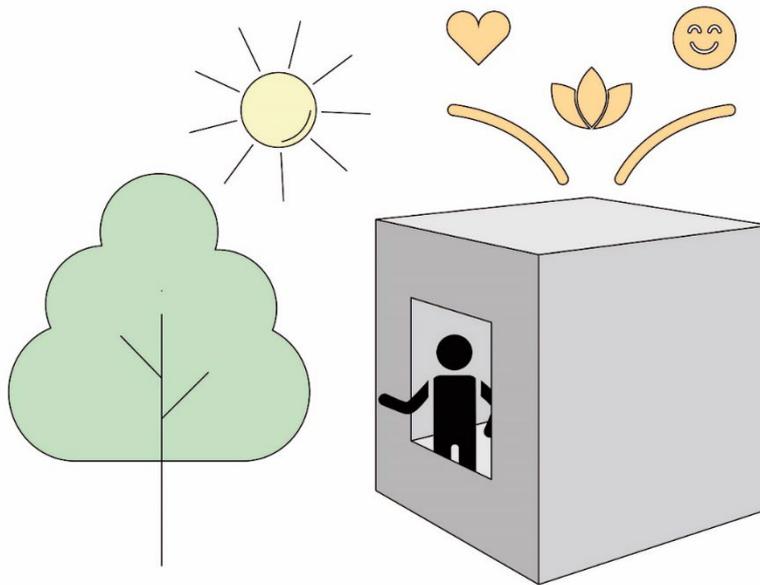


Green architecture and well-being

Case studies of preschool design in the Netherlands

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Summary

This thesis aims to investigate the impact of green architecture features on the well-being of children and staff in Dutch preschools, addressing a gap in previous research. It considers six forms of well-being: physical, emotional, environmental, financial, personal development, and work-life balance. Seven green architecture features are outlined: energy efficiency, water efficiency, environmentally preferred building materials, waste reduction, toxic reduction, indoor air quality, and smart growth. Greenery in architecture is noted to reduce stress, promote social interactions, support child development, stimulate personal growth, and encourage physical activity, with potential drawbacks such as allergic reactions and excessive sunlight exposure.

Four Dutch preschools, Open Air School, Het Volle Leven, IKC De Kleine Kapitein, and De Avonturier, are analyzed, highlighting the impact of Green Architecture features on the well-being of the children and staff and how this is visible in architectural elements. Common green architecture implementations include biodiversity, waste reduction, strategic window placement for airflow and natural light, and multifunctional layouts supporting interaction and ventilation. These features positively influence energy efficiency, indoor air quality, and smart growth, ultimately enhancing physical and emotional well-being.

Introduction

When studying architecture at the TU Delft, sustainability and the implementation of greenery are big topics of discussion during multiple subjects. However, when discussing this topic it is almost always about the implementation of your design and mostly about how this could benefit the environment. These topics are rarely discussed in reliance to the occupants of the building, how will the design choices you make regarding sustainability and greenery influence the people using your building?

Although a lot has been written about the positive effects of green spaces on well-being, previous research has primarily focused on the examination of public green spaces, such as parks and forests, as well as private greenery, such as gardens. However, there has been a lack of investigation into the use of greenery in architectural elements. This particular area of study remains unexplored and requires further investigation. This research will try to fill this gap and will on one hand, take a broader interpretation of "green," while on the other hand, focus on preschools in the Netherlands specifically.

Research question

With the focus being on the occupants of the building this research aims to find an answer to the question: How did Green Architecture features contribute to the well-being of children and staff in Dutch preschools? This question will be answered by looking into the effects greenery has on the well-being of occupants, by doing case studies and by looking into the introduction of Green Architecture features in the architecture of these preschools. And by looking into the effect these features have on the well-being of the building users.

This -paper will focus on both literature research and case studies (analyses and literature research) of different preschool buildings. With the general literature research, the connection between greenery and well-being will be investigated and the main principles of Green Architecture will be laid down. The preschools will be studied specifically in the form of case studies, with a focus on the use of Green architecture principles and on how and why they are implemented.

Methodology

This -paper will start with the definition of important phrases and concepts such as green architecture, well-being and its influence on learning. Afterwards, the main principles of green architecture will be investigated and how their connection with well-being is evident. Then the case studies will be introduced. Here the main principles of green architecture will be looked upon. How are these principles evident and how do they contribute to the well-being of the occupants? Lastly, in the conclusion an overview will be given of all the principles and of which of the principles are the most important for the well-being and how these principles can be seen in the architecture of the preschools. With this conclusion, the research aims to make a matrix that can be used for future designs. In addition to this matrix, some recommendations will be given on the designing of a preschool in The Netherlands.

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Theoretical framework

Well-being

According to the Cambridge Dictionary (2024), well-being is the state of feeling healthy and happy. This feeling of well-being is subjective and cannot be measured. The term 'well-being' can be interpreted in various ways, with some focusing more on the medical, mental, or personal aspects. This research will focus on the built environment and its effects on the well-being of its users. Therefore, this study will not delve into the subjective state of the human being. The internal and external factors of the built environment could influence six forms of well-being (Hays, 2024).

