MULTISENSORY DIMENSIONS FOR THE VISUALLY IMPAIRED

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Abstract— Vision is the primary sense used in independence and social participation in the built environment, and its loss can significantly impact an individual's quality of life. In this study, multisensory dimensions in building design were studied as to how they can contribute to the navigation and wayfinding of visually impaired (VI) individuals in a normal setting. The study aims to develop a multisensory design for a facility that is inclusive of VI individuals, aligning with SDG 9: Industry, Innovation, and Infrastructure. Designing infrastructure that engages human senses can enhance the well-being of VI individuals, thereby supporting SDG 3: Good Health and Well-being. Gaps in multisensory considerations were identified through a review of policies and guidelines. It employed phenomenological research, supported by a thematic analysis of 30 international studies, validated through case studies of five international buildings, and assessed the impact of multisensory solutions on independence. The findings show that olfactory cues can be a guiding tool in navigation and wayfinding in addition to haptics, auditory, and visual. Multisensory dimensions in a building design can significantly enhance the independence of VI individuals through the process of spatial planning in consideration of linear circulation, different textured materials, adequate lighting, sound of the water, and aromas.

Keywords— spatial navigation, wayfinding, olfactory landmarks, haptic cues, auditory cues

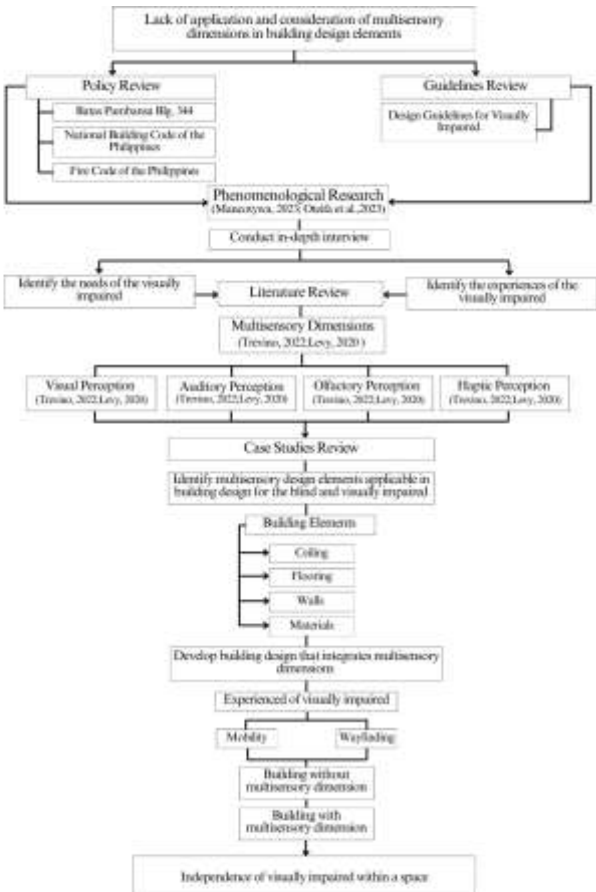
I. INTRODUCTION

Vision is the primary human sense, essential for daily activities and societal engagement (Hutchmacher, 2021). Globally, over 2.2 billion people are visually impaired, with 1 billion cases being preventable yet untreated (World Health Organization, 2023). Vision loss, defined as the inability of the eye to conduct and interpret light, is categorized into total blindness, where there is a complete absence of light, and low vision, where some light is perceived but not correctly interpreted (Bullock, 2024). Losing vision makes navigating society significantly more difficult, as visually impaired (VI) individuals must navigate spaces predominantly designed for sighted people, creating barriers and limiting their spatial perception (Oteifa et al., 2017). Society's reliance on vision poses significant challenges for VI individuals, affecting navigation, wayfinding, and engagement in unfamiliar spaces (Bullock, 2024; Ongtagco et al., 2018).

Accessibility laws in the Philippines, such as the Magna Carta for Disabled Persons (R.A. 7277) and Accessibility Law (BP 344), aim to promote equal access for persons with disabilities (PWDs), including the VI. However, these provisions often cater more to mobility impairments and fail to address the unique needs of visual impairments (Dela Cruz, 2023; BP 344 Implementing Rules and Regulations (IRR), 2024). To individuals with visual impairment, the built environment significantly influences their ability to navigate safely and independently (Havik et al., 2015). Unfortunately, these environments are frequently characterized as hostile and 'disabling by design' (Imrie, 2012). Lehrer (2011) points out that people without visual impairments often struggle to envision the challenges individuals with visual impairments face within the built environment. As a result, VI individuals face severe limitations in navigating the built environment, highlighting the importance of integrating multisensory design to create inclusive spaces (Lovric, 2023). Multisensory design stimulates vision, touch, sound, and smell in a unified manner, enabling independence and accessibility for VI individuals (Roy & Arora, 2023; Bullock, 2024).

