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Architectural Design: Towards Autism Spectrum Disorder Wellbeing

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ABSTRACT
Autistic individuals have distinct brain architecture; they are facing challenges to involve in community life due to a lack of "autism-friendly" environments that may include across schools, public spaces, workplaces, hospitals and airports, etc. Autism people may tolerate unusual behavior, attempting to compensate and understand their environment.
Design facilities have the potential to enhance the quality of life for autism, through the built environment and the comprehensive services they provide. Several studies conducted in the area of autism design, however, most of studies based on evidence-based research focusing on the manipulation of sensory responsiveness in autistic individuals, even though their primary issue is cognitive dysfunction. Consequently, these aspects contributed to incompatible and inappropriate design guidelines that do not often address the unique behavioral and cognitive needs of autistic individuals.
Therefore, there is a lack of concrete and comprehensive guidelines based on scientific psychological research. In addition, there is no effective scientific fact translation model that can fix the knowledge gap between psychological evidence and the design aspects. This research was conducted to resolve these issues. The study will concentrate on translating scientific psychological facts to design problems in order to extract design strategies based on psychological analysis of autism deficiency.

KEY WORDS: *Autism Spectrum Disorder, Learning Environment, Cognition Theories*.

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I. INTRODUCTION

According to Centers for Disease Control (CDC, 2020) the estimated prevalence of autism spectrum disorder (ASD) increased by approximately 10%, to 1 in 54 children in the United States by 2020. Need for schools which are tailored to address the autistic student are becoming crucial. ASDs are reported to have distinct brain architecture due to their lifetime neuro-developmental disorder that is present from birth or at an early age and affects three major domains, including: social interaction, communication, restrictive and repetitive behavior (DSM-5; American Psychiatric Association, 2013).

Their impairments effect on the cognition and interpretation of surroundings. They may accommodate for unusual behavior trying to compensate and understand their environment. For individuals with autism, education, is one of the most significant aspects boosting them to enjoy better lives. The mainstream school is not designed fulfill the specific demands of those with autism. Facilities provided through the built environment and the comprehensive services for ASDs have the potential to enhance the quality of life and improve their impairments.

II. MATERIAL AND METHODS

In order to reach the appropriate design strategies for ASDs' schools, an intensive study on ASD cognitive psychology domain will conduct first. Then these results were translated into design guidelines and strategies that are informed by best practice case studies.

Phase I: literature review

The search was conducted using databases that provide knowledge from cognitive psychology, clinical psychology and neuroscience. The search was conducted according to five categories related to cognitive theories. For each category, specific keywords were applied; Autism Spectrum Disorder, Design for Autism, Local Processing Bias, Theory of Mind, Executive Functioning, atypical sensory responsiveness: "visual

(perception)", "auditory (perception)", "tactile (perception)", "olfactory (perception)". In regards, a search for the appropriate references given in the studies initially investigated was conducted.

Phase II: Design considerations for ASD's cognitive deficiencies
Key Fact was established from the literature reviewed. KF was then outlined in 26 statements that reflect the most important concepts of social and non-social cognition of ASD. Then these results were translated into design problems for ASD to be considered in built learning environment (LE).

Phase III: Design guidelines and strategies LE based on cognition theories
Design considerations were elaborated into design guidelines and strategies that are informed by best practice case studies.

Research Problem: There is no appropriate and efficient knowledge translation that can overcome the gap between psychological evidence and design implications. This lack have often contributed to arbitrary and inappropriate designs of learning environment that do not always address the distinctive behavioral and cognitive demands of individuals on the autism spectrum.

Research Objectives: 1) Eliminating the knowledge gap between autism psychological aspects and design considerations for more supportive learning settings. 2) Developing design strategy of ASD learning environment to delimit the impairments of autism, besides enhancing their potential and well-being.

Research Hypothesis: 1) Cognitive theories are the scientific key to understand how autism individuals interact, and interpret their environment. 2) Cognitive considerations are one of the most vital aspects towards a compatible design strategy of autism learning environment that manipulate their overwhelming behavior and accommodate perceptual their demands.