- Physical well-being;
 - o This is about the physical state of your body. For example, if you are being sick or feeling pain. Physical well-being can be improved by food, movement and adequate rest.
- Emotional well-being;
 - o Emotional well-being is about feeling down or feeling stressed. Even the smallest thing as recognising and talking about these problems can help. Emotional well-being could also influence your physical well-being in the form of stress.
- Environmental well-being;
 - o Feeling safe in your environment is essential for well-being and can be either mental or physical. Mental safety includes being treated equally and feeling respected, while physical safety can reduce stress.
- Financial well-being;
 - o Financial stability means not stressing about bill payments which can negatively impact emotional well-being.
- Personal development;
 - o It is important for your well-being to have a sense of personal development and to have something to strive for or anticipate in the future. Lacking a goal or a positive outlook on the future may result in feeling melancholy or a lack of motivation.
- Work-life balance;
 - o Struggling to balance work and life can lead to stress. To improve your work-life balance, focus on getting enough rest, taking care of your physical and emotional well-being, and creating boundaries between work and personal time.

A balance of these six factors will lead to an improvement of the overall well-being, concentration, and a reduction in stress levels. Achieving this balance can also lead to a decrease in the frequency of feeling unwell. It's important to note that this balance may vary from person to person, making it difficult to standardize.

Green architecture

The term "green" is used to refer to buildings that are designed and constructed to minimize their impact on the environment. This includes not only the construction process itself but also the entire lifespan of the building (Omolewa, 2023). Other commonly used terms for this type of architecture include "sustainable" and "environmentally friendly" architecture. Such buildings are characterized by their careful use of resources, their energy efficiency, and their overall environmental sustainability. The principles of green architecture are becoming increasingly important in today's business and academic environments, as organizations seek to reduce their carbon footprint and promote more sustainable, environmentally responsible practices (Sharma, 2023).

The term "Green Architecture" can be divided into seven components. These components are focused on the building process and the lifespan of the building, to minimize harm to the environment and support it.

The 7 features of green architecture are (Jackson, 2022);

- Energy efficiency and renewable energy;
 - o Energy efficiency is a term used to describe the reduction of energy usage in buildings as much as possible, while still maintaining a comfortable indoor climate. One of the main focuses of energy efficiency is the heat island effect, as it plays a significant role in the cooling demand and energy consumption of a building. The goal is to minimize energy usage and waste as much as possible.
 - o Renewable energy is energy that comes from a renewable source, a source that can't be depleted and doesn't harm the environment.
- Water efficiency;
 - o Water efficiency, like energy efficiency, aims to reduce the amount of water used in a building, both during its construction and throughout its lifespan. This can be achieved by making informed choices about building materials and their origin, as well as by using low-flow fixtures such as water-efficient showerheads and toilets. Additionally, water can be reused within the building, such as by collecting rainwater on the roof and using it for flushing toilets or watering plants. Currently, drinking water is often used for these purposes, which increases the building's water demand.
- Environmentally preferable building materials;
 - o During the building process, sustainable materials that are energy and resource-efficient are used to minimize waste. For instance, if a steel plate is used to cut out connection pieces, the leftover plate with holes in it is not discarded. Instead, it is repurposed as a room divider or an art piece. Similarly, the grid size of the building is chosen in compliance with the length of the wood or steel beams to ensure there are no leftover pieces when they are cut to the correct size. These techniques not only reduce waste but are also cost-effective since less material is required.
- Waste reduction;
 - o The concept of waste reduction in Green architecture is closely related to the use of environmentally preferable building materials discussed earlier. Waste reduction focuses on minimizing waste rather than energy consumption. This can be achieved by using material-efficient methods as well as recycling building

materials from demolished buildings or the same building during renovation. Reusing and recycling materials reduces the need for new materials, which in turn decreases waste and minimizes greenhouse gas emissions from the production of new materials.

- **Toxics reduction;**
 - o To reduce the toxicity of the building materials, materials with the EPA's and DfE logos are advised. These logos ensure the materials meet the health and safety standards of the pesticide registration process.
- **Indoor air quality;**
 - o As the term suggests, this factor is about the quality of the indoor air and can be measured with the air quality index. This index is there to protect the occupant's health. The air quality can be improved by for example adding a green roof and aluminium-weather-resistant insulated access panels or by improving the natural air flow by incorporating this into the layout of the building.
- **Smart growth and sustainable development;**
 - o This last aspect of Green architecture is concerned with how the building is used and how it contributes to sustainability efforts and the reduction of toxic pollution. This can be achieved by incorporating sustainable features that are easily visible or by including educational programs that promote sustainability. Educating people about sustainability and making sustainable choices in building design ensures that future buildings will also be sustainable and that people are more conscious of the environmental impact of buildings.

The effect of greenery

Since the 1990s, the link between biodiversity and well-being has become an important topic of public discussion and scientific research. This was due to the Brundtland Report and the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 (Naeem et al., 2016). Due to the influx of research done on this topic, many connections between access to greenery and the level of well-being were found, including stress reduction, promotion of social contacts, support for optimal childhood development, stimulation of personal growth, providing a sense of purpose, and encouraging physical activity (De Vries, n.d.).

Wageningen University and Research (2019) conducted a study on the effects of plants in the workplace. The research focused on the measurable impacts of these plants, finding that they increased air humidity by 5% in summer and by as much as 17% in winter, thereby enhancing the physical well-being of workers by improving indoor air quality (Klopmaker, et al., 2019). Employees involved in the study were less likely to perceive the temperature as too hot or too cold and found the workspace more attractive and enjoyable with the introduction of plants. This positive change was also reflected in the employees' moods, as they were more content with their own work and that of their colleagues. Furthermore, the employees reported that they were less likely to think about work in their free time, improving their work-life balance. Overall, these improvements resulted in an average of 1.6 fewer sick days per year.