In the Philippines, 11.87% of the PWD population, or 212,600 individuals, are VI (SPED Philippines, 2017; NCDA, 2024). Despite the significant number of affected individuals, there is a notable lack of studies on integrating multisensory design to address the needs of VI individuals, particularly in educational institutions; this highlights the need to explore how multisensory dimensions can enhance navigation and wayfinding through visual, auditory, olfactory, and haptic stimuli, fostering independence and inclusivity (Levy, 2020; Jeamwatthanachai et al., 2019). The problem centers on the lack of exploration of how multisensory strategies can be effectively adapted and implemented in building design within the Philippine context, as well as the insufficient investigation into their current effectiveness. This shows the need for further research to assess the application of multisensory design and contribute to the existing coherent design language for its application. The study analyzes the integration of multisensory dimensions (visual, auditory, olfactory, and haptic) into building design, focusing on bridging gaps in current practices and proposing to develop actionable design solutions that contribute to the independence of the VI population.

Figure 1. *Conceptual Framework*



The research is relevant in addressing the need for building designs for the VI in the Philippines, aligning with SDG 9 "Industry, Innovation, and Infrastructure." It also meets practical needs, allowing individuals to experience a safe environment (UNESCO, 2021), and contributes to SDG 3, which promotes "Good Health and Well-being."

II. METHODS

A set of phases are conducted to achieve the research objectives. The first phase of the study focuses on reviewing the existing Philippine policies that are related to the sensory features present in a built environment including (a) National Building Code of the Philippines (NBCP); (b) Accessibility Law (Batas Pambansa Blg. 344); and (c) Fire Code of the Philippines (Republic Act 9514). A review of guidelines are followed to identify the gap and determine if there are sufficient consideration in building design for the visually impaired in Universal Design (UD), Inclusive Design (ID), Barrier-Free Design (BD), Multisensory Design (MD), and Accessibility Design (AD).

The second phase is a validity check through phenomenological research based on the subject user's experiences. Phenomenological research identifies the common themes that are collected in the shared experiences of individuals to describe a phenomenon through in-depth interviews (Mckoy & Boyd, 2023). This human experience is based on understanding rather than statistics. It requires that only a limited number of people be interviewed due to saturation, which means to continue collecting data until no new themes or insights emerge (Oteifa et al., 2023). An interview guide prepared by the researchers undergoes ethical review by a statistician to ensure that it complies with the standard of ethics. The participants should also be diverse in terms of: (a) Age; (b) Gender; and (c) Specified condition. The content of an in-depth interview includes: (a) user's experience, and (b) sensory signal. The statistical data of the target respondents is provided by the Persons with Disability Affairs Office (PDAO). The study uses sampling where researchers consider their convenience in the collection of data due to the reason that the respondents are not easy to be found in selected localities. A total of 25 VI respondents are selected from the researchers' respective cities, including Baguio City of Benguet, Palayan City of Nueva Ecija, Santiago City of Isabela, Vigan City of Ilocos Sur, and San Carlos City of Pangasinan.

The next phase is a literature review that provides the basis for addressing the questions: (a) what was done; (b) what was found; and (c) what remains to be investigated. The review was confined to journals and books published between 2014 and 2024 to ensure accuracy and validity. Identifying the existing literature on multisensory dimensions enriches the understanding of how to apply these concepts in different building typologies properly. To ensure the applicability of the multisensory dimensions in the buildings, the next phase is case studies review. It determined the recurring themes, sub themes, and patterns in achieving multisensory dimensions. The review consist of five international buildings: (a) Hazelwood School for the Blind; (b) Anchor Center for the Blind; (c) School for the Blind and Visually Impaired in Gandhinagar, India; (d) Redemptorist School for the Blind; (e) Center for the blind and visually impaired (Taller de Arquitectura). The final phase is the impact analysis where the experiences of the VI individuals in a building with and without multisensory consideration are compared and analyzed to prove that independence can be achieve with the existence of the multisensory dimensions.

