DESIGNING FOR THE SENSES

Developing architectural guidelines for educational environments for visually impaired children

Technical University Delft
Faculty Architecture
Dwelling graduation studio:
Designing for care in an inclusive environment
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Abstract

This thesis explores how sensory design principles, shaped by the perspectives of visually impaired children, can enhance the accessibility of educational environments. The primary research question is: "*In what way can the perspective of a child and sensory design principles enhance the accessibility of educational environments for visually impaired children in, for example, the Tarwewijk?"* The study emphasizes the integration of sensory elements such as sight, touch and sound to create more navigable and supportive spaces for these children.

A mixed-methods approach was employed, consisting of a literature review, observations in blind-simulation environments, and interviews with an architect who has a visual impairment. These methods provided valuable insights into the practical application of sensory design for visually impaired children.

The research revealed that multisensory design elements, like tactile markers and sound cues, significantly enhance accessibility and foster cognitive and social development in visually impaired children. Prioritizing sensory inclusivity in design can promote greater independence and engagement in these spaces.

In conclusion, sensory design informed by the needs and perspectives of visually impaired children improves the accessibility and usability of educational environments. Future research should build upon these findings by incorporating more case studies and expert insights to deepen understanding and enhance design practices.

Keywords: sensory design, visually impaired children, accessibility, educational environments, multisensory design, tactile markers, sound cues, sensory inclusivity, independence, cognitive development, social development.

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Research plan

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Problem statement and relevance

Imagine not being able to see anything. How would you find your favourite clothes in your closet? How would you navigate your way to school or work? How would you recognize your classmates or colleagues? Each day presents challenges where simple tasks require significantly more attention and preparation.

Without sight, you must rely on your other senses. For example, you may need to feel each item to choose your clothes, ensuring your closet is carefully organised with labels or textures you can identify by touch. Navigating to school or work can be complicated, especially in unfamiliar areas or busy places. Technology, such as GPS navigation with voice guidance, can assist, but it also introduces new challenges. Recognising people is even more challenging. Without sight, you cannot distinguish faces; instead, you rely on voices, scents, or perhaps someone's unique way of walking.

In Western culture, sight has long been considered the most important sense. However, all our senses play a crucial role in expressing and processing our experiences of the world. The sense of sight stimulates our "focused vision," while all other senses form our "side vision". This side vision helps us transform what we see into real experiences within space and our bodies. While side vision connects us to our surroundings, focused vision can distance us, making us feel like mere observers. When not all senses are stimulated, it can result in feeling less connected to the world and to our experience of life (Pallasmaa, 1996). Pallasmaa criticizes the emphasis on vision in modern architecture, arguing that all senses should be engaged to create spaces that connect people to their surroundings. I support this perspective, as it is central to my research and highlights the importance of sensory inclusivity in environments.

Designing for all senses is essential for individuals with visual impairments. Because their sense of sight is either limited or absent, this group relies heavily on their other senses to understand the world around them (Havik, E.M., 2012). In the Netherlands, approximately 300,000 people live with visual impairments, and around 200,000 of them experience severe low vision or blindness (Oogfonds, n.d.).

Figure 1, Schaafsma. M. (2021)

Mark Schaafsma, a Dutch photographer, created a photo exhibition titled "MIJN GeZICHT". This exhibition features a series of double portraits, displaying both a typical portrait and how the visually impaired person perceives that portrait (Schaafsma, 2021). Figure 1 showcases several portraits from this exhibition, illustrating the impact that visual impairments can have on perception. This quote from Null, R. (2012) can be connected to this exhibition and points out how important it is to design for the visually impaired: "*We tend to discount people who are less than what we popularly consider to be "normal". To be normal is to be perfect, capable, competent, and independent. Unfortunately, designers in our society also mistakenly assume that everyone fits this definition of normal. This just is not the case.*"

The report "*Health and Care in Tarwewijk, a Neighbourhood Analysis (2024)*" highlighted two main topics I plan to explore in my research. Firstly, the neighbourhood of Tarwewijk lacks inclusive design for people with visual impairments. This is evident through the absence of contrasting colours and textures on the streets, which makes it difficult for visually impaired individuals to move around safely and independently. Secondly, while SBO Sonnevanck, a school in the Tarwewijk offering special primary education, provides additional support for children facing various difficulties, it lacks an inclusive sensory design accessible to children with visual impairments. These two main topics highlight the need to incorporate sensory design elements to create an educational environment in the Tarwewijk which is accessible for visually impaired children.

Typically, the architectural design for young children is influenced by adult perceptions that often prioritise aspects such as form, colour, and structure. While these elements are important, they do not fully capture how children experience and engage with their environments. For children, spaces are not merely visual—they are actively explored, interacted with, and used as they grow (Said, 2007).

When designing educational environments for visually impaired children, it's essential to consider their sensory experiences and their perspective as children. Although research has explored design for the visually impaired and for children separately, there is still a gap in understanding how to effectively design for visually impaired children. This research aims to create sensory design guidelines specifically for educational environments tailored to visually impaired children, based on their unique perspectives.

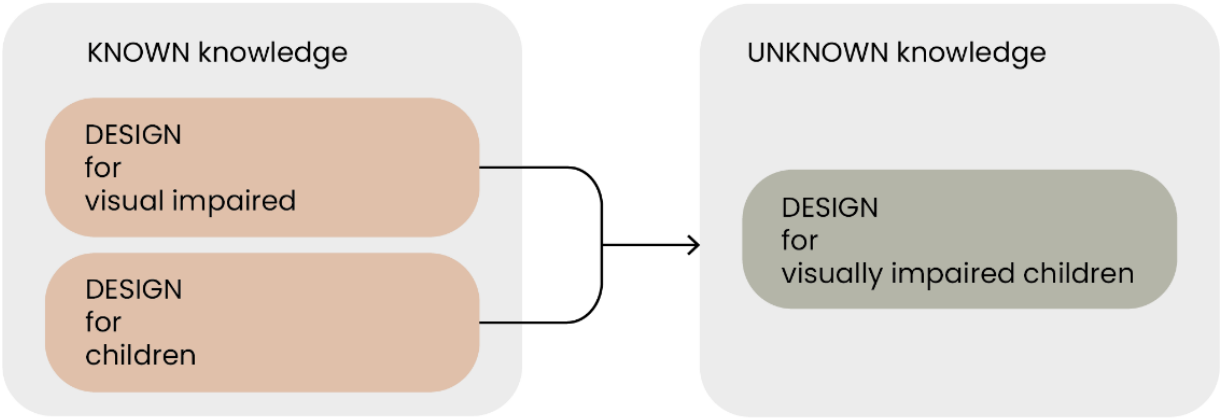

Figure 2, explanation research gap

Theoretical framework

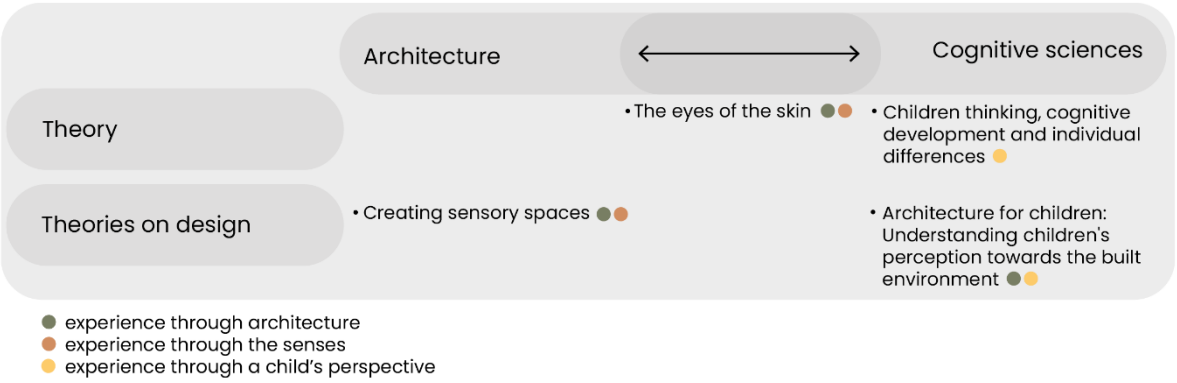

Figure 3, theoretical framework diagram

In this theoretical framework, a foundation is established through a collection of books and papers. These sources connect primarily to two areas of knowledge: architecture and cognitive sciences. Some sources are primarily focused on one of these fields, while others integrate both architecture and

cognitive sciences, enriching the framework with insights from each discipline. Additionally, a distinction is made between two types of content: theory, which includes phenomenological approaches that explore human experience and perception, and design theories, which concentrate on practical principles and strategies for creating spaces.

In "*The Eyes of the Skin*" (1996), architect and professor Juhani Pallasmaa critiques the excessive emphasis on sight in architectural design and underscores the importance of engaging all the senses to create meaningful spatial experiences. His ideas were particularly impactful during a period when architecture was increasingly viewed as sterile and disconnected from human experience, largely due to minimalist and functionalist trends. Pallasmaa's influence extends into various disciplines—design, philosophy, psychology, and art—making his theories valuable beyond the field of architecture. This interdisciplinary relevance has secured his position as a key figure in contemporary architectural theory. His concepts are central to my research, as they emphasize the necessity of sensory inclusivity in environments, especially for individuals with visual impairments.

Barbara Erwine is an architect and educator recognized for her contributions to architecture, especially in the areas of inclusive design and sensory environments. Her book, "*Creating Sensory Spaces*" (2017), provides a framework for designing environments rich in sensory experiences. The book integrates principles from architecture, perceptual psychology, and engineering, showcasing detailed case studies that demonstrate practical applications of sensory design.