Besides the impact greenery can have from being on the inside of a space, greenery can also have a positive effect by being in the surroundings of a building. Greenery could provide urban cooling, better air quality and better water quality due to evaporation and toxic-reducing properties. Furthermore, greenery could help with protection from floods by strengthening the dikes ensuring climate security (Remme, et. al., 2021). Adding to this, green environments could also have a positive effect on the amount of physical exercise that is being conducted in the environment (Warburton, et. al., 2006). Due to the green streets and the easy access to greenery, people are more likely to go outside, cycle to work or school instead of taking the car and are more likely to exercise. These results can be brought back to the positive effect greenery has on stress and people's moods (Zhang, et. al., 2019).

The research findings do indicate that the positive effects of greenery were generally greater for women compared to men and even greater for the elderly (De Vries, et. al., 2023). These effects were particularly significant for cardiovascular, movement, airways, and digestive system health. However, there were no notable improvements found for psychological and neurological issues, except for stress. Multiple studies have shown a significant reduction in stress levels associated with exposure to green environments (World Health Organization [WHO] et al., 2021).

However, some disadvantages can also be found regarding greenery and well-being; allergic reactions, vector- and water-borne diseases, excessive sunlight exposure and injuries (Remme, et. al., 2021). The research results were mixed regarding skin cancer. On one hand, having a garden was linked to a positive effect on the occurrence of skin cancer. On the other hand, it was found that the larger the garden, the lower the positive effect. This is most likely due to prolonged sun exposure in larger gardens (De Vries, et. al., 2023). Nevertheless, all research showed that the advantages of greenery on well-being outweighed the possible disadvantages. This report will therefore focus on the advantages and disregard the disadvantages for now.

Open-air school

In Amsterdam, in the courtyard of a housing block, a preschool designed by Jan Duiker and Bernard Bijvoet can be found. The Open-air school was built in the 1920s with the main goal of helping children with special needs by incorporating nature into the design (figure 1). Duiker and Bijvoet achieved this by maximizing the entry of light and air into the school. The school consists of a central staircase connecting the 4 stories. Each of the east and west quadrants of the school contains one classroom per floor. The south quadrant also has one classroom on each floor, however, this is an open classroom. The north quadrant only contains a staff room on the ground floor. The school's facade is almost entirely made of glass panels, which allow the classrooms to be flooded with natural light and fresh air (Architecture, 2019). The Open Air School in Amsterdam served as an example for many other schools. The principles of using light and air to help children develop better can be seen in all of these schools. However, the Open Air School in Amsterdam is the only one located in a neighbourhood. The others are mostly situated in natural settings, such as meadows (WikiArquitectura, 2020).



Figure 1; Open Air School, Amsterdam (Hidden Architecture, 2019)

Architectural components

With the introduction of light and air as one of the main focus points of the design, most green architectural features that are introduced in The Open-air school are used in relation to this.

The façade is almost entirely made out of windows with a thin metal frame. With the facades being made out of glass, a lot of materials could be saved, compared to making a closed façade. Moreover, the design allows the windows to open up almost the entire facade of the classrooms, enabling an abundance of natural light and fresh air to permeate the spaces. This not only creates better learning conditions but also contributes to reducing stress among the occupants.

The construction of the building furthermore contributes to the inlet of light and air into the classrooms. The construction consists of concrete columns and stiff floors, as seen in figure 2. Normally the columns of a building are placed on the corners of the building. However, for The Open Air School, Duiker and Bijvoet decided to place the columns in the middle of the façade. This ensured the corners of the classroom were opened up entirely. Furthermore, this placement of the columns is favourable for the distribution of forces since the facades are not load-bearing. Resulting in less material needed for the construction of the building.



Figure 2; Floorplan and side image of the Open Air school where the construction is visible (Hille, 2011)

The classrooms are positioned on the east and west sides of the building, providing windows to the northeast, southeast, northwest, and southwest (see figure 2). Due to the building's orientation, the classrooms receive sunlight throughout the day as the sun moves from east to west in the Netherlands. Additionally, as the wind in the Netherlands blows from west to east, it passes through the building, creating a passive ventilation system that ensures fresh air throughout the day. Therefore, the building's orientation supports the physical and mental well-being of the students and teachers by providing ample sunlight and fresh air in the classrooms.

The preschool's outer classrooms are shielded from wind and rain by the adjacent classrooms and the roof above each outer classroom. As a result, the outer classrooms are accessible throughout the year. Being located outside allows the students to learn about nature and in nature, which contributes to their personal development and understanding of the natural world. This not only helps with their emotional well-being by reducing stress, but also fosters a deeper understanding of the environment.

Sub conclusion

The Open Air School in Amsterdam is specifically designed to maximize the intake of sunlight and fresh air. This is particularly important because the students at the preschool have mental challenges. Sunlight and fresh air help improve their concentration and reduce stress, benefiting their physical and emotional well-being. The school's design features that contribute the most include construction and facade design to optimize the intake of light, as well as the orientation of the classrooms and outdoor areas to ensure passive ventilation and sunlight throughout the day.