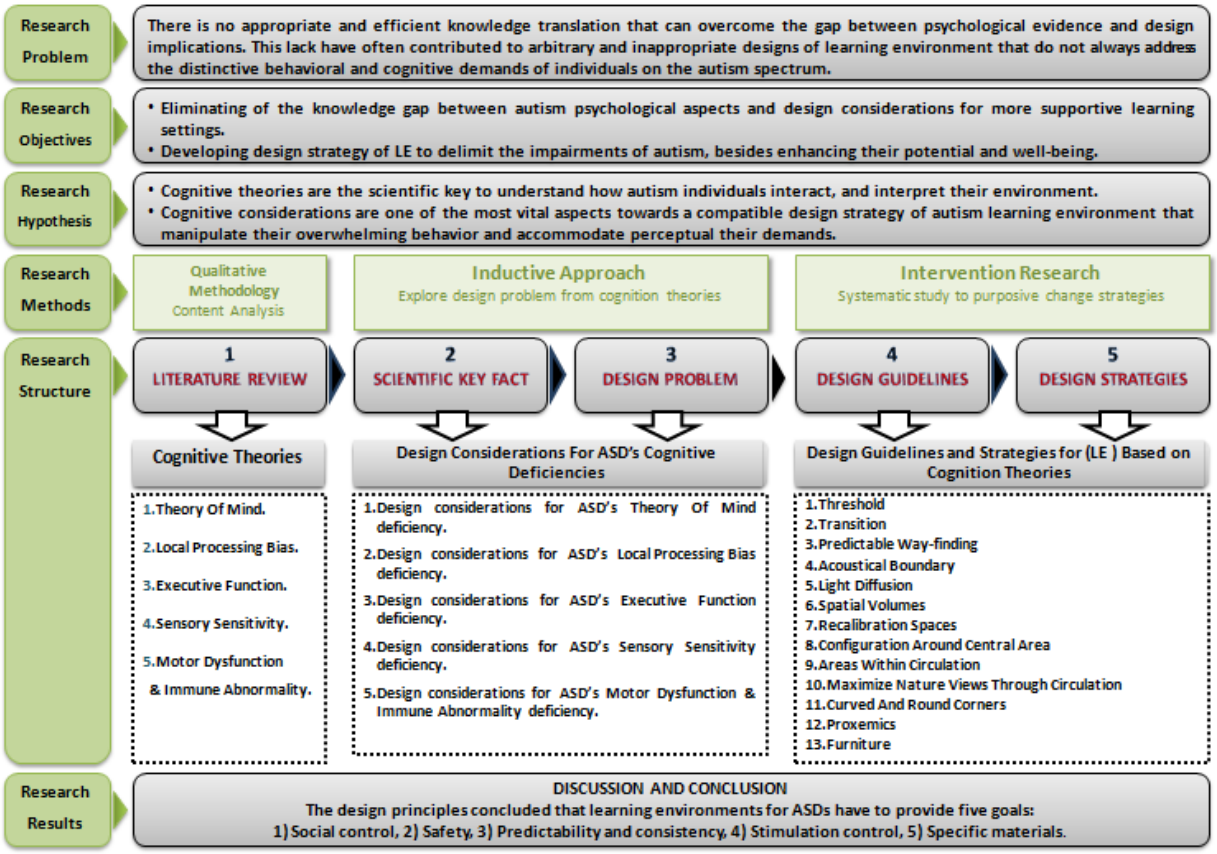


Figure 1: The flow of the research structure

III. OVERVIEW OF ASDS' COGNITIVE THEORIES

Recent research has investigated three cognitive theories in an attempt to explain the core features of autism in terms of underlying cognitive deficits (Hoy et al., 2004). One such theory is the theory of mind, which, along with the theory of local processing bias, can explain many of ASD's deficiencies and limitations. However, a third cognitive theory, the executive dysfunction, can better describe repetitive behaviors and restricted interests found in people with ASD (Frith & Happe, 1994).

3.1 Theory of Mind

Theory of mind (ToM) is the potential to identify to oneself and others mental states such as values, intentions, desires, feelings and awareness, among others in order to define and expect actions (Leslie & Frith, 1988). ASD individuals have recorded underdeveloped ToM, which is known as "Mind-Blindness" as they have difficulties in interpreting and understanding the mental states of other people, it can be hard to sympathize and often feel confused by the behavior of others (Baron-Cohen, 1989; Ozonoff & Miller, 1995). Studies on neuroscience have now demonstrated that people with ASD display significantly less activity in brain regions that is critical for mentalizing in neuro-typical people (Castelli, Frith, Happe, & Frith, 2002).

3.2 Local Processing Bias

The essential theory of cognition in ASD is local processing bias (LPB). It means that ASD people interpret their world in a detailed, local manner (Attwood, 2007; Plaisted, Saksida, Alcantara, & Weisblatt, 2003). Typical individuals dominate in the interpretation of their surroundings by global processing.

Different hypotheses identify LPB differently, some of which contribute LPB to a global processing deficit, while others claim that global processing is intact but local is strengthened. Proponents of this theory contend that other ASD characteristics, such as hyper or hypo-arousal sensory stimulation, intense sensitivity to minor environmental changes, and delimited desires, can also be explained by LPB (Hoy, Hatton, & Hare, 2004).