To explore how sensory principles can be applied in educational settings, "*Children's Thinking: Cognitive Development and Individual Differences*" (2017) provides valuable insights into children's cognitive development. Researchers Bjorklund and Causey focus on psychology, particularly regarding child development and the role of play in learning. Their book offers a deeper understanding of how children perceive and interact with their environment, serving as a foundation for designing spaces that support their cognitive and sensory developmental needs.

Finally, Ismail Said's paper, "*Architecture for Children: Understanding Children's Perception towards the Built Environment*" (2007), emphasizes a child-centred approach to architectural design. As an architect, educator, and researcher, Said is recognized because he underscores the importance of designing spaces that reflect children's perspectives rather than relying on adult assumptions. This is particularly vital when creating environments for visually impaired children. His paper effectively connects child development theory with architectural principles, ensuring that sensory design addresses the specific needs of children.

These works collectively establish a comprehensive theoretical framework that facilitates the creation of sensory-rich educational environments for visually impaired children. This framework ensures that the design prioritizes the perspective of the child. During the research, additional sources will be identified to effectively address the sub-questions. These sources will be consistently introduced and documented within the research report.

Hypothesis

Incorporating sensory design elements that engage all five senses- touch, sound, smell, and taste- and considering the perspectives of visually impaired children will enhance their capacity to navigate, discover, and learn in educational environments. This strategy will contribute to their comfort and sense of connection with their surroundings.

Research question

The central research question guiding this research is:

"*In what way can the perspective of a child and sensory design principles enhance the accessibility of educational environments for visually impaired children in, for example, the Tarwewijk?"*

This research question will be answered through these sub-questions:

1. "*How do children develop cognitive and sensory skills, and in what ways do these shape their perception of their surroundings?"*
2. *"How do visually impaired children develop cognitive and sensory skills, and in what ways do these shape their perception of their surroundings?"*
3. *"What sensory design elements can be integrated to support visually impaired children's educational environments?"*

By addressing these sub-questions, the research aims to provide a comprehensive understanding of how sensory design principles, informed by the perspectives of visually impaired children, can be applied to create more accessible educational environments in Tarwewijk.

Methods

This research will use a mixed-methods approach to address the research questions and their sub-questions. The methodology will include both a literature study and fieldwork. The study will begin with a literature review to establish a solid foundation of knowledge. The sources outlined in the theoretical framework will be thoroughly studied. After completing the literature study, fieldwork will be conducted to gather data and validate the theoretical insights. This phase will involve observations and interviews.

Observations

At the beginning of this research, I aim to explore the lived experience of navigating the world without vision. In Nijmegen, the museum "muZIEum" provides a unique opportunity to guide visitors through a completely dark environment to simulate the experience of blindness. This hands-on experience is designed to enhance my understanding of the challenges individuals face with visual impairments, fostering greater empathy for those who experience the world without sight.

To deepen this understanding further, I plan to attend the "Oogbeurs", a specialized event in the Netherlands focussing on resources, innovations, and community for visually impaired individuals. This event features various workshops and attracts a range of organizations and stakeholders. By observing, participating in workshops, and engaging with attendees, I aim to broaden my perspective on the needs, tools, and experiences of visually impaired individuals.

Additionally, to address the sub-questions, I will visit Visio school in Grave for visually impaired children to closely observe how they interact with their environment. I will pay particular attention to their use of sensory cues such as sound, touch, and smell as they navigate spaces. These observations will help identify design elements that either facilitate or hinder their learning and movement, offering insights into supportive design considerations for visually impaired individuals.

Interviews

Semi-structured interviews will be conducted with one visually impaired architect. Arco Ooms, an accessibility advisor in the Netherlands, works with "Ongehinderd" to promote accessible building

design for people with disabilities. Drawing from his visual impairment, he advises architects to integrate accessibility as a core design element, much like sustainability, supporting the creation of inclusive spaces across the country (Ongehinderd, n.d.).

The second interview will be with Anjuli De Geest. She is an accessibility advisor at Visio "*Zicht op Toegankelijk*", where she provides guidance to municipalities, healthcare institutions, and educational organizations on improving accessibility in renovation and new construction projects. Her mission is to promote an inclusive society, a passion rooted in her background as an occupational therapist and mobility instructor at Koninklijke Visio (Visio, n.d.)

By conducting interviews with Arco Ooms and Anjuli de Geest I aim not only to validate but also to expand upon the insights gained from the literature study. These conversations will provide a deeper understanding of the accessibility challenges and design principles related to visual impairments. This approach will integrate the personal experiences and perspectives of those directly affected, creating a more complete view that bridges theoretical concepts with practical realities.

The observations and interviews will be documented in our "Fieldworkbooklet", which I will co-author with Sander Groen. He will also focus on individuals with visual impairments and sensory design, ensuring a collaborative and comprehensive approach to our research.

What	Which organisation	When
Museum for the visually impaired	muZIEum	17-10-24
Event for the visually impaired	Oogbeurs	01-11-24
Interview Anjuli De Geest	Visio	12-11-24
Interview Arco Ooms	Ongehinderd	28-11-24
School visit for visually impaired children	Visio	02-12-24

Table 1, planning fieldwork

Research plan diagram

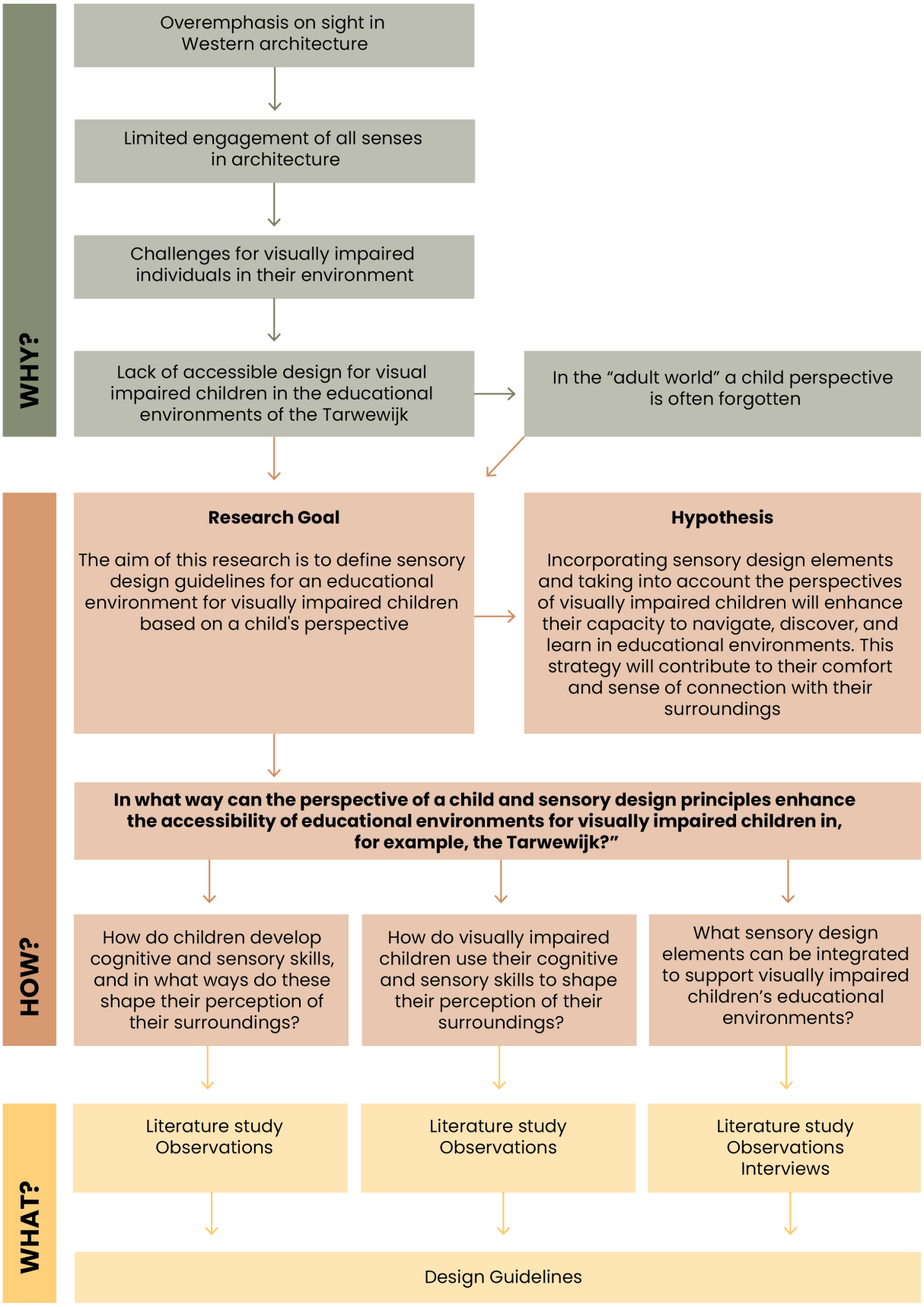

Figure 4, research plan diagram

Timeplan

No.	Task	Weeks									
		1	2	3	4	5	6	7	8	9	10
1	Data collection sub question 1										
2	Data collection sub question 2										
3	Data collection sub question 3										
4	Data analysis										
5	Draft version										
6	Final version										

Table 2, general timeplan

No.	Source	Weeks			
		1	2	3	4
1	The eyes of the skin				
2	Atmospheres				
3	Sensory design				
4	Creating sensory spaces				
5	Children's Thinking				
6	Architecture for Children				
7+	Unknown: additional sources on missing information				

Table 3, Read plan data collection

Weekday	Research	Design
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		

Table 4, Week planning

Sources

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Research rapport

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How do children develop cognitive and sensory skills, and in what ways do these shape their perception of their surroundings?

