Enhancing Educational Spaces for Neurodiverse Learners: Design Standards and Inclusive Solutions

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Abstract

It has been recently found that a notable proportion of the world population exhibits some form of neurodivergent behaviour. They are present in every setting including the educational environments. However, architecture often neglects the unique needs of these neurodiverse individuals, especially in the educational environments. In this context, this study investigates how well the current school designs meet these needs compared to the 'Design for the Mind' standards outlined in the British Standards Institution Publicly Available Specification (BSI PAS) 6463:2022.

The study employs a qualitative approach as a research method. Thus, it acquired secondary data from the BSI-PAS 6463:2022 to examine the specifications. The document states the importance of design for neurodivergent individuals and provides various elements that affect the demographic. Semi-structured interviews were also conducted with the educators and administrators in schools designed for special-needs. Thematic analysis of the data revealed recurring themes, such as the necessity for calming spaces, sensory-sensitive environments, and community-oriented designs. The use of Braun and Clarke's framework ensured a thorough exploration of stakeholder experiences, while coding software aided in organizing complex data. The research thus gathered insights on the spatial layouts, sensory considerations, and the impact of physical design on the well-being of the neurodiverse learners.

Findings show significant gaps in current infrastructure, particularly in creating accessible and supportive spaces. Recommendations have been made on incorporating quiet zones, sensory regulation features, and more inclusive layouts. This study emphasizes the need to extend neurodiverse-friendly design principles beyond the schools, creating environments that support diverse communities in all public spaces.

Keywords: Neurodiverse Design, Accessibility, Educational Spaces, Inclusive Architecture, Community-Centred Design.

Introduction

Neurodiverse populations include those suffering from Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), cerebral palsy, dyspraxia, dyslexia, dyscalculia, and Tourette syndrome(Morris-Rosendahl DJ & Crocq MA, 2020). 15-20% of the

world population have been found to exhibit some form of neurodivergent behaviour. India has a neurodiverse population of 9.2% below 6 years old and 13.6% among the children of 6 to 9 years old categories (Arora et.al., 2018). According to Armstrong (2010), neurodiversity challenges the traditional medical model, which views these conditions as problems to be 'fixed'. Society therefore promotes a strengths-based perspective that highlights the unique abilities and contributions of neurodiverse individuals.

The spaces where children learn have a profound impact on their development, especially for those who experience the world differently. For neurodiverse learners, classrooms and other educational environments can either nurture their growth or present obstacles that hinder their potential. Despite increasing awareness of these needs, many schools continue to rely on conventional design approaches that fail to accommodate sensory sensitivities and other unique requirements. In this light, Neill and Ethridge (2008) speak about how the traditional classroom can be transformed through an appreciation of differing approaches to teaching and learning, the application of effective physical design, and adoption of instructional technology.

The sensory deficits are more prominent in ASD. Children with ASD may have hypersensitivity and hyposensitivity to visual, auditory, haptic, and olfactory stimulus. Most ASD children have hypersensitivity to bright light (LED, fluorescent lights), flashing light, and auditory stimulus (hyperacusis and misophonia). The stimulus causes unpleasant, painful and frightening experience in patients. Abnormal perception of tactile stimuli and altered pain perception are observed in ASD. Touch and texture can cause irritation to the children and often reports hypersensitivity and hyposensitivity to touch and pain. Problems in proprioception and somatosensation leads to the deficits in sensory-motor integration that cause gross and fine motor deficits. In fact, the texture of fabric, seating, food, room etc. can affect the children with NDD (Danesh AA et.al., 2021).

It is important to address the measures to improve the quality of life of these children along with pharmacological and behavioural interventions. Currently, special and normal schools are not designed to consider children with neurodevelopmental challenges. Although Paige (2022) talks about the availability of a plethora of information about altering teaching methods to accommodate neurodivergent students, there is less information about how to set up their learning environments for success.

The variations between the hypersensitivity and hyposensitivity to stimuli are very prominent and the needs also vary according to the types. For example, children with hyposensitivity to auditory stimulus do not respond when a name is called. They also enjoy strange noises and loud or excessive noises. A hypersensitive child on the other hand, will be overly sensitive to loud noises and cannot function with background noise. Children with hyposensitivity to light have difficulty in the perception of objects in low lighting conditions and love to be in bright sunlight or love bright colours. The children with hypersensitivity to light avoid bright light and can be easily distracted by movement. The children with hyposensitivity to tactile stimuli often touch people or objects unconsciously, and respond very slowly to increases in pain or temperature. Similarly, children with hypersensitivity to tactile stimuli get distracted by the texture of fabric, do not like grooming, and do not like to be touched or to be wet. Hyposensitivity to proprioception can make the children lean against other people or objects, and are unaware about body position in space. The children with hypersensitivity to proprioception show discomfort in most of the positions and have difficulty in manipulating small objects (Hodges et.al., 2020).