3.3 Executive Function

Executive function (EF) or executive dysfunction, as it is frequently known, is an equitable word relevant to a series of abilities that enable individuals to accomplish a specific target (Welsh & Pennington, 1988). These capabilities include functions such as making plan, memorization, inhibition, self-monitoring, generating ideas and flexibility (Griffith et al., 1999).

Executive dysfunction has been suggested to represent defects in the frontal lobe and to be responsible for repetitive and restricted behaviour in autism (Happe, 1999), that play an essential role in the social and cognitive deficits found in ASD children of school-age (Ozonoff et al., 1991).

It's important to know that not all people with ASD have issues with all the aspects of executive function such as Planning, Problem Solving, Working Memory, Attention, Reasoning, Initiation, Inhibition, Cognitive Flexibility and Monitoring.

3.4 Sensory Sensitivity

It is a disorder that induces either hyposensitivity or hypersensitivity stimulation (Vincenta, 2011). In the case ofa hypersensitive person, a specific sense can function too well, causing an accumulation of information (Lawson, 2007).

In reaction, a hypersensitive person may choose to calm down or distract from pain by rocking, swinging, punching, pressing, covering his or her eyes, flapping and spinning. If sensory overload results, what the person sees, hears, and feels demands a longer time of perceptions to interpret the object, context, or environment (Lawson, 2007).

On the other hand, people that are entirely lacking in sensory processing are considered hyposensitive. In the case of a hyposensitive person with ASDs, the brain actually does not receive sensory input. In order for a hyposensitive person to activate his or her nervous system and repair sensory processing, he or she will bang into objects; seek out or create noise; self-injury; lick things; become stuck to light or bright items; or run around (Lawson, 2007).

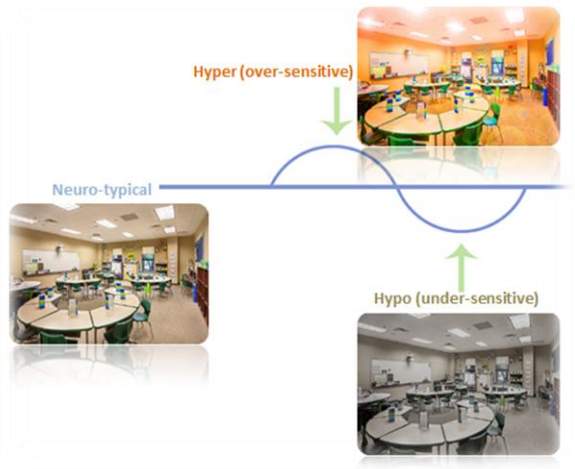


Figure 2: Hyper and Hypo sensitivity

LPB is likely to be a coping mechanism that allows ASD individuals to tolerate an unusually overload of external stimuli. Therefore, that hyposensitivity behavior can be a reaction to a sensory-rich and complex environment and underlying it is hypersensitivity.

3.5 Motor Dysfunction & Immune Abnormality

ASD individuals have a smaller size of the vermal area of the cerebellum, contributing to posture and movement troubles (Scott et al., 2009; Coffman et al., 2011) that can promote excessive withdrawal from energetic play and physical exercise (e.g. running) and lead to problems with the musculoskeletal. Empirical study shows that individuals on the ASD have impaired activation in previous frontal regions, brain areas linked to cognitive movement control (Samson et al., 2012).

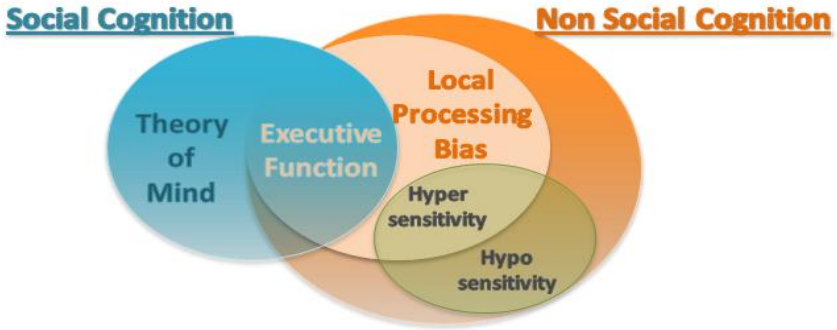


Figure 3: Cognitive Theories

Due to its relevance for so many activities, cognitive theories have a strong impact on the everyday well-being of individuals on the ASD. They are a key aspect of positive behavior which is a crucial component of the learning environment. Therefore it is necessary to satisfy the cognitions deficits when addressing the specific needs of people on the ASD. All children in an educational environment would also benefit from a simple design to support ASD's students.