The paper titled "*Architecture for Children: Understanding Children's Perception of the Built Environment*" (2007) by Said presents a child-centred approach to design, emphasizing the importance of creating spaces that reflect children's perspectives. As an architect, educator, and researcher, Said highlights the critical need to design environments that stimulate the developmental stages and needs of children. He divides childhood development into two main stages: early childhood and middle childhood, connecting these stages to children's environmental requirements.

Development in early childhood

In early childhood, imagination and play dominate a child's experiences. Children perceive their surroundings as a stage for exploration and creativity, allowing them to invent stories, mimic roles, and engage in dynamic play. Said (2007) emphasizes that this phase is vital for rapid language and communication development, often driven by interactions with peers and adults. Physical movement during this stage is significantly influenced by the objects and spaces children encounter. Indoors, furniture and toys provide opportunities to enhance motor skills, while outdoor elements such as plants and animals inspire curiosity and cognitive engagement. Activities like interacting with birds or insects in gardens proved beneficial for their cognitive functioning by fostering attention and awareness.

Development in middle childhood

Middle childhood is a time when children become more curious and start thinking more logically about things they can see and touch. This stage emphasizes hands-on learning, where play becomes a medium for understanding the environment. Children at this stage rely heavily on their senses—sight, touch, hearing, and smell—to explore and connect with the world around them. Outdoor spaces become emotionally important, providing hands-on experiences that help children connect more deeply with nature. Through these interactions, children build reasoning skills, gain knowledge, recognize patterns, and make conclusions about the world around them.

Children's environmental needs

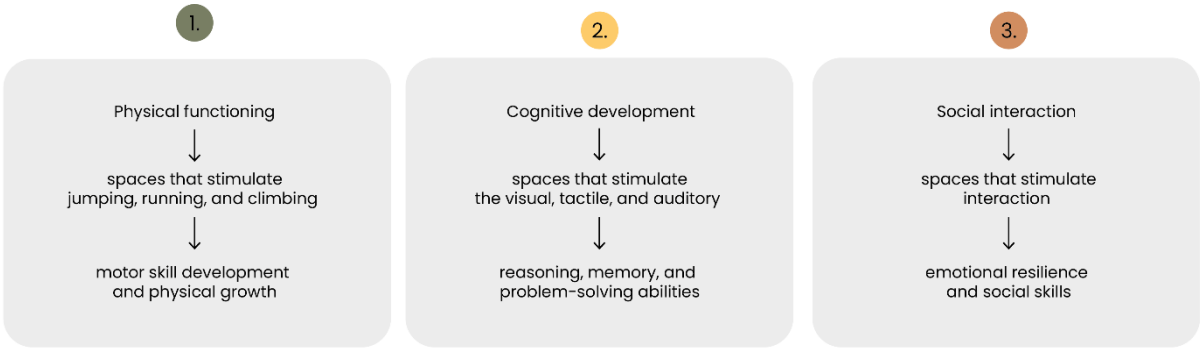


Figure 1, children's environmental needs based on literature form Said (2007)

For children to develop optimally, environments must be tailored to their specific developmental needs. Said outlines three essential aspects that should be considered in the design of these environments. First, physical functioning is critical, with activities such as jumping, running, and climbing playing a

crucial role in promoting motor skill development and physical growth. Second, cognitive development is enhanced in spaces that stimulate the visual, tactile, and auditory senses, which help improve reasoning, memory, and problem-solving abilities. Lastly, social interaction is vital for fostering emotional resilience and social skills, and environments that encourage interaction with peers and adults contribute significantly to these aspects of development. By addressing these three key elements, environments can better support the overall growth and well-being of children, see Figure 1.

Said's findings are supported by the book "Children's Thinking: Cognitive Development and Individual Differences" (2017) by developmental psychologists Bjorklund and Causey. Bjorklund, an expert in cognitive development, evolutionary psychology, and educational psychology, and Causey, who specializes in child cognition and social development, provide a comprehensive exploration of how children think, learn, and develop. According to Bjorklund and Causey, play and social interaction are fundamental to developing learning and problem-solving skills.

Answer sub-question

Children develop cognitive and sensory skills through play, social interaction, and sensory engagement, all of which are profoundly shaped by their environment. Environments must be designed to meet children's developmental needs and support their physical, cognitive, and social growth. For children with specific needs, such as those with visual impairments, sensory engagement is particularly crucial for helping them navigate their surroundings. Ultimately, environments that nurture all aspects of a child's development are essential for fostering healthy cognitive and sensory growth, as these spaces play a key role in shaping a child's perception of and interaction with the world around them.

How do children with a visual impairment develop cognitive and sensory skills, and in what ways do these shape their perception of their surroundings?

In the book "*Architectuur door andere ogen*" (2012), Jordans, Van de Kraats, and Van den Wildenberg, explore how people with visual impairments perceive architecture. As architects and researchers, the authors focus on various ways individuals with a visual impairment experience architecture.

One touching example in the book is the story of Veronique, who became aware of her visual impairment at the age of four. She recalls a moment in church when people were singing a song with the line, "*You look with your eyes.*" Veronique was puzzled and thought, "*What do you mean, you look with your eyes? Don't you look with your hands?*" This quote illustrates the confusion and gradual realization of a child unfamiliar with the concept of seeing. Instead of relying on visual perception, Veronique discovered her surroundings through touch and smell: "*I learned what a tree was by climbing it, feeling the crown, and inhaling the scent of fresh wood and damp leaves.*" This example highlights how children with visual impairments use their other senses to understand their environment.

The publication "*Kinderen die slecht zien, ontwikkeling, opvoeding, onderwijs en hulpverlening*" (1999) by the Bartiméus Foundation describes the development of children with visual impairments. The Bartiméus Foundation provides care and support to individuals with visual impairments, focusing on enhancing their independence and well-being. While some of the information may be outdated, it remains challenging to find recent data on the development of children with visual impairments. These children, like their sighted peers, develop in areas such as physical, cognitive, and social skills.

Physical Development

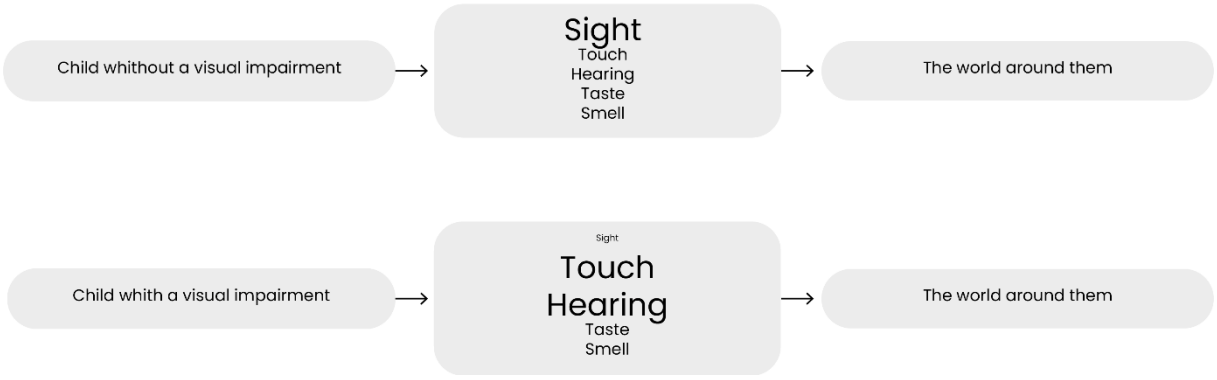


Figure 2, perception of the world by children through the senses

The Bartiméus Foundation (1999) explains that vision plays a significant role in motor development, even for visually impaired children, who follow their unique developmental path. To adapt, these children rely more on tactile and auditory perception, allowing them to interact effectively with their environment. Forming a mental image of their surroundings is essential, and this process greatly depends on body awareness and the body schema.

Children with partial vision loss create a fragmented image of their environment, which they later enhance with touch and sound information. The body serves as the starting point in this perception, often requiring children to move around to gain a broader understanding of their surroundings. Their hands and sense of touch are crucial for exploring objects and spaces, while hearing plays an important compensatory role. Sounds help children comprehend their environment, enabling them to determine

distance, direction, and movement, see Figure 2. This leads to the development of auditory-tactile associations (Bartiméus Foundation, 1999).

The developmental journey of visually impaired children is akin to that of sighted children but involves unique adaptive mechanisms. Therefore, supporting compensatory senses such as hearing and touch is more aligned with the child's needs than striving for “normal” development (Bartiméus Foundation, 1999).

Cognitive Development

The Bartiméus Foundation (1999) mentions that since vision is not fully functional in visually impaired children, educators and caregivers must assist with concept formation. This can be achieved by verbalizing, explaining, and organizing information to help make the world more understandable. The goal is not only to compensate for the absence of visual information but also to help children make connections. For instance, when explaining why a mother takes an umbrella, one might say, “*It's because it is raining outside*.”

Visually impaired children need to test their internal perceptions against reality. For example, a toddler might mistakenly think that a floating French fries container is a duck, or they might confuse a black-and-white spotted animal in a field with a cow instead of recognizing it as a dog. Additionally, learning through observation and imitation can be more challenging for them, as they may not perceive modelled behaviours (Bartiméus Foundation, 1999).