Open Air school	Physical	Emotional	Environmental	Financial	Personal development	Work-life balance
<i>Energy efficiency</i>	-	-	-	-	-	-
<i>Water efficiency</i>	-	-	-	-	-	-
<i>Building materials</i>	-	-	-	-	-	-
<i>Waste reduction</i>	Windows Construction principles	Windows Construction principles	-	-	-	-
<i>Toxics reduction</i>	-	-	-	-	-	-
<i>Indoor air quality</i>	Layout	Layout	-	-	-	-
<i>Smart growth</i>	-	Outside classroom	-	-	-	-

Tabel 1; Architectural components visible at the Open Air school in Amsterdam (own work, 2024)

Het Volle Leven

The preschool 'Het Volle Leven', which translates to 'the full life', is located in The Hague, The Netherlands. It consists of 23 classrooms, a gym, and an extensive outdoor play area. The design was created by HVE Architects, with landscape design support from Studio EVO (HVE Architects, 2022). The phrase 'Het volle leven' originates from Jan Ligthart and emphasizes the inclusion of nature in the learning process (Leven, n.d.). The preschool was initiated by parents concerned about the budget for the schoolyard. This led to a comprehensive review of the entire building, which was in poor condition and required demolition and rebuilding. The new schoolyard is intended to be an integral part of the educational system, in line with the school's name (Van Es, 2022).



Figure 3; Het Volle Leven, The Hague (Arno, 2022)

Architectural components

The preschool design includes two main parts: the building and the schoolyard. The building houses 22 out of the 23 classrooms and is designed to create an open and airy environment. This layout ensures good air quality in every room to promote the physical well-being of the students and teachers, showcasing the connection between green architecture and well-being. The building's form was designed to go around the existing trees, ensuring they did not have to be taken down. This reduced waste from demolition and showcased the idea of working with or around nature instead of the other way around. This made the buildings form a learning objective for personal development, which is included in the educational system for smart growth and sustainable development.

The last classroom is located outside, in the schoolyard. This classroom can be used to teach about nature and the connection people have to it. Learning in nature is a great example of the green architecture feature "smart growth and sustainable development." Additionally, because this classroom is outside, it helps reduce stress among students and gives children a positive outlook on the future by learning about nature and how to help achieve a sustainable environment.

The schoolyard is designed with large green spaces, various play areas, and the outdoor classroom (see figure 4). The large green areas are filled with different types of plants and trees, providing the schoolyard with high biodiversity. This biodiversity promotes the physical well-being of the students in two ways. First, it promotes physical activity due to the greenery, contributing to the smart growth and physical well-being of the children. Additionally, the air quality is improved by the many different plants that absorb toxins from the air, resulting in better indoor air quality, which in turn helps with concentration and the overall health of the users.



Figure 4; The green and blue schoolyard of preschool 'Het Volle Leven' (Platform STAD, 2022)

The trees that are placed in the schoolyard provide natural shading. Because of this shading, the area is being cooled down. Due to this cooling effect, the need for mechanical cooling is reduced since there is a lower cooling need. This is an example of an energy-efficient way of cooling the building. Research suggests that a better indoor climate, such as the one created by natural cooling, can reduce stress and improve the Physical and emotional well-being of the occupants.

The last design feature that can be seen in the schoolyard is the water retention system. Most of the pavement consists of semi-paving made out of recycled materials so that water can pass through. This together with plants that root deep into the ground make for controlled water retention, ensuring environmental well-being. Furthermore, the rainwater can be recycled with the water pump. This pump is connected to a pipe system that leads to the garden, watering the plants. Because rainwater is used for watering plants, no 'clean' water has to be used, making it a water-efficient system. The pump can be handled by the children creating an involvement of the children, helping their personal development.

IKC De Kleine Kapitein

De Kleine Kapitein, or in English the little captain, is a preschool located on Cruquiseiland in Amsterdam. The building, designed by NAT Architects, was completed in 2021. In addition to the preschool, it also houses a daycare, after-school care, and two sport and gymnastics halls (Dekker, 2022). The preschool is constructed based on the principles of the Dalton School, with a focus on flora, fauna and children. This implies that the school, including the building and the education, is designed to prioritize the freedom of choice for the children, as well as their cooperation and social interaction (DKC de Kleine Kapitein, n.d.). De Kleine Kapitein consists of multiple classrooms that can be opened up to interact with other classrooms or with the learning squares in the hallways. The school also has a large schoolyard that is open to the neighbourhood in the evenings (NAT Architecten, n.d.).



Figure 6; Render of IKC De Kleine Kapitein, Cruquiseiland Amsterdam (Sijperda and sijperda-hardy, n.d.)

Architectural components

The building in which De Kleine Kapitein is located is made out of a steel construction and concrete floors. The use of weight-bearing steel columns allows for the seamless replacement and repositioning of walls and facades, resulting in a space that is not only adaptable but also easily expandable. This versatile design promotes a free-flowing layout, ensuring optimal airflow throughout the building. The abundance of fresh air contributes to superior indoor air quality, creating an environment that is conducive to reducing stress and enhancing concentration for all occupants.