III. RESULTS AND DISCUSSION

To identify the existing considerations of multisensory elements in a building design for Persons with disability (PWD) including the VI, Accessibility Law (BP 344), Fire Code of the Philippines (RA 9514), and National Building

Code (PD 1096) were studied. Based on the review, the most frequent building elements that were mentioned are braille and audio elements. It means that the sense of touch and hearing are the most priority of the Philippine policies in terms of accessing information and spaces. Braille is installed on walls, doors, and elevators and is used in displays and automated teller machines (ATM). Audio, on the other hand, was used in fire alarm systems, ATMs, and as a voice synthesizer guide in elevators. The multisensory considerations outlined in Philippine policies were compared with five existing design guidelines to identify any gaps. Universal Design (UD), Inclusive Design (ID), Barrier-Free Design (BD), Multisensory Design (MD), and Accessibility Design (AD) emphasize visual and auditory cues, covering lighting, glare control, color contrast, sound, and auditory guidance. ID, BD, and AD address safe non-slip flooring, while protrusion hazard marking and detectable warning surfaces are included in all guidelines except MD, which offers limited attention. Temperature and sensory comfort are minimally considered by ID and MD, while olfactory cues are only addressed by ID and MD. As a result, the findings revealed that olfactory cues are also considered in multisensory design, in addition to visual, auditory, and haptic.

Phenomenological research

In-depth interviews were conducted with 25 participants to identify common themes and patterns based on visual, auditory, haptic, and olfactory experience of the visually impaired in a building design. The interview guide is composed of two parts: (a) user's experience; and (b) sensory signals.

Table . *Thematic analysis on user's experience*

THEMATIC ANALYSIS

User's experience			VI 1	VI 2	VI 3	VI 4	VI 5	VI 6	VI 7	VI 8	VI 9	VI 10	VI 11	VI 12	VI 13	VI 14	VI 15	VI 16	VI 17	VI 18	VI 19	VI 20	VI 21	VI 22	VI 23	VI 24	VI 25
Moving around the space	Guiding tool	Cane	✓		✓			✓										✓		✓	✓				✓		✓
		Assisting person	✓		✓				✓			✓									✓						✓
		Familiarity in layout									✓			✓					✓						✓		
	Areas that are difficult to navigate	Crowded areas							✓	✓		✓										✓					
		Obstructed pathways	✓		✓															✓					✓		
		Dimly lit areas						✓		✓														✓			
		Narrow spaces	✓										✓	✓		✓								✓	✓	✓	
		Rough roads																									✓
		Unfamiliar spaces				✓		✓				✓		✓	✓		✓				✓						
		Canteen																									
	Spaces easy to navigate	Familiar spaces						✓	✓					✓					✓	✓				✓			
		Wide enough hallways						✓		✓			✓	✓		✓								✓	✓	✓	
		Comfort Rooms (CR)									✓	✓															
Recognizing spaces	Indicators	Signage					✓											✓	✓	✓	✓	✓		✓		✓	
		Tactile features					✓			✓								✓	✓	✓	✓	✓		✓		✓	
		Textured materials on wall					✓			✓								✓	✓	✓	✓	✓		✓		✓	
Perception of space	Challenges	Easily get tired				✓									✓	✓											
		Difficulties accessing the stairs		✓				✓																			
		Moving slowly																					✓				
		Excessive noise				✓						✓		✓	✓	✓	✓	✓					✓	✓		✓	
		Getting hit and lost						✓	✓	✓	✓								✓								
		Overly spacious areas	✓	✓	✓	✓	✓										✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		Overcrowding			✓		✓		✓	✓																	
		Uneven pathways																				✓					
	Suggested solutions	Appropriate signage	✓	✓								✓	✓											✓	✓	✓	
		Enough size of areas and spaces										✓	✓		✓									✓	✓	✓	
		Clear descriptions of places										✓	✓											✓	✓	✓	
		Adequate lighting																					✓	✓	✓		
		Proper spatial layout				✓	✓										✓			✓		✓					
		Tactile features																									
		Railings											✓														
		Escalators											✓														

The findings indicate that VI individuals face varying levels of difficulty navigating spaces depending on the building's layout and their specific impairment, as they often face unnecessary limitations imposed by features of the built environment (House of Commons, 2016, 3). According to the participants, poorly designed, excessive noise, narrow, and complex areas are the most difficult to access since they limit accessibility; this results in the reliance on guiding tools or assisting persons, which hinders independence in wayfinding and navigation (Bullock, 2024). Despite the barriers, participants recognize sensorial solutions as potential ways to address the main issue.