It is undeniable that it is important to address the measures to improve the quality of life of these children along with pharmacological and behavioural interventions. Currently, special and normal schools are not designed to consider children with neurodevelopmental challenges. In this context, this study focuses on understanding how educational spaces can be designed to better support neurodiverse learners, particularly within the Indian context. Drawing from firsthand insights of educators and administrators, the research explores existing challenges while identifying opportunities to align with globally recognized standards, such as the BSI PAS 6463:2022 - Design for the Mind guidelines.

The research aims to contribute to the understanding of the role of design in positively responding to spatial experiences of students with neurodiverse issues in educational settings and to propose inclusive solutions based on the existing guidelines. The objectives of the study are as follows.

- To examine existing infrastructure and whether they cater to the varying needs of students, identifying the strengths and the shortcomings.
- To gather insights from faculty, teachers, and other stakeholders on perception of space, sensory control, and accessibility in educational settings.

Theoretical Framework

Universal Design for Learning (UDL)

Much has been theorized in relation to educational environments. Among them, UDL framework, Environmental Psychology, Attention Restorative Theory, and Sensory Integration Theory stand out.

The UDL framework has been conceived by researchers at the Centre for Applied Special Technologies (CAST) in the late 1980s as a result of the alignment of three conceptual shifts: advancements in architectural design, developments in education technology, and discoveries from brain research (Ralabate 2011). The roots of UDL are found in early civil rights and special education legislation that emphasize the right of all students to a free, appropriate public education in the least restrictive environment (Hitchcock et al., 2005). UDL provides a flexible framework for designing educational spaces that accommodate diverse learning needs (Meyer et al., 2014). This study derives some aspects of the theoretical framework from the UDL principles to assess flexible learning environments that support varied cognitive and sensory needs, and adaptability of spaces to promote autonomy and comfort for neurodiverse students, while providing equitable access to resources through inclusive spatial planning and assistive technologies.

Environmental Psychology

Environmental psychology is the study of the transactions between people and their physical settings (Gifford, 2007a). In these transactions, individuals change their environments, and their behavior and experiences are changed by their environments. It includes theory, research, and practice aimed at making the built environment more humane and improving human relations with the natural environment (Gifford et. al.).

Berto (2008) points out that the exposure to natural environments produce positive mood chances. It is argued that actual exposure to natural stimuli can mediate the negative effect of stress, reducing the negative mood state, simultaneously enhancing positive emotions. In particular, natural settings have restorative influences on three affective dimensions: positive effects, anger/aggression, and fear. According to its theories and findings, people report more positive emotions (such as friendliness) and fewer negative emotions (such as sadness) when viewing urban scenes with trees than when viewing the same scenes with inanimate objects .

Attention Restorative Theory

Attention restoration theory (ART) provides an analysis of the kinds of environments that lead to improvements in directed-attention abilities. Nature, which is filled with intriguing stimuli, modestly grabs attention in a bottom-up fashion, allowing top-down directed-attention abilities a chance to replenish (Berman et al. 2008). Attention restoration theory or ART (Kaplan, 1995, 2001) offers a novel approach to identifying and restoring a cognitive mechanism. Berman (2008) tells us that ART is based on past research showing the separation of attention into two components: involuntary attention, where attention is captured by inherently intriguing or important stimuli, and voluntary or directed attention, where attention is directed by cognitive-control processes. This research also derives its theoretical framework by incorporating these ideas from ART.

Sensory Integration Theory

Sensory Integration Theory (SIT) is defined as "the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment". In this connection, Sieg (1988) articulates the impact of visual and auditory stimuli on people which is very easy to observe. Adding to this, Ayres (1972b) focus on the vestibular, proprioceptive, and tactile systems. In fact, Ayres (1972b) says that "the human being is not only a highly visual animal, he is so conscious of being visual the word perception is usually constructed to mean visual perception." Thus, this theory contributes to construct the theoretical framework of this research by incorporating the essence of sensoriality in human experiences of spaces.