De Kleine Kapitein is an almost energy-neutral building and has been awarded the label of a Fresh School class B. This means that the preschool generates almost all the energy it uses year-round. Additionally, there is a separate system per room to regulate the indoor climate. This is made possible by the 400 solar panels on the roof and the heat pump, which eliminates the need for any gas usage in the building. These systems are designed to optimize the indoor climate for each specific group and activity. Furthermore, when a room is not in use, the systems for that room are shut down to prevent any unnecessary energy usage while maintaining an optimal indoor climate for the occupants.

The facade of the building, visible in figure 7, is constructed from recycled stone and rest materials, significantly reducing waste during construction. Not only does it benefit the environment, but it also serves as a valuable educational tool for children. The visible and accessible recycled materials provide a hands-on opportunity for children to learn about the potential of "waste" materials and the concept of reusing items instead of discarding them when they can no longer serve their original purpose.

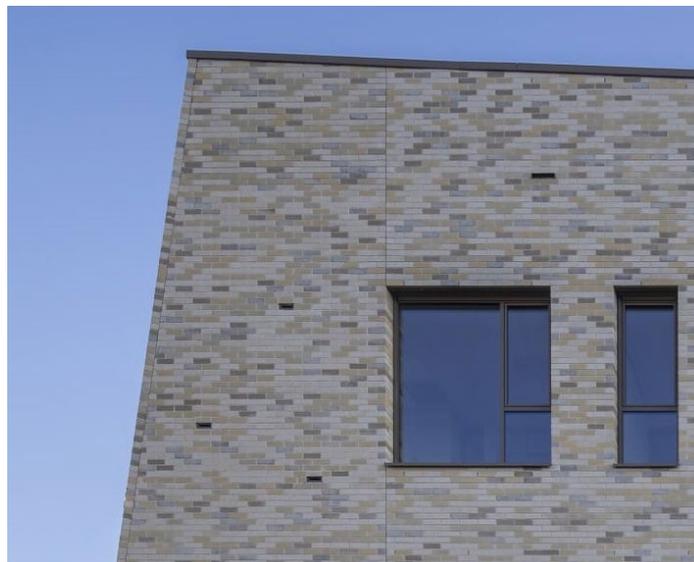


Figure 7; Façade of IKC De Kleine Kapitein made out of recycled stone with integrated nesting boxes (K Dekker, 2022)

Within the facade, nesting boxes for birds, bats, and insects are placed (see figure 7). These boxes provide a nesting place for these animals, which in turn helps the greenery in the playground to flourish. Similar to the cladding, these boxes demonstrate to the children how architecture and biodiversity can be combined, and how animals contribute to the world around us. These nesting boxes contribute to both the personal development of the children by teaching them about nature, and to the smart growth by showing the influence architecture can have on nature.

The schoolyard is filled with lots of greenery and play areas. The greenery helps to cool down the outside air through evaporation. Since the school is located in Cruquiseiland, a densely populated urban area, the greenery helps to reduce the effects of the Heat Island effect experienced in the rest of the island. This cooling effect extends to the inside of the school as well, as the outside air is used in the ventilation system. As a result, less energy is needed for cooling, leading to improved indoor air quality, reduced stress, and better concentration.

Sub conclusion

De Kleine Kapitein is a preschool located in a densely populated urban area in Amsterdam. The school focuses on fostering a strong connection between children and nature. The building is constructed to be energy-neutral, resulting in an energy-efficient environment with ample fresh air. The facade is constructed using recycled materials and incorporates nesting boxes for birds, bats, and insects. These waste-reducing and environmentally friendly features contribute to the personal development of the children. Additionally, the school's green outdoor space helps mitigate the heat island effect by cooling the schoolyard, which in turn helps maintain a cooler environment inside the school, reducing stress and aiding concentration.

<i>IKC de Kleine Kapitein</i>	Physical	Emotional	Environmental	Financial	Personal development	Work-life balance
<i>Energy efficiency</i>	Natural cooling	Installations Natural cooling	-	-	-	-
<i>Water efficiency</i>	-	-	-	-	-	-
<i>Building materials</i>	-	-	-	-	-	-
<i>Waste reduction</i>	-	-	-	-	Recycled cladding	-
<i>Toxics reduction</i>	-	-	-	-	-	-
<i>Indoor air quality</i>	Layout Natural cooling	Installations Natural cooling	-	-	-	-
<i>Smart growth</i>	-	-	-	-	Biodiversity	-

Tabel 3; Architectural components visible at IKC de Kleine Kapitein in Amsterdam (own work, 2024)

De Avonturier

De Avonturier is a preschool situated in Vugt. It is the result of the merger of two former preschools, De Baarze and De Wieke, a kindergarden, a primary school, and various sports facilities. Additionally, the new design had to establish a connection with the existing youth centre located next to the given plot (Withaar, n.d.). The design, completed in 2018, was created by KOW Architects, and the major challenge was accommodating the many different users of the building, each with unique opinions and wishes (De Architect, 2019). To maintain a small-scale feel throughout the vast building, KOW created a separate entrance for each function and joined them via an atrium in the centre of the building (KOW, 2024).



Figure 8; Render of De Avonturier, Vugt (Colinda & KOW, 2024)

Architectural components

In addition to the atrium that connects the different parts and users of the building, De Avonturier has some big windows on the outside of the building. Besides being able to look onto the green schoolyard, these windows also help to naturally ventilate the building. The warm air rises in the atrium, creating a draft from the classrooms to the atrium and ensuring ventilation throughout the classrooms. Although the building also has a mechanical ventilation system due to the scale, the windows and atrium provide more light, fresh air, and better indoor quality. This contributes to the physical and emotional well-being of the students and employees.