Social Development

The Bartiméus Foundation (1999) highlights that verbal and nonverbal communication complement each other. Facial expressions, body posture, tone, and pace of speech add additional meaning to words. However, visually impaired children often miss this nonverbal information, making it difficult for them to understand the intentions of others. As a result, they may need to ask for clarification more often and struggle with making eye contact, which complicates the verification of information. This can lead to confusion for their conversation partners, especially since a visual impairment is not always immediately apparent

Poor vision makes navigating the world and obtaining information more challenging. Visually impaired children often experience reduced control and awareness, leading to insecurities. They take longer to understand the effects of their actions and frequently rely on assistance from others, which can affect their self-confidence. Therefore, they require more time, patience, and perseverance to acquire new skills (Bartiméus Foundation, 1999).

Earlier in this study, the significance of physical, cognitive, and social development through play was emphasized for children without visual impairments. This importance is further confirmed for children with visual impairments by the Bartiméus Foundation (1999). Additionally, the workshop “*Rehabilitation for Blind Children and Youth*” at the “*Oogbeurs*,” led by pediatric physiotherapist M. Joore and developmental coach M. Dierick from the organization “*Kennis over zien*,” highlighted the importance of sensory development through playful activities (Groen&IJpenga, 2025). This approach helps visually impaired children navigate challenges more effectively.

The role of play in children’s development

The Bartiméus Foundation (1999) explains that play is essential for a child's development across physical, cognitive, social, and emotional domains. It enables children to practice important skills and build relationships. While the play development of children with visual impairments shares similarities with that of their sighted peers, it can sometimes be delayed due to visual limitations and other factors.

Children with visual impairments often face challenges when exploring their environment because they cannot see everything clearly, particularly distant or hard-to-distinguish objects. This difficulty can hinder their overall understanding of their surroundings and restrict the variety and flexibility of their play. Additionally, they may struggle with imitation since they cannot observe what others are doing (Bartiméus Foundation).

For children with visual impairments, play materials must be designed to be easily visible, using bright colours and clear shapes. These materials should engage multiple senses and be appropriately challenging. Moreover, clarity and good lighting are important for facilitating a pleasant play experience. The play area should be well-organized, ideally with defined spaces or play corners, and a calm environment free from excessive distractions can promote focused play. Thus, creating a safe and stimulating environment is vital for children with visual impairments to engage in play (Bartiméus Foundation, 1999).

This information was supported by discussions during the "*Rehabilitation for Blind Children and Youth*" workshop, where similar practical approaches were emphasized, such as providing well-defined play spaces to aid orientation. The workshop also addressed the connection between tactile training and learning braille, as well as the concept development process through which children form mental images of objects and situations through touch (Groen&IJpenga, 2025)

Sensory engagement

The foundation of sensory design is rooted in the work of Juhani Pallasmaa, a Finnish architect and author of "*The Eyes of the Skin*" (1996). He critiques the overemphasis on sight in architectural design and highlights the importance of engaging all the senses to create meaningful spatial experiences. According to Pallasmaa, architecture must foster a deeper connection between humans and their environment. He states, "*It is evident that 'life-enhancing' architecture has to address all the senses simultaneously, and help to fuse our image of self with the experience of the world.*"

Pallasmaa's theory was further explored in "*Creating Sensory Spaces*" (2017) by Barbera Erwine, an architect, researcher, and writer who advocates for a multisensory approach to design. Erwine aims to create environments that engage all human senses, fostering a strong sense of place and connection. In her book, she discusses each sense individually, noting that as children, we learn about the five human senses: sight, hearing, touch, taste, and smell. This framework dates back to Aristotle's (around 350 BC). This paper will start with researching these five senses.

Building on the insights of Pallasmaa and Erwine, it is clear that sensory design is crucial. However, for people with visual impairments, designing for all the senses is not just important but necessary. In her 2012 thesis, "*Wayfinding and Accessibility for Visually Impaired People*", researcher Havik emphasizes how individuals with visual impairments navigate and understand their environments through their other senses. She states, "*Because their sense of sight is limited or absent, visually impaired people rely heavily on their other senses to provide information about the world around them.*"

This idea is further supported in the book "*Architectuur door andere ogen*" (2012), written by Jordans et al., which states: "*A blind person uses all their senses to perceive what their eyes cannot. A staircase, for example, must be experienced step by step: they smell the wood, hear a reflection, and feel the step.*" And "*a well-designed environment always provides sufficient information and makes the invisible visible, the imperceptible perceptible. Differences in scent, texture, acoustics, atmosphere, and color provide support in this process*."

By designing spaces that engage multiple senses, we can create environments that give visually impaired children the information they need to navigate and understand their surroundings, ultimately enhancing their overall experience and connection to the world, see Figure 3.

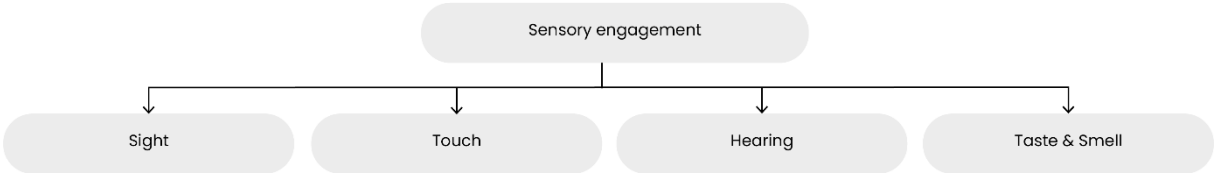


Figure 3, Sensory engagement devided into the five senses

Sight

The "*Oogfonds*" is a Dutch organization dedicated to promoting eye health and supporting individuals with eye diseases and visual impairments. The foundation offers comprehensive information about how the eye functions and the nature of visual impairments. The eye operates similarly to a camera: light enters through the lens and is projected onto the retina. The visual information is then transmitted via the optic nerve to specific areas of the brain, where details such as contours, movement, colour, shape, location, and faces are recognized and processed (Oogfonds, n.d.).

Individuals are considered visually impaired when their visual acuity, even with corrective lenses, is no greater than 0.3 (with 1.0 being the standard for normal vision) and/or when their visual field is 30 degrees or less. Poor vision can stem from various causes, including ageing or disorders within the visual system. Conditions such as cataracts, damage to the vitreous body, or retinal issues like macular degeneration can lead to blurry vision, decreased contrast sensitivity, or loss of visual field. Additionally, brain damage, dementia, or trauma can affect the optic nerve or brain, resulting in reduced or even complete loss of sight. Approximately 8% of men and 0.4% of women in the Netherlands have colour blindness due to defects in their colour-detecting cones. Night blindness, or difficulty seeing in low light, is often caused by issues with the rods in the retina (Oogfonds, n.d.).

Jordans et al. (2012) discuss how objects are perceived by individuals with visual impairments. This topic is further explored in "*Zicht op ruimte*"(2014), a handbook on visual accessibility and usability in the built environment, authored by accessibility experts Den Brinker, Apituley, and Smeets. They explain that objects reflect light, which is essential for visibility. The perception of an object depends on various factors, such as the composition of light, colour reflection properties, size, and contrast with the surrounding environment.

Light plays a crucial role in perceiving the environment, even for those with very limited vision. Anjuli de Geest, an accessibility expert at "*Koninklijke Visio*", explains, "*Light is vital for perceiving the environment. Even individuals with very limited vision (such as 0.02% acuity) can often detect light and use it as a means of orientation.*" For many people with visual impairments, light serves as an important tool for orientation and perceiving details in the environment (Groen&IJpenga, 2025)

While sufficient lighting is essential for accurate perception, den Brinker et al. (2014) explain that excessive brightness can be detrimental. Glare from intense sunlight or reflections on wet surfaces can temporarily or permanently impair vision, making it difficult to see details and complicating navigation. This issue is further illustrated by Figure 4, developed by "*Kennis over Zien*," a Dutch collaboration focused on sharing knowledge about visual impairments.

Figure 4, Visualization of the word glare (Kennis over zien, 2024)

One key solution to this problem is to avoid reflective surfaces. Architect Arco Ooms, who has a visual impairment himself, emphasizes this point in an interview. He states, "*Reflective surfaces, such as shiny countertops, can act as mirrors and cause disturbing glare for people with visual impairments. Choose for matte or non-reflective finishes; these are not only functional but also visually calming."* Utilizing matte materials can reduce glare and create a more accessible and pleasant living environment for those with visual impairments (Groen&IJpenga, 2025).

Contrast is also vital for making spaces accessible to individuals with visual impairments. Architect Arco Ooms highlights in an interview, "*For people with low vision, the contrast makes all the difference.*" The use of clear markings on stairs and different textures on floors can significantly enhance navigation within a space. Small details, such as a textured surface at the beginning of a staircase, can provide important tactile feedback for individuals who rely on their sense of touch (Groen&IJpenga, 2025).

These insights are supported by Jordans et al. (2012) and den Brinker et al. (2014), which detail how brightness and colour contrast aid in orientation within a space. Contrast is not limited to extreme differences in black and white but primarily involves noticeable differences in brightness. These brightness contrasts must be significant enough to be visible, even to individuals with colour vision deficiencies. By emphasizing key points, such as edges or transitions, navigation within a space becomes much easier.

Touch

Palasmaa (1996)describes the fundamental difference between sight and touch: "*The eye is the organ of distance and separation, whereas touch is the sense of nearness, intimacy and affection. The eye surveys, controls and investigates, whereas touch approaches and caresses*." Vision creates distance between us and the world, while touch brings us closer to our environment and connects us to it. Palasmaa argues that it is impossible to design a good building without considering the sense of touch, because touch is the first sense to develop and forms the basis for the development of other senses. He explains that we 'think' with our hands and 'see' with our skin. The sense of touch is essential for creating meaningful, sensory spaces that connect people both physically and emotionally with their surroundings.