Biophilic Design and its Impact on Neurodiverse Learners

Yet another concept and a theoretical articulation comes what s now known as Biophilic Design. According to Hartig et al. (2011) and Wilson (1986), the concept of biophilia has been introduced by the social psychologist Erich Fromm in 1964. Subsequently, it has gained prominence through the work of the biologist Wilson in the 1980s. In fact, Kellert & Wilson (1995) posited that increasing urbanization contributes to a growing disconnection from the natural world. Many have subscribed to this notion. The application of biophilia has since appeared among various disciplines, such as biology, psychology, endocrinology, and architecture. They all highlight the importance of re-establishing connections with Nature and the natural systems (Jha & Behera, 2022; Menezes et al., 2021; Robinson & Pallasmaa, 2015). Given the richness of these theoretical articulations, the theoretical framework of this research adopts the framework of Biophilic Design as a major approach to design of educational spaces for Neurodiverse Learners, we often tend to ignore.

Review of Literature

Numerous research examine the issues of creating supportive environments to accommodate the neurodiverse people. For example, Mostafa (2014) explores how architecture, as a discipline, focuses on controlling and moulding the physical environment to aid certain functions and excite certain behaviour. In doing so, he introduces 7 principles of dealing with Autism: the ASPECTSSTM design index: Acoustics, Spatial Sequencing, Escape, Compartmentalization, Transition Spaces, Sensory Zones, and Safety. Mostafa (2014) highlights the profound impact of sensory elements such as colour, texture and noise levels.

Gislason (2010) argues that there is a lack of research in architecture that contributes to the gaps in inclusivity in design. According to him, the underlying problem is that research separate teaching and learning models of education from designed spaces and the physical environments. He thus proposes a framework that emphasizes the organization of teaching, scheduling, and curriculum that should reflect the cultural values/assumptions of the teachers and is also aligned with the physical design of a school. In this connection, Butch and Lane (2024) discuss extensively the isolating and complex experience of neurodivergent students by emphasizing the systemic barriers, like inaccessible areas of a campus. He argues that this is due to a lack of sensory considerations, that constrict the productivity of the neurodiverse students.

Barret et. al (2015) examine the environmental aspects such as light, temperature, air quality, ownership, flexibility, complexity, and colour and point out that they contribute to 16% of the variations in the performances of the students. Similarly, Kelly (2024) talks about the over-reliance on standard design structures that discount neurodiverse students leaving them at a significant disadvantage. However, higher education focuses on 'access-based' meanings. T hey focus on removing barriers to equal opportunity, not to guarantee success. This leads to a reluctance to provide more well-rounded support, as it might be perceived as creating an unfair advantage. Ariani and Mirdad (2015) talk about the factors that can lead to resistance to making changes to accommodate accessibility. These factors include financial constraints, adherence to traditions, a glaring disconnect between the designers and the users, and a lack of design standards that support this accessibility.

Adding to these, Neill and Etheridge (2008) describe the redesign of a classroom into a 'flexible learning space' (FLS) intended to support a variety of pedagogical approaches. They derive the criteria from PAS 6463:2022-Design for the Mind.

As has been shown, many studies have helped in designing the environment for people suffering from neurodiverse issues. However, not many studies focus on the perspective of the stakeholders. Government policies to accommodate the neurodivergent population are yet to be established in many countries. In this context, this study emphasizes the gap between the existing policies and the facilities available for the neurodivergent population. This study explores these issues them from the perspective of stakeholders and can thus lead to better and more realistic solutions to address these gaps in future.

Research Methodology

Approach to Data Collection

This research employed case Studies and interviews as research methods. In the case studies, the stakeholders were asked to rate the educational environments and the services, and their effect on the students, from 1 – 5: 1 being the highest and 5 being the lowest. Four Schools were studied. The interviewees were school faculty and teachers, with a few differing as interns within the organization. Four were interviewed and all the interviewees wre above the age of 18. Complying with Braun and Clarke (2006), the study uses thematic analysis in an open-ended way, to investigate how well buildings designed for special-needs educational purposes serve their purpose. It focuses on suggesting additional standards for such buildings, referring to BSI PAS 6463:2022 Design for the Mind Standards.

Interviews with the Stakeholders

Interviews were held with the faculty of selected special-needs schools. Participant interviews occurred in their places of work on a pre-arranged and mutually agreed day. Interviews were semi-structured; a guide provided a loose structure to explore the topics of interest. Where appropriate, the interviewer prompted participants to expand on relevant and interesting responses. The interviews focused primarily on capturing experiences connected with-

- Availability of recluse spaces within the educational infrastructure
- Perception of space
- Use of materiality in reducing unnecessary sensory stimulations
- Role of colour intensities when experiencing the space.

Design Checklist

A specific criterion for a good neurodiverse design was obtained from PAS 6463:2022 Design for the mind. The checklist focused on the following.

