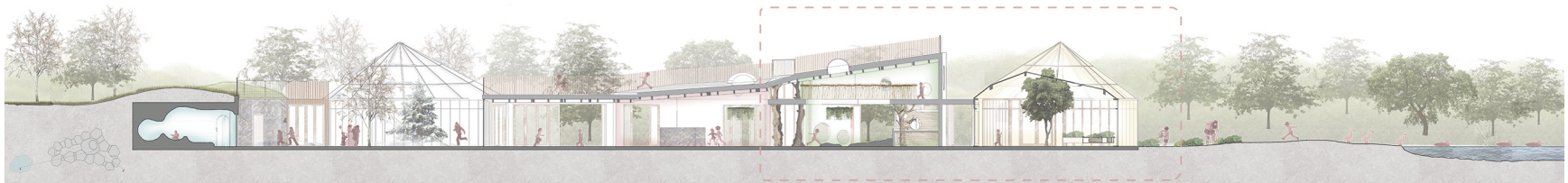
Floor plan



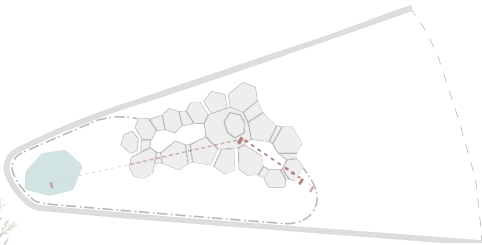
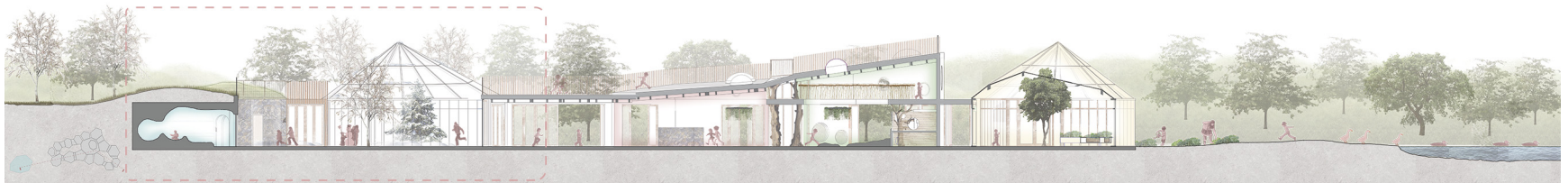
Floor plan enlargement 1



Floor plan enlargement 2



Critical section and critical section enlargement 1



Critical section and critical section enlargement 2

The playground also extends to the roof, children can access it from the east and west part of the building where the landscape meets the roof (see diagrams below). Children can then run onto the roof and come down through the lobby to start the loop again. To provide security for the children, a wooden fence envelopes the periphery of the site and joins with the roof's railing.

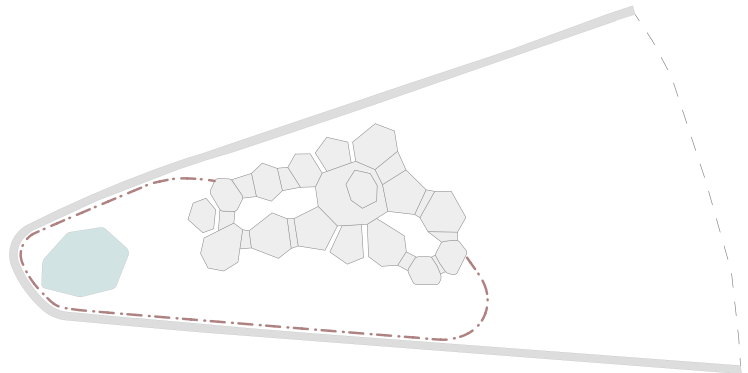


Diagram showing, in red dash line, the wooden fence around the exterior room.