Jordans et al. (2012) delve deeper into how people with visual impairments use their sense of hearing to understand their environment. It explains that touch provides important information for forming a complete picture of an object. The texture is explored with fingertips, volume is understood by grasping

the object, and temperature is sensed by holding it for a while. When exploring objects through touch, multiple strategies are often required, as large objects are explored bit by bit, demanding much from memory and concentration. This differs from sight, which immediately provides a total picture.

Palasmaa (1996) also explains how touch, for example through the soles of our feet, provides us with a deeper connection to nature: "*Gravity is measured by the bottom of the foot; we trace the density and texture of the ground through our soles.*" Feeling the earth, such as standing on a sun-warmed stone, makes us part of nature. This idea is further supported by Jordans et al. (2012), where a blind woman describes: "*My soles organize the world.*" Differences in texture, such as between sidewalk tiles, gravel, asphalt, carpet, or wood, provide important information about a space. The use of tactile markers in buildings, such as texture or colour contrasts, is a simple and effective way to improve the orientation of blind and visually impaired individuals. These markers help in perceiving transitions between different spaces and provide a better understanding of the environment.

Hearing

Palasmaa (1996) explains the fundamental differences between sight and hearing: "*Sight isolates, whereas sound incorporates; vision is directional, whereas sound is omnidirectional. The sense of sight implies exteriority, but sound creates an experience of interiority. I regard an object, but sound approaches me; the eye reaches, but the ear receives.*" Palasmaa emphasizes that sight, due to its directed nature, creates distance, while sound, through its omnipresence, fosters a sense of connection with our environment. While the eye separates objects from the world, the ear brings us closer and makes sound an essential part of a deeper sensory experience of spaces.

Erwine (2017) describes how sound is a constantly active source of information: "*Sounds surround us constantly, both during the day and in the dark, even during sleep. While the eyes can be closed to visual stimuli, the ears are always open.*" This makes hearing unique in its continuous gathering of signals from the environment. The ear enables people to distinguish, recognize, and interpret sounds. For example, we recognize voices, determine the direction of a sound, and react to stimuli, such as walking to a door when hearing the bell. Hearing is not only essential for communication and emotional understanding but also plays a crucial role in spatial orientation.

Jordans et al. (2012) further explored how people with visual impairments use sound to understand their environment. For blind and visually impaired individuals, sound is an indispensable source of information. Sounds provide clues about the size of a space, the location of objects, and the presence of others. Through echoes and reflections, blind individuals can orient themselves, and some use echolocation for this. Daniel Kish, who has been blind since he was 13 months old, explains in his TED talk "*How I use sonar to navigate the world*" (2016) how he emits sound waves by clicking his tongue. These sounds bounce off objects in the environment and return, allowing him to form a picture of the space around him. This process is known as echolocation.

Arco Ooms, an architect with a visual impairment, underscores the importance of good acoustics. "*Good acoustics can make all the difference,*" he says. Materials that reduce echoes, such as soft surfaces and strategically placed sound-absorbing elements, help those who rely on auditory signals for their orientation. Sound provides valuable information, such as pitch, timbre, rhythm, loudness, distance, and direction. These aspects are indispensable for blind and visually impaired individuals to recognize and navigate spaces (Groen&IJpenga, 2025)

Smell and taste

Palasmaa (1996) describes the essential role of smell in our experience of space and memory. He points out the remarkable capacity of our sense of smell: "*We need only eight molecules of substance to trigger an impulse of smell in a nerve ending, and we can detect more than 10,000 different odors.*" Smell has

the power to anchor deeply in our memory and bring memories to life. Palasmaa illustrates this with a personal recollection of his grandfather's house: "*I cannot remember the appearance of the door to my grandfather's farmhouse in my early childhood, but I do remember the resistance of its weight and the patina of its wood surface scarred by decades of use, and I recall especially vividly the scent of home that hit my face as an invisible wall behind the door.*" This smell, according to Palasmaa, embodies the essence of "home" and contributes to the unique identity of every space. Scents make memories tangible and create a profound, sensory connection to places.

Jordans et al. (2012), further explored the process of odor perception. Odor molecules bind to receptors in the olfactory epithelium in the nasal cavity, sending a signal to the brain. This signal directly reaches the limbic system, the part of the brain that regulates emotions and instinctive responses. This makes smell a powerful tool for evoking emotions, which partly explains why odors are often difficult to name, but are strongly stored in our long-term memory. Additionally, smells are crucial for our orientation: they can not only warn of danger, such as gas leaks or spoiled food, but also create an atmosphere within a space.

Blind and visually impaired individuals often have an enhanced ability to recognize odors, which they can use to navigate their surroundings. Scents, along with tastes, can help differentiate between various locations. However, incorporating taste into architecture is particularly challenging because it is directly associated with the consumption of food and beverages, which cannot be inherently integrated into the physical design or structure of a building (Jordans et al., 2012).

Despite their potential as navigation aids, both smells and tastes present significant challenges. Architect Arco Ooms, who is visually impaired, notes that smells and tastes are often too unpredictable and inconsistent to be relied upon effectively. Smells, in particular, are affected by variables like air currents, temperature, and ventilation, which can cause scents to mix, amplify, or even neutralize each other within a space. This variability makes designing with scent a complex task that requires a deep understanding of how odors interact and disperse in different environments (Groen & IJpenga, 2025).

Answer sub-question

Children with visual impairments develop cognitive and sensory skills in distinct ways, as they rely more on their non-visual senses to understand and interact with the world. The development of cognitive skills in visually impaired children often parallels that of sighted children; however, these children adapt by engaging their sense of touch, hearing, and even smell to create a mental image of their surroundings. For example, Veronique, a child with visual impairment, learned about objects like trees not by seeing them, but by feeling and smelling them. Touch is particularly crucial, as children use their hands to explore and identify objects, relying on tactile information to compensate for their lack of sight.

As they develop their cognitive skills, visually impaired children gradually build a mental map of the world by testing their perceptions against reality. This process is enhanced by verbal descriptions that help clarify and connect the information gathered through their other senses. Touch and sound provide them with an understanding of the environment, which shapes their perception by forming associations, such as linking the feel of rough textures to certain objects or specific sounds to particular locations.

Engagement of the senses, especially touch and hearing, aids these children in navigating their surroundings and influences their perception of space. For instance, using tactile markers and different textures helps them orient themselves within a space, while sound assists them in understanding the size and layout of rooms. Through the development of these adaptive cognitive and sensory skills, children with visual impairments cultivate a perception of their surroundings that is rich in sensory details, thereby enhancing their overall understanding of the world around them.

What sensory design elements can be integrated to support visually impaired children's educational environments?

This chapter discusses design guidelines for creating educational environments for children with visual impairments. The guidelines are organized into three levels of design: the context of the design location, the school and classrooms, and the schoolyard. These design principles are further divided into general features, layout, and sensory engagement.

The general features highlight the overarching vision and broader goals that the design seeks to achieve. The layout focuses on arranging the building in a clear and logical manner, ensuring that it naturally guides its users. This approach minimizes the need for artificial tactile markers and enhances the likelihood that all visitors—regardless of whether they have impairments—find the space easy and pleasant to navigate.

Sensory engagement emphasizes the senses of sight, touch, and hearing. The decision was made not to explore smell and taste in detail, as designing for these senses presents significant challenges. Smells are unpredictable and can vary significantly over time, making them difficult to use for navigation. Additionally, odors can interact within a space, either intensifying or neutralizing depending on air flow, temperature, and ventilation. This complexity makes designing with smell particularly challenging, as it is essential to understand how different scents interact and disperse throughout an area.

Context of design location

General features

In recent years, the design of physical learning spaces in primary schools has gained significant attention due to its potential to enhance student engagement, academic performance, and community connections. Two studies offer insights into how these educational environments can be reimagined to achieve these goals.

The 2024 paper titled "*A Systematic Literature Review of Design Considerations, Challenges, and Guidelines in Primary School Physical Learning Space Design*" by Dr. Rongrong Sun, an architect, and Dr. Muhammad Firzan Abdul Aziz, an economist, examines crucial elements of effective school design. These authors advocate for schools to take on a broader role within their communities by providing shared facilities that serve teachers, parents, and neighbourhood initiatives. These communal spaces promote collaboration, strengthen social ties, encourage idea exchange, and foster community-driven projects.

Create shared facilities with the neighbourhood

Similarly, the 2022 study titled "*Pedagogy-driven Design Fundamentals of 21st Century Primary Schools, Physical Learning Environments,*" conducted by Mehmet Gültekin and Gözde Özenç İra from Anadolu University, explores how contemporary educational pedagogy should influence the design of learning spaces. The researchers argue that modern school buildings should be adaptable and open, fostering a sense of community connection and inclusivity. By integrating schools into the fabric of their neighbourhoods, design can create environments where both students and community members feel welcome.

Design a flexible and community-oriented building

In summary, creating flexible and community-oriented buildings is crucial for enhancing the educational experience and strengthening community ties.

Lay-out

In designing accessible and visually appealing school environments, the layout is crucial for ensuring usability and inclusivity. In their book "*Zicht op ruimte*" (2014), accessibility experts Berry den Brinker, Atja Apituley, and Jeroen Smeets highlight two key aspects: the main entrance and the pathways surrounding the school.