Table1: Checklist for the Interviews
Source: Author

1	Wayfinding
2	External spaces and access
3	Internal layouts
4	Mechanical, electrical, plumbing (MEP)
5	Acoustics and noise management
6	Light, lighting and reflection
7	Surface finishes
8	Safety, recovery and quiet spaces

Participants

Purposeful sampling is a widely used technique in qualitative research whereby those cases most likely to be information-rich on the point of interest are selected to effectively use limited resources (Patton, 2002). In this research, the interviewees were school faculty and teachers, with a few differing as interns within the organization. All the interview participants were above the age of 18. Researchers sent an email to potential participants and requested them to take part in the interview process concerning their observations on how neurodiverse children experience spaces, specifically designed for them. Four respondents were interviewed for this study. All the interviewees participated without any incentives.

To protect the privacy of the participants, names of the interviewees are not mentioned and the participants shall be referred to as subjects. As the goal of the study was to gain an in-depth understanding of the point of interest, generic data such as the mean age of the participants, etc. are not reported. All the procedures were according to the ethical guidelines.

The organizations from which the participants were selected hold a key focus on helping neurodiverse children with their education and skills while being mindful of the difference in environmental and personal needs and challenges faced by these children as opposed to the neurotypical demographic.

Data Collection

Case Studies were conducted where AR visited various special-needs schools to assess and experience the existing infrastructure.

Table2: Evaluation of the Schools
Source: Author

School	Wayfinding	External spaces	MEP	Acoustic and noise	Lighting and finishes	Surface finishes	Safety and recovery
S1	3	4	3	4.5	4	4	3.5
S2	2	1	3	2	3	3	1
S3	1	3	3	4	3	3	1
S4	1	4	3	3	2.5	4	1

Open-ended interviews were conducted with a set questionnaire as a framework for the data required. The questionnaire comprises the following.

1. How is the space designed to accommodate children experiencing meltdowns or overwhelming emotions?
2. Why is flexibility in design important for children in such environments?
3. Does the building's material help buffer noise to prevent disturbances?
4. Do children with sound sensitivities use noise-cancelling headphones, and how are they supported?
5. Are warm or cool lights used, and how does this choice affect children?
6. What role do materials play in maintaining a comfortable environment?
7. What are the age ranges of the children, and how does the design accommodate diverse needs?
8. Are there specific design elements aimed at creating a calming environment?
9. How does the space encourage community-building among the children?

Data Analysis

This study used thematic analysis (Braun and Clarke, 2006). This required the transcription of interview recordings and followed by coding. Initially, the authors read and re-read the transcripts to identify the potential themes. The second level of analysis involved

inputting the transcription files into the Nvivo software to obtain a more comprehensive set of codes. They considered particularly how to retain the diversity of the initial codes while producing overarching elements, and higher-level sub-themes. In the third stage, the analysis was conducted to identify quotes congruent with the overarching themes. Next, the authors reviewed themes before defining and naming them. Finally, once themes were finalised by the authors, the write-up of the report began.

Findings

The analysis produced four major themes.

1. **Effects of the physical environment**

All participants agreed that the existing physical environment plays a huge role in the well-being of the children and sub-themes of colours, materiality, textures, etc. play a predominant role in the design of spaces.

> "We avoided overly vibrant or jazzy colours, as they could potentially cause distress. Instead, we opted for earthy tones to create a calming, healing environment."
>
> Subject 1: Interviews

Participants also mentioned the lack and need for specific recluse and quiet spaces where people can go in case of breakdowns or other overwhelming experiences.

> "there aren't any specific rooms for that purpose. When a child has a breakdown, they're typically sent outside to the balcony, where they calm themselves down but a separate room designed with adjustable lighting and other calming features would be very helpful."
>
> Subject 3: Interviews

Control Over the Sensory Environment

In their accounts, three out of the four participants highlighted the importance of a controlled sensory environment to provide a space that doesn't cause sensory overstimulation. A few sub-themes that came up were sound, light and temperature and their effects on the users.

> "we do have children with sound sensitivities who bring headphones. They can choose to wear or remove them as they feel comfortable, just as they would in any public space. It's all about giving them the agency to decide what's best for them."