Table . *Thematic analysis on sensory signals*

Sensory Signals																										
Haptics	Textured materials	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Tactile sensory	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓					✓
	Braille signage	✓	✓	✓	✓			✓	✓		✓				✓		✓	✓	✓	✓	✓					✓
Auditory	Sound of nature	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Verbal announcements	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Varying volumes and heights						✓	✓	✓	✓													✓			
	Quiet area						✓	✓	✓	✓	✓															✓
Visual	Appropriate lighting		✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Cool tone lighting		✓				✓	✓	✓	✓	✓												✓			
	Standard height of ceiling				✓			✓	✓		✓	✓	✓	✓	✓	✓						✓				
Olfactory	Odor	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Air quality	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Multisensory elements in building design are essential for identifying and navigating spaces, as these features connect key destinations (DesignHorizons Team, 2024). In relation to sensory signals, participants regarded olfactory cues such as odor and air quality as a guiding tool, since aromatic scents can help identify a space (Cushley et. al, 2024). Textured materials, tactile cues, and braille signage are also mentioned under haptics, making the sense of touch crucial in designing (Saxena & Rana, 2024). Participants viewed visual elements, such as proper lighting and ceiling height for reflection, as well as auditory including sound of nature, verbal announcements, acoustics, and room volume, as helpful solutions to support independence in navigating a space, since visual and auditory are key elements in perceiving the surroundings (Kedar, 2022).

Literature review

To ensure that haptics, visual, auditory, and olfactory cues are widely used in building design, 30 published international research studies were reviewed.

Table . *Literature review of multisensory dimensions studies*

	MULTISENSORY ([illegible])	IDENTIFIED SUBTOPICS	Author 1	Author 2	Author 3	Author 4	Author 5	Author 6	Author 7	Author 8	Author 9	Author 10	Author 11	Author 12	Author 13	Author 14	Author 15	Author 16	Author 17	Author 18	Author 19	Author 20	Author 21	Author 22	Author 23	Author 24	Author 25	Author 26	Author 27	Author 28	Author 29	Author 30	TOTAL	PERCENTAGE	TOTAL IN PERCENTAGE	HIERARCHY	
STRATEGIES	VISUAL	COLOR		✓	✓	✓		✓	✓		✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓	22/30	73.33%	66.66%	VISUAL	3
		LIGHT	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	25/30	83.33%			
		FORM DEPTH		✓		✓	✓		✓	✓	✓	✓	✓		✓			✓		✓				✓			✓				✓		13/30	43.33%			
	AUDITORY	SOUND AND ECHOES	✓	✓	✓	✓	✓		✓	✓					✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	24/30	80.00%	71.11%	AUDITORY	2
		MATERIAL ([illegible])	✓			✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓			✓			✓	✓	✓	19/30	63.33%			
		AUDITORY LANDMARKS SIGNALS	✓		✓	✓		✓	✓	✓	✓		✓	✓		✓		✓		✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	22/30	73.33%			
	HAPTICS	HAPTICS CUES	✓	✓			✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	25/30	83.33%	77.77%	HAPTICS	1
		TEMPERATURE	✓	✓		✓	✓	✓	✓	✓	✓				✓		✓		✓	✓		✓	✓	✓			✓		✓	✓	✓	✓	20/30	66.67%			
		TEXTURED MATERIAL		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	✓	25/30	83.33%			
	OLFACTORY	SMELL SCAPE	✓	✓		✓	✓	✓	✓	✓			✓				✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	23/30	76.67%	55.56%	OLFACTORY	4
		LANDMARKS / VEGETATION			✓	✓			✓		✓	✓		✓	✓	✓	✓	✓				✓					✓	✓	✓	✓	✓		16/30	53.33%			
		AROMATIC			✓	✓			✓		✓	✓	✓	✓	✓	✓	✓			✓				✓						✓			12/30	40%			

The analysis of 30 studies conducted by the following authors: Author 1 - Bakir et al. (2022), Author 2 - Boucherit et al. (2022), Author 3 - Annakin & Everett (2023), Author 4 - Almaz (2022), Author 5 - Sari et al. (2020), Author 6 -