The main entrance serves as a focal point in the layout, significantly contributing to both accessibility and the overall appeal of the school. According to Den Brinker et al., the entrance should be prominently visible from the street and easily recognizable. It must convey a welcoming atmosphere and display a clearly readable house number along with the name or purpose of the building. Distinct architectural features, such as a tall canopy, can enhance its visibility and help it stand out as a landmark. For example, the design of the Visio school in Grave includes a tall canopy at the entrance, ensuring the building is easily identifiable (Groen & IJpenga, 2024).

Design a clearly recognizable and welcoming main entrance

Pathways around the school are equally important for creating a functional and accessible environment. Den Brinker et al. emphasize that these paths should contrast sufficiently with their surroundings. They should also incorporate differences in material or texture to aid navigation. Ideally, the paths should be flat, without elevation changes or single-step risers, to ensure ease of movement for all users. Obstacles should be avoided entirely. In cases where elevation changes are unavoidable, stairs or ramps must be marked with high contrast and equipped with additional lighting for visibility and safety.

Design clear, flat paths without obstacles

By prioritizing a clearly recognizable entrance and creating obstacle-free, visually distinct pathways, schools can develop layouts that are both inviting and accessible to a wide range of users.

Sensory engagement

Designing sensory-friendly school environments involves creating spaces that engage users through visual and tactile experiences while ensuring accessibility and ease of navigation. Den Brinker et al. (2014) and Anjuli de Geest (Groen&IJpenga, 2024), provide key recommendations to enhance sensory engagement, particularly regarding lighting and tactile elements.

Visual engagement

To make the school entrance easily identifiable, especially at night, Den Brinker et al. emphasize the importance of strong lighting. Brightly lit areas act as beacons, signalling the entrance's location and creating a welcoming atmosphere. This advice is echoed by Anjuli de Geest (Groen & IJpenga, 2024), who recommends illuminating the entrance more brightly than the surrounding street.

Illuminate the entrance stronger than the street in the evening

Additionally, Anjuli de Geest advises that pathways leading to and around the school should be evenly illuminated with orientation lighting to prevent glare and ensure safety (Groen&IJpenga, 2024).

Provide paths with even lighting in the evening

Den Brinker et al. also suggest that critical areas such as corners, intersections, and narrow points require increased lighting to enhance visibility and alertness for pedestrians.

Increase lighting at critical points where pedestrians need to be extra alert

If the entrance is not immediately visible upon entering the premises, clearly readable signage should be strategically placed along pathways to guide visitors. This is confirmed in the interview with Anjuli de Geest (Groen & IJpenga, 2025).

Place signage to the entrance

Tactile engagement

Den Brinker et al., (2014) highlight that pathways should incorporate variations in material or texture to aid navigation and orientation. These tactile elements help users distinguish paths from their surroundings and provide additional guidance.

Use different materials and textures in the paths around the school

By combining thoughtful lighting strategies with tactile design elements, schools can create environments that are not only accessible but also intuitive and engaging for everyone.

Sub-conclusion context of design location

In conclusion, designing effective and inclusive physical learning spaces for primary schools requires a comprehensive approach that incorporates community-oriented principles, thoughtful layouts, and sensory engagement. By creating flexible buildings that function as hubs for both education and community interaction, schools can strengthen social connections and encourage collaboration.

A clear and welcoming main entrance, along with pathways that are obstacle-free and visually and tactilely distinct, ensures accessibility and usability for all users. Additionally, strategic lighting and signage improve visibility and safety, making these spaces more intuitive and inviting.

General features

Create shared facilities with the neighbourhood

Design a flexible and community-oriented building

Lay-out

Design a clearly recognizable and welcoming main entrance

Design clear, flat paths without obstacles

Sensory engagement

Illuminate the entrance stronger than the street in the evening

Provide paths with even lighting in the evening

Increase lighting at critical points where pedestrians need to be extra alert

Place signage to the entrance

Use different materials and textures in the paths around the school

School

General features

A modern school building is more than just a physical structure; it is a dynamic environment that promotes learning, collaboration, and personal growth. By integrating key principles of comfort, accessibility, flexibility, and interactivity, schools can evolve into functional and inspiring spaces for children.

As Gültekin and Ira (2022) highlight, the design of a school building can serve as an educational tool itself. By incorporating interactive elements and educational displays, architecture can actively contribute to the learning process. This transforms the building into a living classroom, enriching the student experience and making education tangible and engaging.

Design the school building as an educational tool

According to Sun and Aziz (2024), a comfortable learning environment significantly enhances students' well-being and performance. Factors such as ergonomics, temperature control, lighting, and acoustics must be carefully managed to ensure a productive atmosphere. Safety is equally critical, encompassing both physical safety—such as clearly visible stairs—and emotional safety through predictable and clear spatial layouts. Flexibility is another essential characteristic of 21st-century schools. Spaces must adapt to the diverse needs of students and accommodate various learning styles. From movable furniture to multipurpose areas, flexible designs foster creativity and adaptability in education.

Ensure comfort, safety, and flexibility in the design

Designing from the perspective of a child is crucial for creating accessible and comfortable spaces. Sun and Aziz (2024) recommend adjusting proportions to suit children, such as incorporating lower tables, chairs, and easily accessible facilities. Clear orientation points help young users navigate spaces with confidence and ease.

Take into account the perspective and proportions of a child

A school environment should inspire children to learn through play and exploration. Interactive and stimulating spaces, such as playful furniture and educational installations, encourage curiosity and creativity. This approach, emphasized by Sun and Aziz (2024), transforms the learning environment into a place of joyful discovery. This notion is confirmed during the workshop *"Rehabilitation for Blind Children and Youth"* at the Oogbeurs (Groen&IJpenga, 2025)

Encourage playful discovery and learning

Every space within a school should serve as a hub for learning and interaction. From classrooms to hallways and common areas, all spaces must support both formal and informal learning activities. Designing areas that stimulate collaboration and socialization ensures that students can thrive academically and socially (Gültekin & Ira, 2022; Sun & Aziz, 2024).

Design spaces that promote learning, stimulate collaboration and socialization

Technology plays a pivotal role in modern education, and school designs must reflect this shift. Features such as interactive screens, advanced ICT facilities, and charging stations for devices are essential for seamlessly integrating technology into the learning process (Gültekin & Ira, 2022; Sun & Aziz, 2024).

Consider the application of technology

Accessibility is fundamental to inclusive education. School designs must eliminate barriers and ensure that all spaces are wheelchair accessible. This allows students of all physical abilities to move and learn freely, fostering equality and inclusivity (Sun & Aziz, 2024).

Make the design accessible for everyone

By incorporating these principles, school buildings can transcend their traditional function and become transformative environments that inspire, support, and adapt to the diverse needs of students.

Lay-out

The design of school spaces is crucial for ensuring effective navigation and learning for all students, especially those with visual impairments. A clear, logical, and flexible layout allows students to move comfortably and safely through the environment, enhancing the overall learning experience.

Den Brinker et al. (2014) recommend avoiding organic shapes in school designs, particularly for corridors and classrooms. Rectangular layouts are easier for children, especially those with visual impairments, to understand and navigate. For instance, curved walls can confuse blind individuals using canes, potentially leading them to walk in circles. This observation was supported by students from the Visio School in Grave and Richard van Wezel during his workshop "*Orientation in the Brain*" (Groen & IJpenga, 2025).

Avoid organic shapes and use rectangular layouts in the design

Richard van Wezel (Groen & IJpenga, 2025) also emphasized the challenges that people with visual impairments face when understanding different levels of a building. To enhance orientation and accessibility, it is crucial to minimize the number of floors and provide clear routes to different levels.

Minimize the number of floors

In the book "*Architectuur door andere ogen*" (2012), authored by Martijn Jordans, Bastiaan van de Kraats, and Marij van den Wildenberg, the authors explore how people with visual impairments perceive architecture. As architects and researchers, Jordans, van de Kraats, and van den Wildenberg emphasize the importance of creating sensory architecture that accounts for various ways of experiencing the world. The book suggests that children with visual impairments benefit from a circulation layout that offers fewer directional choices. By reducing the complexity of navigation, we can significantly enhance their ease of movement.

Implement a logical circulation layout with clear, simple directions

Both Jordans et al. (2012) and Den Brinker et al. (2014) stress the importance of placing information points, such as building maps and reception desks, near the entrance. These points should be easily accessible and indicate the locations of key facilities, including elevators, stairwells, and emergency exits. An intuitive layout minimizes the need for excessive signage and supports orientation. Anjuli de Geest confirmed in an interview that the layout of the building should be simple and intuitive (Groen&IJpenga, 2025).

Place the information point and the reception at the entrance

Both Jordans et al. (2012) and Den Brinker et al., (2014) also confirm that to further enhance the navigability of the space, essential facilities like reception desks, elevators, toilets, and coat racks should be located near the entrance or grouped in other easily accessible areas. These spaces should be

highlighted with additional lighting, contrasting colors, or larger sizes to improve visibility and reduce reliance on signs.

Place essential facilities near the entrance or cluster them in central locations

Gültekin & Ira (2022) and Sun & Aziz (2024) emphasize the importance of flexible learning spaces. Classrooms of varying sizes—large areas for collaboration, medium classrooms for group work, and small spaces for individualized learning—support diverse educational activities.

Incorporate a variety of classroom sizes

López-Chao et al. (2012) explore the relationship between learning spaces and student performance in the paper "*Classroom Indoor Environment Assessment through Architectural Analysis for the Design of Efficient Schools*". The writers found that classrooms with views of nature or outdoor landscapes enhance student performance in subjects like math and language. Incorporating green walls and natural elements also contributes to a calming environment, boosting concentration and focus.