> "We mostly rely on natural light. During the day, the main activity spaces and rooms upstairs don't need artificial light. Downstairs, the natural light is a bit less, but even then, just one light is usually sufficient."
>
> Subject 1: Interviews

Benefits to the Community

A third theme is how the architecture brings together the community, which further works together to handle any challenges that might emerge from time to time

> "We run this as a community. The group cooks together, cleans up together—maybe not for every meal, but at least two or three times a week. After meals, there's cleanup and other community tasks. They clean up activity rooms, their own rooms, and other spaces."
>
> Subject 4: Interviews

> "However, loud noises made by peers can sometimes trigger others. Thankfully, the children have a close bond, almost like a brotherhood, so they comfort each other, making it easier to handle."
>
> Subject 2:Interviews

Accessibility

Participants described the accessibility status of the spaces while referring to both good and bad infrastructure.

> "The entire ground floor is wheelchair accessible. The top floor isn't, and that's a conscious decision. Considering the reality of public accessibility in our country, we've ensured that everything important is accessible on the ground floor. The children rarely go upstairs, and when they do, it's usually for specific, safe purposes."
>
> Subject 2: Interviews

> "No, since it's a government-funded organisation, they rely heavily on donations and have limited resources. They don't have much infrastructure to aid in accessibility, but it would definitely help if they did."
>
> Subject 3: Interviews

Discussion

Traditionally, the design industry has ignored the needs of the neurodiverse community and forced them to adapt to the existing conditions. It is high time we recognise this shortcoming and work towards changing it. The British Standards Institute took an initiative for the same when they published the PAS 6463:2022 Design for the Mind. The participants agree with most, if not all the standards, either by experiencing benefits or feeling the lack of infrastructure.

The standards focus on Wayfinding; External spaces and access; Internal layouts; Mechanical, electrical and plumbing (MEP); Acoustics and noise management; Light, lighting and reflection; Surface finishes; Fixtures, fittings and furniture; and Safety, recovery and quiet spaces. The need for these criteria even in an Indian context has shown itself through the semi-structured interviews conducted.

When informed of the criteria, most participants agreed that these interventions would be beneficial for neurodiverse users, not only in an educational setting but in any public building. This shows that consideration of the neurodiverse community is a big step towards making our designs and our building universally accessible.

The themes identified divulge not only the physical benefits of a well-designed place but also the social gains of architecture. They imply bringing communities closer and giving a deeper understanding about everyone who is a part of the community and their individual needs from a space.

Conclusion

This paper concludes that while the current educational settings and the facilities show some progress, significant inadequacies remain, particularly in providing dedicated quiet spaces and ensuring accessibility. These insights suggest that a more intentional application of neurodiverse design standards could greatly improve both the educational experience and overall well-being of neurodiverse individuals. It is clear that design elements like controlled lighting, sound-proof zones, better wayfinding techniques and restorative rooms could enhance the quality of these spaces. Given this, the study advocates for the expansion of these design considerations beyond educational settings to make all public spaces more inclusive. It also emphasises the need for conducting further quantitative research and surveys to understand the implementation of government policies in schools designed for the children with special needs.

This study thus argues that there is a need for a paradigm shift in how we design for neurodiverse communities. It urges the architectural practices and policymakers to prioritise

inclusivity and accessibility in creating such environments. By doing so, It would be possible to create spaces that not only accommodate but also empower neurodiverse individuals to thrive.

Limitations and Future Research

Many factors limit the generalizability of the findings of this paper. First and foremost the conclusions have been derived from a small-scale qualitative analysis. There is a lack of consideration of a larger geographical scope. While the study shows strong support for the prescribed standards, it leaves room for questioning the same due to its small sample size. Noting the limited scope of this study, further work could examine the outcomes using larger samples and relevant objective psychometric measures. Furthermore, larger samples allow the testing of predictive relationships and the development of models.

This study focused on a city-level geographical scope can be enhanced by focusing on a larger geographical area with participants from various cultural and experiential backgrounds. The variability in institutional resources stands out as a limitation as the participating schools had varying levels of infrastructure and financial resources, making it difficult to assess the universal applicability of certain design interventions, particularly those that require significant investment. Research could also explore the role of emerging technologies such as AR/VR and smart building systems in enhancing the quality of neurodiverse experience of any space. Nevertheless, this study holds scope to go beyond just the educational setting considered.

Ethics statement

This study was conducted strictly according to ethical guidelines. Participation was voluntary and the respondents were informed that they could withdraw at any time, should they wish to do so. All interviews were recorded with the permission of the participants and they were later anonymized and transcribed. Anonymized interviews were stored on a password-protected computer for later analysis. Organisations and participants remain anonymous as per the participants' requests.

Author contributions

`AR collected data and participated in thematic analysis. SNM and SRV were instrumental in giving inputs for analysis and feedback for writing the final report. All authors have read and approved the manuscript.

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