Alagappen (2020), Author 7 - Setiawan et al. (2021), Author 8 - Oteifa et al. (2017), Author 9 - Elsamman et al. (2021), Author 10 - Kosasih (2014), Author 11 - Naidu, K. et al. (2022), Author 12 - Perez, J. (2024), Author 13 - Seitawan, N. et al. (2022), Author 14 - Trevino, T. (2022), Author 15 - Malekafzali, A. (2018), Author 16 - Levy, J. (2020), Author 17 - Hesham et al. (2024), Author 18 - Berube, P. (2022), Author 19 - Zhu, T., Yang, Y., (2023), Author 20 - Karlsson, S. (2023), Author 21 - Cho, J. D. (2021), Author 22 - Spence, C. (2020), Author 23 - Krajewski, S., Khoury M. (2021), Author 24 - Lloyd-Esenkaya (2020), Author 25 - Crowley, T. (2024), Author 26 - Krishnaprasad, A. (2020), Author 27 - Jenkins, G.R. (2015), Author 28 - Choudhury, D. (2016), Author 29 - Wong, H. (2021), Author 30 - Ranne, J. (2019) led to the identification of haptics as the primary used dimension followed by the auditory, visual, and olfactory cues. The review also highlighted the identification of the multisensory dimensions solutions applied in a building design:

Haptics

The sense of touch plays a key role in perceiving temperature, materiality, and ergonomics, which are essential factors to be assessed in haptics. Materials and textures give an appropriate perceptual information of a space (Levy, 2020; Otiefa et. al, 2017; El samman et al., 2021). According to Samman et. al (2021), different flooring materials create contrast in texture to facilitate movement from place to other. Contrasting floor identity can be done through installation of different tactile tiles per area of a building. For example, wet rooms like toilets and kitchens can have one type of flooring, while waiting spaces such as reception or seating areas can have another, and a different type can be used for circulation areas (Fernando & Hettiarachi, 2016). Another approach in circulation is the use of tactile tiles that indicate line signals to go forward, while dotted signify to stop (Fallatah et al., 2020; El samman et. al, 2021). In relation to stairs, handrails should extend 2 feet past the end of the stairs to signal their presence (Lukman et al., 2020; Narthker et al., 2019). Incorporating handrails with tactile braille text, along with other tactile pathways, will help them navigate the space more easily (Almaz, 2022). Visually impaired individuals don't solely rely on tactile paving but also on their memory, particularly in challenging spaces. As a result, rooms should be designed with perpendicular layouts rather than circular ones, as circular designs can disorient users (Baktara et al., 2021). Fernando & Hettiarchi (2016) highlighted the importance of ventilation of a room or the feeling of heat and cold as it can be used as an indicator to easily sense and differentiate spaces.

Auditory

Auditory cues are related to haptic sense as materials and textures along with form, produce acoustic feedback control echoes in defining depth, space recognition and orientation (Otiefa et al., 2017; Perez, 2024). When considering materiality for acoustic design, it is essential to examine the acoustical properties of the materials to ensure they achieve the desired acoustic outcomes (Trevino, 2022). Acoustical ceiling in zigzag pattern absorbs sound reverberation, produces different levels in sounds caused by different reflections, and is considered the best way to control noise (Fernando & Hettiarachi, 2016; Wong, 2014). Classrooms are also covered by wood panels at walls, wood tiles and slide-resistant with acoustic support on the floor to improve the acoustics (Almaz, 2022; El samman et al., 2021). Installation of speaking devices in elevators and audio signals such as alarm or countdown to an intersection is also considered to help the blind (Almaz, 2022). Additionally, utilization of audio markers like fountains and water elements delineate an area within the built environment (Firestone & English, 2016).

Visual

The sight is the primary sense that helps a person perceive light, form and color. Furthermore, buildings can only be understood with the use of light complemented in colors, angles, and shape (Naidu, 2022). Visual cues include the use of high-contrast objects and materials, along with the strategic use of light, to help visually impaired individuals navigate spaces and define areas like entrances and exits (Levy, 2020; Trevino, 2022). Fernando & Hettiarachi (2016) studied that daylight bulbs or smart lighting systems are preferable as they ease the passage from outside to inside, whereas lighting that is too warm can be disorienting due to its hues differing from natural daylight (Fernando & Hettiarachi, 2016; Karyono et al., 2020; Wong, 2014). According to the UK building regulations, smart lighting systems made up of LEDs can predict lighting conditions, which necessitates visual contrast with doors, step nosing, and handrails, requiring a 30 light reflectance value (LRV) at 100 lux luminance. (HM Gov, 2015). Aside from proper lighting, materials used should also be assessed based on their surface properties, as they can cause unwanted glare. Minimizing discomfort from glare by avoiding shiny or glossy surfaces and light fixtures that emit UV or blue light can improve clarity and enhance navigation (Trevino, 20220). Another consideration is the use of colors like green, red, blue, and yellow, as they are high in contrast and represent true colors. Additionally, white ceilings are recommended for better reflectance qualities (Wong, 2014). Neon colors should be avoided since they can be distressing to people with color and light sensitivity (Fallatah et al., 2020). To facilitate the proper identification of spaces, Macular Society (2023) mentioned that signages should be located at eye-level in an easy to read font such as Calibri, Helvetica, and Arial.