The classrooms are ventilated with a combination of mechanical and natural ventilation systems that allow fresh air from outside to flow in. The school is surrounded by a large green schoolyard that helps reduce the temperature of the air outside. This not only helps to combat the Heat Island effect but also cools down the air used for ventilation inside the building. Since the air is already cooled by the evaporation of the greenery in the schoolyard, the mechanical ventilation systems do not have to work as hard to cool down the air, reducing energy usage.

Despite this, the indoor climate remains comfortable and conducive to the emotional and physical well-being of both students and staff.

The program for the school building was quite large, which resulted in a massive structure. However, there were three monumental trees located in the schoolyard that needed to be preserved (see figure 8). To achieve this, KOW Architects designed the building in a way that allowed the three trees to remain in the schoolyard while also being highlighted from both inside and outside the building. This approach not only reduced waste by avoiding the need to cut down the trees but also provided an opportunity for personal growth due to the trees' central location.

KOW Architects made the decision to combine functions into multi-functional spaces (see figure 9) due to the large preschool program. These spaces can be used by multiple users of the building either one after another or at the same time. The multi-functional spaces can consist of different kinds of workspaces in one big, open court or of play and relax spaces in the hallways that can expand into the classrooms with movable walls. This approach leads to a lot of flexibility in the floor plans and less floor area is needed to accommodate the same amount of functions. Furthermore, by having shared space for multiple user groups, the mental health and personal development of the users can be improved due to new and different interactions.

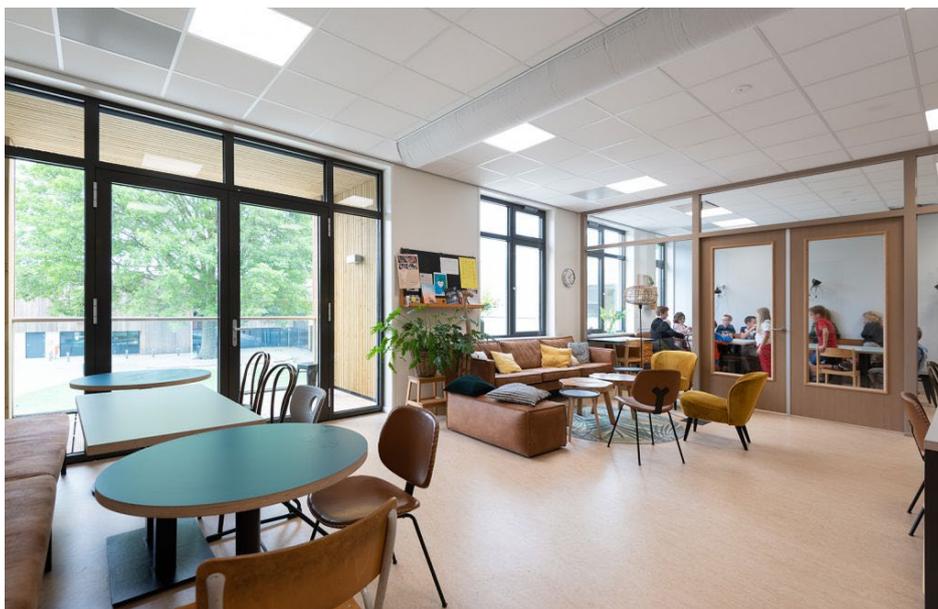


Figure 9; Multifunctional space inside De Avonturier, used by different user groups (Colinda & KOW, 2024)

The construction of the building can be separated from its shell, including the cladding, insulation, and inner walls. This allows for the shell to be repaired independently from the construction, and for the building to be modified or expanded without damaging the entire structure. By implementing this approach, waste during construction can be minimized, as it is not necessary to demolish the entire building to remove, for instance, the outer walls. Additionally, this design can serve as a learning opportunity for children, who can gain knowledge about sustainable building practices and the manufacturing process, thus enhancing their personal development.

Sub conclusion

The preschool De Avonturier is a preschool combined with many more functions and users, resulting in a design that combines different functions and users to optimise the layout while ensuring the emotional well-being and the personal development of children. Furthermore, this school ensures both physical and mental well-being by improving indoor air quality and by implementing energy-efficient ventilation systems such as natural cooling of outside air. While designing measures were made to minimise waste during the building period and the exploitation period by optimising the layout and by making the shell and construction of the building demountable, helping with the personal development of the children.

<i>De Avonturier</i>	Physical	Emotional	Environmental	Financial	Personal development	Work-life balance
<i>Energy efficiency</i>	Natural cooling	Natural cooling	-	-	-	-
<i>Water efficiency</i>	-	-	-	-	-	-
<i>Building materials</i>	-	-	-	-	-	-
<i>Waste reduction</i>	-	Layout	-	-	Building form Layout Construction principles	-
<i>Toxics reduction</i>	-	-	-	-	-	-
<i>Indoor air quality</i>	Windows	Windows	-	-	-	-
<i>Smart growth</i>	-	-	-	-	-	-

Tabel 4; Architectural components visible at De Avonturier in Vugt (own work, 2024)

Differences in architectural components between preschools in the Netherlands

After comparing the four preschools that were previously discussed, it became evident that certain Green Architecture components have a greater impact on the well-being of preschool users than others. Some components appeared to have no connection at all. The Green Architecture components that had the most significant influence were "Energy efficiency," "Waste reduction," "Indoor air quality," and "Smart growth". These components were found to have the most significant impact on the physical and emotional well-being of the users, compared to other types of well-being. Within this finding, it was clear that the physical well-being of the users was closely related to their emotional well-being. Mostly when talking about ways to improve the stress levels of the users both the physical and emotional well-being were improved. This finding is consistent with the theory of different types of well-being. However, this research did not find any evidence to suggest that Green Architecture improves the financial well-being or work-life balance of preschool users.