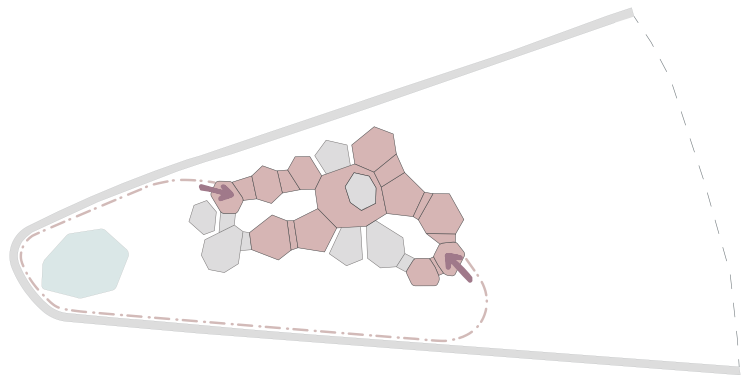


Diagram showing the roofs accessible to children in pink. Arrows showing where the landscape meets the roof.

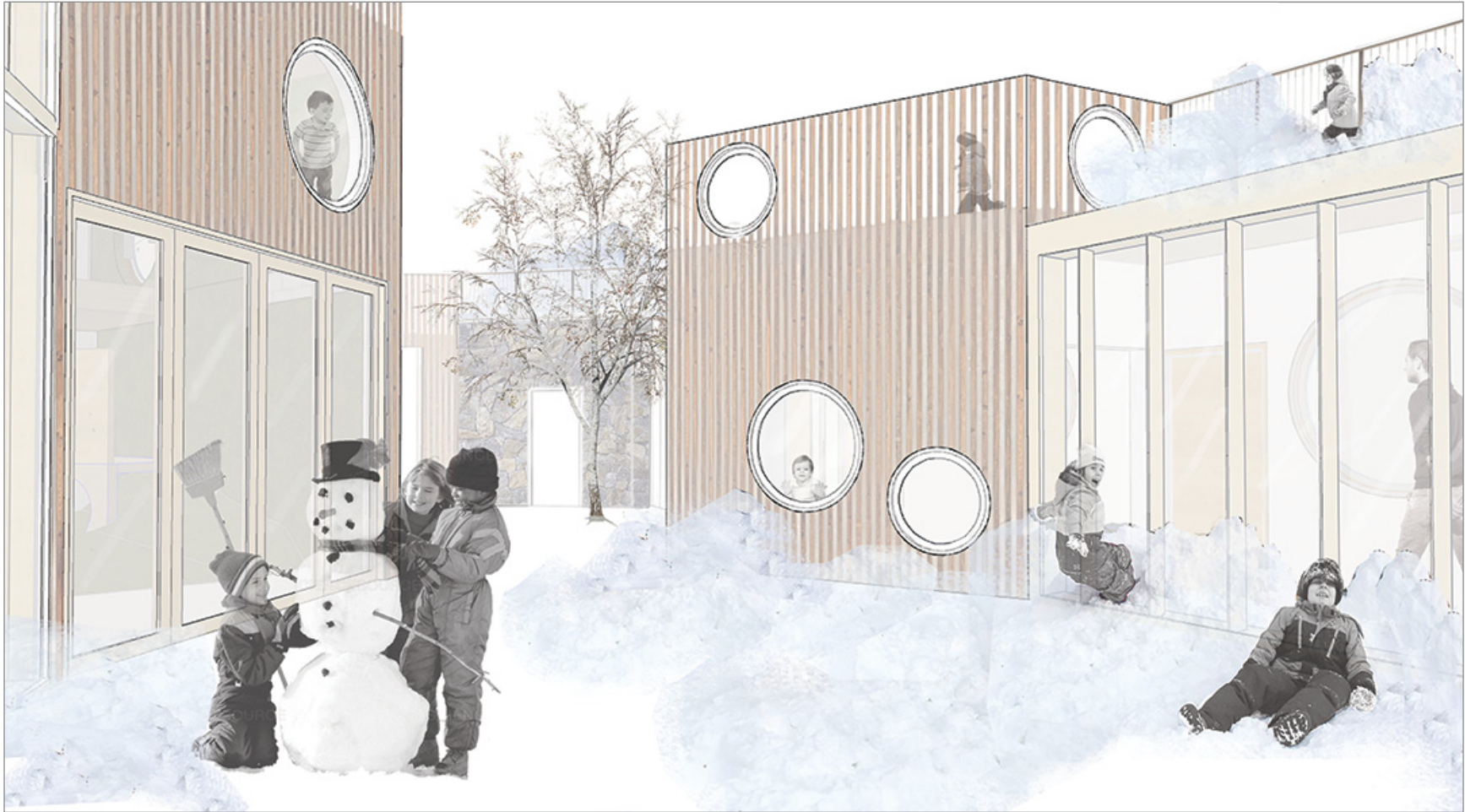
The main entrance located on the north of the building faces Maynard Street and creates a sheltered covered plaza. As children enter the building, they are welcomed by a communal space they where can find a friend petting the local dog or go up the stairs to touch the leaves of the interior trees (see vignette of lobby on page 69).