Olfactory

Olfactory cues engage the sense of smell, providing distinct scent and aromas that will help the VI individuals create a mental representation of their surroundings (Otiefa et al., 2017). Scent provides an initial impression of a space, leaving a lasting impact because it is closely linked to memory. This creates olfactory landmarks that help define and orient individuals within their surroundings (Baktara et al., 2021; Levy, 2020; Naidu,2022; Perez, 2024; Trevino, 2022).

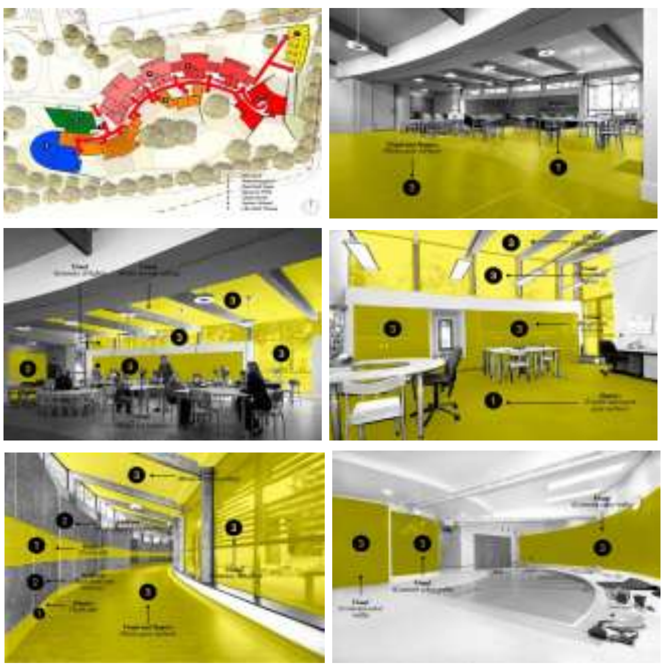
Implementation of sensory aromatic gardens can also stimulate the sense of smell (Annakin & Everett, 2023). Plants such as lemon, rosemary, jasmine, and lavender have strong pleasant aromas providing another method of sensory wayfinding (Jenkins et. al, 2022). While plants with fragrant such as the national flower of the Philippines and Cananga odorata or *ylang-ylang* improve vision by making what is seen more clear (Othmani et al., 2023).

Case study review

To determine the applicability of the identified multisensory dimensions and elements in a building design and their role in promoting the independence of the VI. Five international buildings were reviewed, focusing on the implementation and placement of these cues.

Case Study 1

Figure 2. *Multisensory dimensions and sensory cues present in building 1*



Legend:

1. Haptics
   - Scale of spaces, trail rail, shape, sensory trail, tactile and matte gray surface
2. Auditory
   - High slate and sensory
3. Visual
   - White drywall ceiling, bright red furniture, contrast color walls
4. Olfactory
   - Sensory garden

Building No. 1 is a school completed in 2007 and located in the United Kingdom. It serves 60 students with multiple disabilities, aged 2 to 19. Each student has a combination of two or more of the following impairments: visual impairment, hearing impairment, mobility, or cognitive impairment.

Case Study 2

Figure 3. *Multisensory dimensions and sensory cues present in building 2*

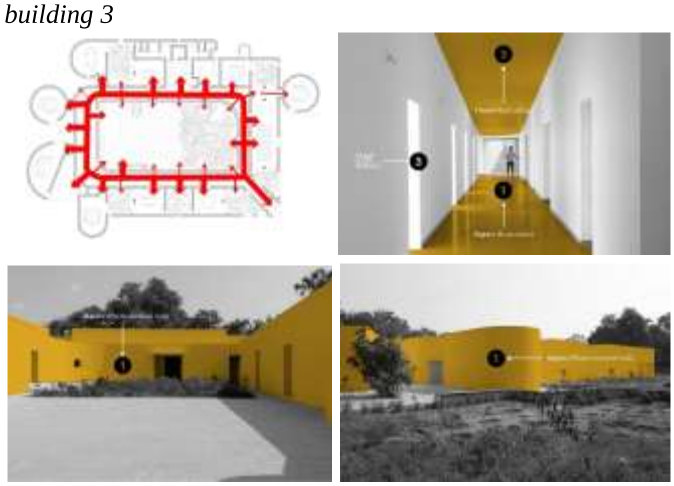
Legend:

1. Haptics
   - Spine, wood, carpet, rubber, and hard-surface, patterned wall
2. Auditory
   - Suspended acoustic baffles, wood
3. Visual
   - Filtered clerestory window, color and contrast, high ceiling, large and glass walls
4. Olfactory
   - Sensory garden

Building No. 2 was built in 1982 and has gained national recognition for its leadership in supporting families and children with visual impairments in the United States.