Comparison	Physical	Emotional	Environmental	Financial	Personal development	Work-life balance
<i>Energy efficiency</i>	Natural cooling 3x	Natural cooling 3x Installations	-	-	-	-
<i>Water efficiency</i>	-	-	-	-	Water pump	-
<i>Building materials</i>	-	-	-	-	-	-
<i>Waste reduction</i>	Windows Construction principles	Windows Construction principles Layout	Recycled semi-paving	-	Building form 2x Layout Construction principles Recycled cladding	-
<i>Toxics reduction</i>	-	-	-	-	-	-
<i>Indoor air quality</i>	Layout 3x Biodiversity Windows Natural cooling	Biodiversity Layout Windows Natural cooling Installations	-	-	-	-
<i>Smart growth</i>	Biodiversity	Outside classroom 2x	-	-	Building form Outside classroom Biodiversity	-

Tabel 5; Summary of all the architectural components in the researched preschools, with an indication of how many times a component was visible (own work, 2024)

Biodiversity is an essential element in Green Architecture, which can contribute to multiple well-being types. Biodiversity can be seen in multiple forms throughout the observed projects, such as the incorporation of green schoolyards, natural cooling, and the preservation of local flora and fauna. One of the primary benefits of biodiversity is its ability to reduce stress levels among building occupants. Studies have shown that exposure to natural environments can significantly improve mental health and well-being. Incorporating biodiversity features, such as green schoolyards, outdoor classrooms, and cooling systems that rely on natural ventilation, can provide users with a sense of calm and tranquility. Moreover, biodiversity can also contribute to physical well-being by improving air quality, reducing the risk of allergies, and providing opportunities for physical activity. Therefore, Green Architecture features such as energy efficiency, indoor air quality, and smart growth can contribute to improving physical and emotional well-being through biodiversity.

The various construction principles implemented in the preschools have a significant impact on the well-being of children. These principles were designed to minimize waste production during the building process and make the building adaptable for future needs. For instance, the Open Air school's construction maximizes the light income in the classrooms by using a material-efficient principle where the columns are located in the middle of the facade rather than on the corners. Similarly, De Avonturier's construction allows for a facade that can be taken apart and separated from the building, making it easier to replace individual components. Both of these principles result in a reduction of materials used during the building's lifespan while also improving the physical and emotional well-being of children. By emphasizing the use of natural light and fresh air, these principles also promote personal development and create a positive learning environment.

The "Energy efficiency and renewable energy" aspect of Green Architecture has a direct impact on the physical and emotional well-being of preschool occupants. One of the key design features that connects these elements is the natural cooling effect that occurs in almost all of the preschools that were studied. This natural cooling is achieved through the use of trees and greenery in the schoolyard, which provides shading and helps reduce the Heat Island effect. This temperature change in the outdoor air results in cooler air being brought into the building, which reduces the need for excessive cooling. In combination with room-specific systems, this approach ensures that no excessive energy is used while maintaining a comfortable indoor climate. As a result, children and staff experience less physical and mental stress, leading to better physical and emotional well-being.

The aspect of Green Architecture called 'Indoor air quality' refers to the amount of fresh air that enters a room at any given moment. In the preschools that were researched, two key architectural aspects were found that can be used to improve the indoor air quality and, at the same time, enhance the physical and emotional well-being of the occupants. The first design aspect is the layout of the building, which can be optimized to ensure that there is sufficient fresh air in every room. The preferred orientation that could help with the layout is an east-west orientation, as seen in The Open Air school. Secondly, the windows in the building play an important role in providing fresh air. The characteristics that could impact this are the size and orientation of the windows, as well as the ability to open them. Good indoor air quality can help to reduce stress, improve concentration, and enhance the overall health of the users, resulting in improved physical and emotional well-being.

Several of the preschools that have been researched have an architectural design feature called an open or outside classroom. Such classrooms are either located fully outside the school building, on the schoolyard or can be opened up for at least half of the facade. The open or outside classroom is designed to promote interaction between children and nature, leading to better emotional well-being and personal development. By exposing children to the natural environment, they can learn about nature and sustainability in a hands-on way. These classrooms are often used for teaching about plants, animals, and other aspects of nature. They also provide opportunities for children to learn about sustainable practices, such as composting, recycling, and reducing waste. Studies have shown that exposure to nature can reduce stress and anxiety while fostering a positive outlook on life.

According to the research, there was only one instance where water efficiency had an impact on the well-being of children, which was at Het Volle Leven. This example involved a water pump that allowed children to water plants and learn about water conservation simultaneously. However, this example was unique and did not support the theory that water efficiency has a significant influence on the well-being of children in preschools in the Netherlands.