Design classrooms with views of nature and integrate green elements

Sun & Aziz (2024) highlight that access to outdoor spaces, such as gardens or outdoor classrooms, encourages learning through movement and nature experiences. Creating direct connections to these areas allows students to learn in varied environments.

Create direct access to outdoor spaces

Discussions with students from the Visio School in Grave revealed that transition spaces, such as an entrance hall with a doormat, help with recognition and orientation (Groen&IJpenga, 2025). Den Brinker et al., (2014) also highlight how an entrance hall can transition lighting intensity, reducing glare and increasing comfort.

Create transition spaces between inside and outside

Jordans et al. (2012) and Den Brinker et al. (2014), along with insights from Anjuli de Geest (Groen&IJpenga, 2025), emphasize the significance of having obstacle-free routes. In narrow corridors or busy areas, structural elements such as columns, open doors, or poorly marked stairs can pose hazards. Ensuring clear and well-designed circulation areas without obstacles can enhance navigation safety for all users.

Avoid obstacles

Anjuli de Geest emphasized the need for clear and understandable signage (Groen&IJpenga, 2025), a point also confirmed by Den Brinker et al., (2014). Clear and intuitive signage is vital for orientation, particularly for individuals with visual impairments. Signage should be placed at decision points along routes, at eye level (120-160 cm), and must not be obscured by glass. Additionally, proper floor numbering and clear markings on stairwells and near elevators are helpful for navigation and emergency situations.

Use readable signage

Both Jordans et al. (2012) and Den Brinker et al., (2014), insights from Richard van Wezel's workshop *"Orientation in the Brain"* and Anjuli de Geest's interview all underline the importance of sensory landmarks (Groen&IJpenga, 2025). These landmarks can include prominent architectural features. Differences in texture or contrast in flooring, walls, and ceilings can signal distinct zones within a building, aiding orientation.

Create sensory landmarks

By implementing these principles, schools can be designed to enhance accessibility, safety, and functionality while fostering effective learning and navigation for all students, regardless of their abilities. These considerations ensure that school environments are not only physically safe but also mentally and emotionally supportive of diverse educational needs.

Sensory engagement

Sun & Aziz (2024) emphasize that a sensory-engaging school design can significantly enhance students' well-being and learning outcomes by stimulating multiple senses, including vision, touch, and hearing. Incorporating elements that activate these senses can help foster engagement, concentration, and overall comfort in the learning environment.

Apply sensory stimulation

Visual engagement

Sun and Aziz (2024) highlight the importance of integrating visual, auditory, and tactile stimuli into school designs to increase student engagement. Natural daylight is crucial for promoting the health of building users, improving student performance, and supporting tasks that require visual comfort. López-Chao et al. (2020) further support this idea, noting that well-lit classrooms can enhance performance in subjects like mathematics. However, too much direct sunlight can cause glare, disrupting visual comfort. This was confirmed by an interview with Anjuli de Geest and observations at the Visio School in Grave, where all glass surfaces are equipped with shading to minimize glare (Groen and IJpenga, 2025).

Utilize indirect daylight and ensure shading is employed to enhance visual comfort

Adjustable lighting is also essential for creating an optimal environment for various activities. López-Chao et al. (2020) emphasize that dimmable artificial lighting is particularly beneficial for creative tasks like drawing. Jordans et al. (2012) and Den Brinker et al. (2014) agree, noting that adjustable lighting allows light conditions to be tailored to individual needs, which is especially important for students with visual impairments. The minimum light levels for different spaces are outlined in Table 1. This information was confirmed in the interview with Anjuli de Geest (Groen&IJpenga, 2025).

Situations	Light Levels (lux)
Indoor spaces, halls, corridors	100
Stairs, ramps, elevators, treadmills	150-200
Living spaces	300-500
Offices, classrooms, assembly work, and kitchens	400-750
Precision tasks with small details and low contrast	1000
Outside buildings	50
Decision points outside buildings	100

*Tabel 1, Minimum lichtniveaus in verschillende buitenruimtes (*Den Brinker et al., 2014)

Use dimmable artificial light

In an interview, Anjuli de Geest explained that light sources should be shielded to prevent glare, and artificial lighting must be evenly distributed to avoid harsh transitions (Groen & IJpenga, 2025). This assertion is also supported by Den Brinker et al. (2014).

Distribute light sources evenly

Both Jordans et al. (2012) and Den Brinker et al. (2014) highlight that large window surfaces, as well as glossy floors, walls, doors, and tables, can easily cause glare. Even when glossy surfaces do not produce direct glare, their reflections from the surroundings can be distracting, rendering screens and boards

difficult to read. Additionally, it is essential to avoid situations where individuals must look directly at daylight for extended periods, such as when standing at a reception desk. This point was reinforced in an interview with Arco Ooms (Groen & IJpenga, 2025).

Avoid stray light and reflections

Both Jordans et al. (2012) and Den Brinker et al., (2014) that wherever visual distinction is needed, it must be based on contrast, a difference in brightness between the object and its surroundings. In Article 35 of ISO 21542, the brightness of an object is expressed in Luminance Reflectance Value (LRV), the percentage of light reflected by an object. A bright white object has a brightness of 100 LRV points, while a deep black object has 0 points. Contrast is the difference in brightness, as shown in Table 2.

Visual Task	Difference in LRV	Examples of contrasting colours
Large surfaces (such as walls, floors, doors, ceilings) and basic components that facilitate orientation (such as handrails, switches, buttons, markings on glass, guide lines)	≥ 30	
Potential hazards and markings with contrast surfaces (such as markings on stairs) and textual information (such as signage)	≥ 60	

Table 2, Minimum brightness differences for tasks in Light Reflectance Value (Den Brinker et al., 2014)

Link the visual task of the space to the associated Luminance Reflectance Value

Sun & Aziz (2024) recommend using a maximum of three prominent color accents in each space and suggest selecting cool, soft colors to improve concentration and memory.

Use a maximum of three color accents per space and opt for cool, soft colors

Tactile engagement

Tactile stimulation is crucial for fostering an engaging environment, especially for students with visual impairments. Anjuli de Geest (Groen & IJpenga, 2025) suggests incorporating various surface materials to assist users in distinguishing between different objects and zones. Additionally, research by Jordans et al. (2012) and Den Brinker et al. (2014) supports the notion that tactile differentiation improves spatial orientation and balance.

Apply tactile differentiation in materials

In long corridors, a guide plank on the wall provides both visual and tactile support for navigation, as noted by Jordans et al. (2012) and successfully implemented at the Visio School in Grave (Groen & IJpenga, 2025).

Apply a guideboard

Hearing engagement

Acoustic design is equally important for creating a sensory-engaging school environment. Sound isolation is crucial for preventing disturbances and ensuring good concentration. Frank ter Beek, a teacher at Visio School, emphasizes the importance of isolating floors, walls, ceilings, and technical

installations to minimize contact sound (Groen & IJpenga, 2025). Jordans et al. (2012) suggest that floating floors effectively reduce contact noise.

Design a good acoustic base for the school

Jordans et al. (2012) explain that appropriate acoustics can enhance orientation and signaling in a space without creating distractions. By differentiating acoustics, various areas can be distinctively identified. For instance, spaces can develop their own unique identities through variations in reverberation times, which can be achieved by altering the shape and height of the environment. These changes affect the reverberation time and sound reflection, providing valuable information about the space through echolocation. This concept was successfully implemented in the design of the Visio School in Grave, particularly in the event space and gymnasium. Additionally, Jordans et al. (2012) noted that a building's entrance can be highlighted by deepening or covering it, which alters sound reflection and creates an acoustic accent at the entrance. This approach was also applied at the Visio School in Grave (Groen & IJpenga, 2025).

Apply acoustic differentiation based on the function of the space

Sun and Aziz (2024) argue that space design should promote a calm learning environment that helps students absorb information effectively. This concept is supported by López-Chao et al. (2020), who found that reducing background noise and reverberation improves both clarity and concentration in classrooms. Jordans et al. (2012) explain that sound reflects off surfaces and tends to bounce more off hard materials. In environments with high reverberation, such as tiled kitchens or bathrooms, it can be difficult to determine the direction of sounds. While excessive reverberation can be disruptive, not all spaces require short reverberation times; variations in acoustics can enhance a space's identity. The Dutch Government Buildings Agency recommends specific reverberation times for different areas in schools, as these guidelines support better concentration, see Table 3.

Reverberation times	Occupancy spaces
1,0-2,2	Music room
0,8-5,0	Sport facilities
0,8	Empty lecture room
0,4-0,6	Empty classroom
0,6-0,8	Office space
0,4-0,5	Living room
0,4	Living room for sensory-impaired people

Table 3, Advised reverberation times of spaces (Jordans et al., 2012)

Take the reverberation time into account during the design process

López-Chao et al. (2020) observe that thermal discomfort can lead to stress and reduced performance, particularly in tasks such as problem-solving and mathematics. Joore and Dierick further elaborate on this by stating that the use of underfloor heating allows children to walk barefoot, which enables children with visual impairments to process tactile information from their environment using their feet (Groen & IJpenga, 2025).

Take the thermal comfort of the students into account

Furthermore, mechanical ventilation systems must adhere to recommended ventilation rates per student to ensure healthy air quality (López-Chao et al., 2020).

Apply mechanical ventilation

López-Chao et al. (2020) also write that by connecting classrooms to outdoor spaces, for example through gardens and windows, fresh air and natural light are integrated into the learning process. This is confirmed by Sun & Aziz (2024).

Apply natural ventilation and create a connection with outdoor spaces

By addressing the sensory needs of students and incorporating visual, tactile, and auditory elements into school design, we can create environments that enhance learning, engagement, and well-being. These thoughtful design choices support concentration, encourage exploration, and ensure that all students have access to a comfortable and stimulating educational space.