Case Study 3

Figure 4. *Multisensory dimensions and sensory cues present in building 3*

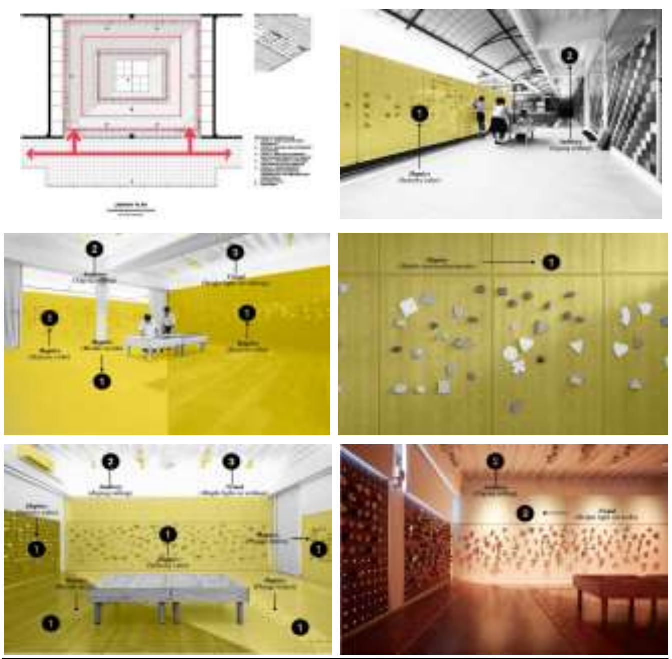


Legend:
1. Haptics
   - Shape of rooms, hard surface, plaster-textured wall, kota stone
2. Auditory
   - Different volumes and heights
3. Visual
   - Light intensity, high ceiling
4. Olfactory
   - Aromatic flowers

Building No. 3 was completed in 2021. It is designed for children from remote villages and towns in Gujarat to provide them with improved educational opportunities and resources for societal advancement.

Case Study 4

Figure 5. *Multisensory dimensions and sensory cues present in building 4*

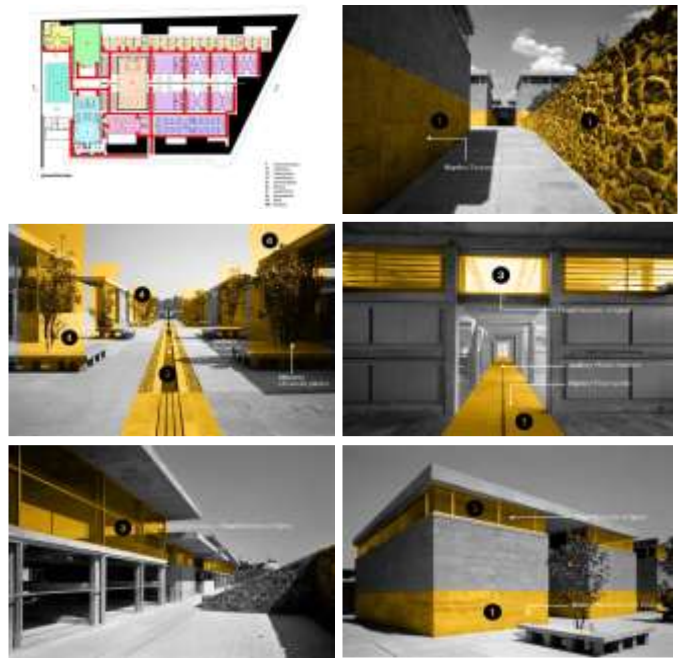


Legend:
1. Haptics
   - Sensory cube, braille tactile, plunge letters, highly textured materials
2. Auditory
   - Zigzag ceiling
3. Visual
   - Bright light on walls and ceilings
4. Olfactory

Building No. 4 was founded in 1986, and it has provided VI children in Thailand with education that will allow them to become independent members of society.