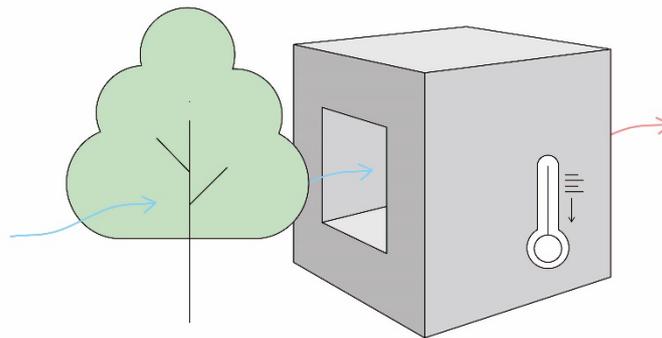
For the researched preschools, no evidence could be found that the Green Architecture features 'environmentally preferred building materials' and 'toxic reduction' had any influence on the well-being of these preschool users.

In conclusion, Green Architecture features have a substantial positive influence on various aspects of well-being, including physical well-being, emotional well-being, and personal development. These influences can be observed through different Green Architecture features that are implemented. However, for the researched preschools, the most vital elements that have a significant impact on well-being are biodiversity, construction types, and natural cooling.

Recommendations

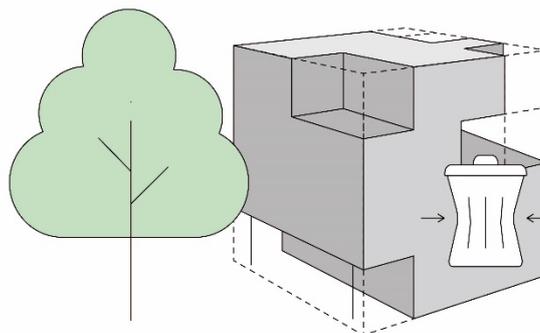
Apart from the key conclusions drawn from this research, some design recommendations can be suggested. These recommendations could be useful not only for designing a preschool in The Netherlands but also for designing preschools in other countries or building types. While some of the findings may vary depending on the regulations of different countries or building types, most of the findings are still applicable.

One of the primary recommendations for designing a preschool in The Netherlands is to incorporate biodiversity into the design. This can be achieved by adding greenery like trees, bushes, or flowers in and around the building. Ideally, the greenery should be placed close to the building, and the ground should be shaded or covered with greenery to minimize the Heat Island effect. The closer the biodiversity is placed towards the building, the more impact it will have on the naturally cooled air inside the building since the air will not have time to warm up again. The added greenery will not only help cool the indoor air but will also help purify it, leading to better air quality. These two main benefits will result in lower energy consumption for the building and lower stress levels for the occupants, which will lead to better physical and emotional well-being.



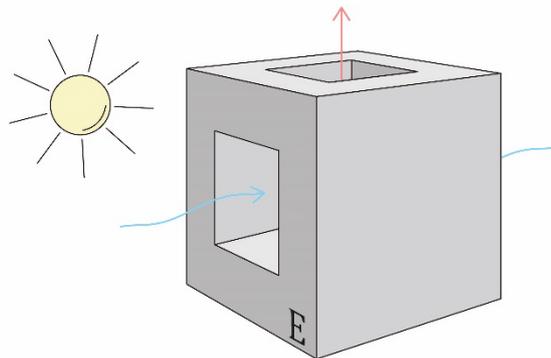
Visualisation of recommendation 1; Biodiversity (own work)

The choice of construction principle for a building can impact its sustainability and the well-being of its users. There are construction principles that can reduce waste during construction and improve the building's usability. Such principles may include allowing more natural light and air into the building or preserving existing greenery. It is recommended to consider natural features such as light, air, and vegetation early on in the design process of the building and its construction.



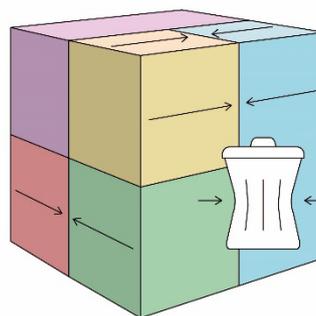
Visualisation of recommendation 2; Construction (own work)

It is recommended to carefully consider the placement of windows when designing a classroom. This is to ensure that the maximum amount of natural light and fresh air can enter the room. For optimal airflow, it is best to orient the windows towards the east or west. Additionally, it is important to ensure that the windows can be easily opened, either fully or partially, to allow fresh air into the room. By taking into account the placement of windows alongside the construction principle, waste can be minimized and even more light can be allowed into the classroom. Windows play an important role in promoting the physical and emotional well-being of the users by reducing physical and mental stress through exposure to sunlight and ample fresh air.



Visualisation of recommendation 3; Windows (own work)

When designing a preschool building, it is important to consider not only the construction and windows, but also the layout of the building. When designing for multiple user groups in one building it could be beneficial to merge spaces and make them accessible to multiple user groups. While doing this waste can be reduced during construction, and users can benefit from meeting each other. Additionally, the building's layout can optimize airflow through the classrooms and the rest of the school, ensuring fresh air in every part of the school. To achieve this, it is recommended to create a draft through the building by either using an atrium or placing windows across from each other.



Visualisation of recommendation 4; Lay-out (own work)

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