Sub-conclusion school

In conclusion, by integrating principles of accessibility, sensory inclusivity, and thoughtful design, school buildings can transform from their traditional roles into dynamic environments that inspire and support the diverse needs of all students, especially those who are visually impaired. Considering sensory aspects through visual, tactile, and auditory elements enhances learning, engagement, and well-being. This creates spaces that are not only functional but also nurturing and inclusive. Such design choices promote concentration, encourage exploration, and ensure that visually impaired children have access to a safe, comfortable, and stimulating educational experience, ultimately setting the stage for transformative learning.

General features


Design the school building as an educational tool


Ensure comfort, safety, and flexibility in the design


Take into account the perspective and proportions of a child


Encourage playful discovery and learning


Design spaces that promote learning, stimulate collaboration and socialization


Consider the application of technology


Make the design accessible for everyone

Lay-out

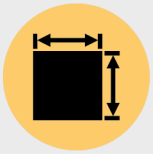

Avoid organic shapes and use rectangular layouts in the design


Minimize the number of floors


Implement a logical circulation layout with clear, simple directions


Place the information point and the reception at the entrance

Place essential facilities near the entrance or cluster them in central locations



Incorporate a variety of classroom sizes

Design classrooms with views of nature and integrate green elements

Create direct access to outdoor spaces

Create transition spaces between inside and outside

Avoid obstacles

Use readable signage

Create sensory landmarks

Sensory engagement

Apply sensory stimulation

Utilize indirect daylight and ensure shading is employed to enhance visual comfort

Use dimmable artificial light


Distribute light sources evenly


Avoid stray light and reflections


Link the visual task of the space to the associated Luminance Reflectance Value


Use a maximum of three color accents per space and opt for cool, soft colors


Apply tactile differentiation in materials


Apply a guideboard


Design a good acoustic base for the school


Apply acoustic differentiation based on the function of the space


Take the reverberation time into account during the design process


Take the thermal comfort of the students into account


Apply mechanical ventilation


Apply natural ventilation and create a connection with outdoor spaces

Schoolyard

General Features

Joore and Dierick (2025) explain that tactile objects, like miniatures of a fallen tree, a car, or elements from a petting zoo, can enhance the conceptual development of children with visual impairments. These objects help them better understand the world around them (Groen & IJpenga, 2025).

Take the conceptual development of the children into account

When designing outdoor spaces, it is crucial to view them as educational tools. Gültekin and Ira (2022) highlight that integrating elements like shaded areas and seating arrangements can significantly enhance learning opportunities.

Design the outdoor space so that it can be used for educational purposes

Furthermore, play areas should be designed to support various sports and activities while fostering creativity, as highlighted by Gültekin and Ira (2022).

Design for different types of play and sports

It is essential to create environments where nature can thrive and diversity is celebrated (Gültekin & Ira, 2022).

Give space to nature and encourage diversity

Involving children in the maintenance of outdoor spaces instills a sense of responsibility, which is crucial (Gültekin & Ira, 2022). This engagement fosters a feeling of ownership over their outdoor environment.

Give children responsibility over the outdoor space

Sub-conclusion schoolyard

In conclusion, well-designed schoolyards play a vital role in supporting children's development. Tactile objects help visually impaired children better understand their surroundings. Outdoor spaces should be designed as educational tools, with shaded areas and seating enhancing learning. Play areas must accommodate various activities and encourage creativity. Additionally, creating spaces where nature thrives and diversity is celebrated enriches the environment. Involving children in the maintenance of these areas fosters a sense of responsibility and ownership, making schoolyards spaces that support both learning and personal growth.

General features

Take the conceptual development of the children into account

Design the outdoor space so that it can be used for educational purposes

Design for different types of play and sports

Give space to nature and encourage diversity

Give children responsibility over the outdoor space

Conclusion

This research aimed to find an answer to the question: "*In what way can the perspective of a child and sensory design principles enhance the accessibility of educational environments for visually impaired children in, for example, the Tarwewijk*?"

Incorporating the perspective of children and applying sensory design principles can greatly enhance the accessibility of educational environments for visually impaired children, particularly in areas like Tarwewijk. These children rely heavily on their non-visual senses—such as touch, hearing, and smell—to understand and interact with their surroundings. By prioritizing these senses in design, we can create environments that allow visually impaired children to navigate and engage with the world, supporting their cognitive and sensory development.

Focusing on tactile and auditory elements in the design can help children orient themselves and move through the space more easily. For example, tactile markers can guide visually impaired children to important locations within a school or playground, while strategically placed sounds can provide auditory cues that help them understand room layouts and differentiate between spaces.

Moreover, sensory-rich environments that encourage exploration through touch, sound, and smell enable visually impaired children to form mental maps of their surroundings. This approach supports their cognitive development in ways that parallel those of sighted children, but through different sensory channels. In the case of Tarwewijk, which is home to a diverse community, designing schools and public spaces with sensory inclusivity fosters social connections and encourages interaction. These spaces can provide both educational and community benefits, promoting collaborative learning and play, and ensuring that visually impaired children are actively engaged and integrated into their environment.

Discussion

In this discussion, I reflect on the findings and limitations of research into the design of educational environments for children with visual impairments, particularly in primary schools. The research revealed that, while there is a substantial amount of literature available on designing spaces for individuals with visual impairments, much of it addresses the general population rather than the specific needs of visually impaired children. Additionally, although there is information about overall school and classroom design, resources specifically focusing on classrooms for visually impaired children and appropriate teaching methods are limited.

A key challenge in this research was that not all findings were backed by multiple independent sources. Furthermore, some sources were outdated, which is problematic given the rapid advancements in scientific knowledge. Additionally, some references regarding child development were not age-specific, making it difficult to draw accurate conclusions about the developmental needs of primary school-aged children with visual impairments.

A major limitation of this research was time constraints, which restricted its depth and scope. With additional time, further research could have been conducted into design guidelines specifically tailored to schools and playgrounds. Moreover, conducting more interviews and observations could have provided better insights into practical challenges and opportunities within this context.

Consulting a larger number of literature sources would also contribute to a broader and deeper understanding of the topic, allowing for stronger and more substantiated arguments. It is evident that further literature would be invaluable for expanding knowledge on designing accessible educational environments for visually impaired children.

Interviews with experts and teachers who work daily with this population could have provided valuable practical insights. Involving the children themselves, through observations or conversations, could have offered a unique perspective to enrich the research further.

By focusing more on recent studies, utilizing a broader range of sources, and incorporating case studies or expert interviews, the findings could have been further strengthened. This approach would contribute to a more complete and nuanced understanding of the topic, significantly enhancing the quality of the research.

In summary, the research provides useful insights into the design of educational spaces for children with visual impairments. However, it is clear that more comprehensive and specific studies are needed. For instance, research into how schools for visually impaired children can also be inclusive for children in wheelchairs is necessary. Additionally, there is a need for more technical information about the acoustic properties of materials and how these can be applied in classrooms to create an optimal teaching environment. The limited scope of the research and the challenges encountered highlight the importance of continued exploration in this area. This is essential to ensure that educational environments are not only accessible but also optimized for the sensory and cognitive development of visually impaired children.

Reflection

Before I began my research, my knowledge about the lives of people with visual impairments was limited. Throughout the process, I confronted the profound impact that a visual impairment has on daily life. It struck me that a visual impairment could happen to anyone, highlighting the vulnerability of human existence and how it influences our interaction with the world.

My visit to the “muZIEum” was an eye-opener; experiencing complete darkness was shocking and greatly expanded my understanding of the challenges blind people face every day. At the same time, I was inspired by their resilience and how they utilize their other senses or express gratitude for what they can still see and do.

My visit to the Visio school in Grave also provided me with new insights. I was impressed by the helpfulness of the students, both towards us and one another. I noticed that while a visual impairment can lead to increased dependence, it can also foster greater mutual support and connection among the students. The care they showed for each other illustrated that a visual impairment doesn’t have to hinder social contact or mutual assistance.

The literature review was an essential part of my research and offered valuable theoretical insights. However, my graduation timeline was delayed, and I struggled to begin writing. I often felt I lacked sufficient information or didn’t fully understand certain aspects. Nevertheless, the process of writing this thesis taught me that perfection is not always attainable and that it’s okay to not have all the answers. Although I am not an expert in pedagogy and don’t have complete knowledge about children, I have learned a lot and did my best to answer my research question with the information I gathered.

The fieldwork that Sander and I conducted further enriched my research. Direct interactions and conversations with people with visual impairments provided me with a clear understanding of how crucial it is for architects to place users at the center of the design process. This research reinforced my belief that understanding the needs, desires, and challenges of users is essential before initiating any design. It confirmed that, as architects, we carry a significant responsibility: to create inclusive and meaningful designs that truly enhance the well-being of others.

Through this research, I feel I have grown both personally and professionally. If I were to conduct the research again, I would focus more on deepening my engagement with the target group. For instance, I would seek more direct contact with children with visual impairments and employ creative methods to better understand their unique experiences. This would further enrich my design approach and ensure that the solutions I create align closely with the needs of the target group.

My research has taught me a great deal about the lives of people with visual impairments and the importance of designing accessible, inclusive environments. It has broadened my perspective and strengthened my belief that architects play a crucial role in improving the quality of life for individuals, especially those who require additional support. The research has not only deepened my knowledge but also highlighted the significance of integrating users’ experiences into the design process. While I have learned much, I recognize that there is always room for further exploration, and ongoing interaction with the target group is essential for creating effective and inclusive designs.

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