The continuity of the ground finish from outside to inside and the direct views of the outdoor spaces, allows children to be in contact with nature as soon as they enter the building. On warm days, big glass folding doors can be opened to allow fresh air to enter the space. The folding doors adjacent to the lobby allow flexibility of the room to create a bigger space to host communal events with parents and friends.



Vignette of lobby - The continuity of the floor finish from interior to exterior helps to create a blurred transition from exterior to interior. A bird image on the wall leading to the roof and the green carpet, resembling grass, allows a symbolic connection with nature.



Vignette of west interior courtyard - The courtyards create an exterior space protected from the strong winter winds as well as the sound pollution coming from the nearby street. Circled windows throughout the building allow children to peek at their friend playing outside.



Physical model - Landscape to roof connection, east



Physical model - Landscape to roof connection, east



Physical model image - Landscape to roof connection, west



Physical model - Landscape to roof connection, west



Physical model - West courtyard



Physical model - Entrance and street relation

## Chapter 6: Conclusion

There is no doubt of the importance that nature plays in our lives from childhood to adulthood. Consequently, since children are at the beginning of human life, it is crucial that we create environments that allow them to engage with nature and this, exponentially more in an urban setting.

Knowing that the global urban population continues to grow, the framework of this thesis can be applied to any urban location. The methodology works best for sites where the urban general population as well as children's population density is high. Additionally, the type of housing of the area plays an important role, since children living in mid to high-rise buildings have less access to green spaces.

To well integrate a nature rich educational facility in an urban site, many questions must be answered. Where is the sun, and how can the building's orientation allow the most sun exposure? Are there existing trees, boulders or water feature that can be kept and put in focus? Is there a change in topography that could be taken advantage of? What are the children's activities in the vicinity of the site? Is there noise pollution, if so what strategies could be used to mitigate it? Answering these questions will help make decision regarding the building's site.

This thesis has developed tools that can be implemented in cities in Canada and around the world. The tools were developed through research analysis of case studies, biophilic design and the natural environment.

The first set of tools, developed through the research analysis of case studies are: tactile learning, openable walls, views of nature, physical contact with nature inside

and outside, varied floor to ceiling heights and using the roof as play space.

The second set of tools developed from the research of Biophilic design refers to the three different types of contact with nature that one may experience, which are, direct, indirect and symbolic. All of these tools could be added singularly or in combinations to existing educational facilities or to new projects under development.

This thesis presents five types of room to implement the tools.

The Outdoor room contains all of the tools and allows children to run, climb, discover and play in groups. This room must be designed to take advantage of the particular nature features present on the site.

The Physical activity room enables children to challenge their physical abilities as well as learn to communicate and help each other. This room needs higher ceilings to allow varied floor heights for children to climb around.

The Transformation room is characterized by its flat floors which creates a spacious area where big objects and toys can be moved around by children. Children can invent worlds of possibilities by experimenting with nature's geometry.

With its curved and soft surfaces, the Retreat room creates a quiet and comfortable space for children to relax and take self time. This room has lower ceilings and nooks scaled for children.

The Educational room is fully glass with high ceiling to allow maximum sunlight and trees to grow inside. Children can play with insects and learn the cycle of life through gardening.



The combination of these rooms creates a complete nature experience for children attending this kindergarten.

The design principals used in this thesis are a result of love for nature and an optimism in the future of urban educational facilities. It is intended to create a framework for future projects aiming to include nature rich environments.

This thesis has shown how architecture can be a vessel to connect early childhood children to nature and encourage their curiosity of the natural environments and ecosystems around us in an urban location.

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