Case Study 5

Figure 6. *Multisensory dimensions and sensory cues present in building 5*



Legend:
1. Haptics
   - Blind and patterned walls, floor tactile
2. Auditory
   - Sound of waters
3. Visual
   - High ceiling, intensity of lights
4. Olfactory
   - Aromatic plants

Building No. 5 is located in Mexico and was completed in 2001. The 14,000 sqm complex was built for the visually impaired in the city's most disadvantaged and highly populated areas.

The result from the case study review of 5 international buildings designed for individuals with visual impairments highlights that the integration of multisensory design enhances the users' navigation and wayfinding experience. Circulation strategies within the buildings include central courtyards surrounded by clear and well-defined pathways and linear circulation layouts, as the circulation used in the buildings allows simplified movements and improved spatial awareness for the visually impaired (Almaz, 2022). Horizontal circulation without steps or ramps was recommended to reduce tripping hazards (Trevino, 2022; Levy, 2020). Orientation within the buildings was supported through strategic spatial layouts and reference points such as courtyards and auditory landmarks. Tactile guidance in the buildings incorporates contrasting materials and textures such as cork, wood, concrete, and kota stone. Slip-resistant and textured floor surfaces are incorporated in building flooring, signaling spatial transitions to ensure safety. To support haptic navigation for VI users without guide canes, it is recommended to incorporate tactile aids, Braille signage, and textured wall finishes. Additionally, for auditory navigation, acoustically treated ceilings help control noise and manage sound reflections.

Impact Assessment

The problem of indoor navigation and wayfinding is further complicated for those with visual impairments (Dias et al., 2015; Muller et al., 2022; Soresen, 2014). VI people suffer from navigation-related activities due to the challenges that they encounter, which results in discouragement from going out for social activities and interactions (Jeamwatthanachai et al., 2019). Several challenges that the VI face are the hindrance to perceive and understanding spatial layouts, making it challenging to form mental maps of indoor environments (Muller et al., 2022), furniture or structural elements also increase the risk of collisions and injuries (Soresen, 2014), and inability to quickly locate exits, stairs or hazards poses significant safety risks during emergencies (Dias et al., 2015). The study was supported by Chidiac's research (2024), which says that the absence of environmental cues such as light, sound, and smell creates gaps in receiving environmental information and equal opportunities for all. The sensory perception usually has a proximal scale, limiting the VI in obtaining spatial information and leading to difficulties in achieving independent navigation (Seetharaman, 2024). The lack of multisensory guidance in building design causes VI individuals to depend on memory, as well as support from a cane and assistance from others (Jeamwatthanachai et al., 2019).

To accommodate the needs and address the challenges encountered by the visually impaired within a building space, multisensory dimensions were applied in five existing international buildings analyzed in the case study review. As a result, multisensory spaces provide the users with more holistic and richer experiences that contribute to the perceptual tasks (the understanding and making sense of the built environment), and cognitive and operating tasks (Bakir et al., 2022). The conducted review of case studies and literature confirms that integrating multisensory design is essential in shaping the built environments for the VI. Navigation and wayfinding are significantly enhanced through haptic, auditory, visual, and olfactory cues, which work together to create an intuitive and accessible environment (Levy, 2020). The key to effective spatial navigation lies in tactile guidance, sound cues, controlled lighting, and olfactory markers. By implementing multisensory design, VI individuals could learn and study with less reliance on assistance, thereby enhancing their independence (Ozgur & Tuncay, 2021).

IV. CONCLUSION AND RECOMMENDATIONS

The study aims to identify the multisensory dimensions that can be applied in a building design contributing to the independence of individuals with visual impairment. The key findings revealed the four multisensory dimensions which includes the haptic, auditory, visual, and olfactory. Slip-resistant treads in stairs, tactile signage, handrails, textured flooring and walls, vibrating objects, and braille in technological elements can provide information through haptics. Aside from the use of sound for wayfinding and alerts, water can be an element for guidance through auditory cues. In addition, color, contrast, and adequate lighting can help with visual orientation to a space, while scent from aromatic plants can also be used in identifying a space. Overall, the building's layout directly influences how VI individuals navigate a space, making a single spine or linear circulation the most efficient pattern of movement. Recognizing how multisensory design emphasizes sensory approaches to assist and guide, architectural solutions should focus on how to balance sensory stimulants to avoid sensory overload. Considerations and inclusion of real-time experiences of the VI individuals should be assessed to provide continuous improvement to multisensory design. The findings of the study could promote more inclusive, navigable spaces that contribute to the independence and accessibility for all users by expanding the immersive experience of multisensory and deepening the connection of VI individuals and the built environment.

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