IV. DESIGN CONSIDERATIONS FOR ASD'S COGNITIVE DEFICIENCIES

An extensive literature review was conducted on cognitive theories using database that provide scientific information from cognitive psychology, clinical psychology and neuroscience to extract the scientific fact upon which a design strategy can interpose to meet the individual's need.

Through 83 studies and 27 reviewed, 15 key fact was identified that represent the most critical obstacle confound autistic individuals regarding cognition. The key fact was then translated to design problems through which design guidelines and strategies were conducted.

4.1 Design considerations for ASD's Theory of Mind deficiency

Table 1: Translating scientific key facts of Theory of Mind into design problem

Key Facts	Design Problems
• Difficulty Empathizing and respect others desires (Baron-Cohen, 2008).	➡ Proxemics / Recalibration spaces.
• Social impairments (Adams, 2013).	➡ Variety of spatial volumes / Threshold.
• No self-consciousness (Sanchez, 2011).	➡ Predictability / consistency / Round corner.

4.2 Design considerations for ASD's Local Processing Bias deficiency

Table 2: Translating scientific key facts of Local Processing Bias into design problem

Key Facts	Design Problems
• Unable to extract information from context (Zeisel, 2006).	➡ Simple and easy configuration.
• Unable to extract meaning from mental images (Samson, 2012).	➡ Way-finding / Predictability and consistency.
• Unable to extract meaning from sensory input (Tavassoli, 2012).	➡ Simple and easy configuration.
• Focus on details-driven (Samson, 2012).	➡ Light diffusion / Acoustical boundary.

4.3 Design considerations for ASD's Executive Function deficiency

Table 3: Translating scientific facts of Executive Function into design problem

Key Facts	Design Problems
• Difficulty problem solving (Maister et al., 2013).	➡ Simple and easy configuration.
• Difficulty adapting to change (Frith; Ozonoff, 1991).	➡ Transition area.
• Difficulty in concentrating (Sanchez, 2011).	➡ Light, colors, shapes and size.
• Difficulty in planning (Sanchez, 2011).	➡ Predictability way-finding.
• Difficulty distinguishing stimuli (Hirstwood, 2011).	➡ Acoustical, visual, tactile stimulation.

4.4 Design considerations for ASD's Sensory Sensitivity deficiency

Table 4: Translating scientific facts of Sensory Sensitivity into design problem

Key Facts	Design Problems
• Overload by sensory stimulation (Vincenta, 2011).	➡ Acoustical, visual, tactile stimulation.
• Withdraw from social interaction (Bhatara et al., 2013).	➡ Variety of spatial volumes.
• Outburst and overwhelming behavior (Mori et al., 2013).	➡ Recalibration spaces.
• Likes / Dislikes intense stimuli (McAllister et al., 2012).	➡ Sensory room.

4.5 Design considerations for ASD's Motor Dysfunction & Immune Abnormality deficiency

Table 5: Translating scientific facts of Motor Dysfunction & Immune Abnormality into design problem

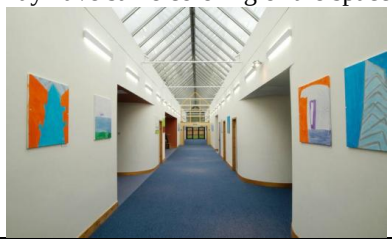
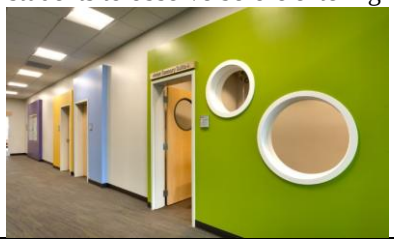
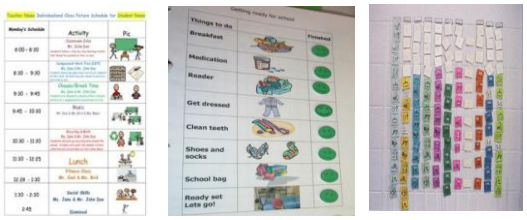
Key Facts	Design Problems
• Smaller size of the vermal area can promote excessive withdrawal from energetic play lead to problems with the musculoskeletal (Scott et al., 2009; Coffman et al., 2011).	➡ Maximize Nature Views through Circulation
• Impaired activation in previous frontal regions, brain areas linked to cognitive movement control (Samson et al., 2012).	➡ Simple and easy configuration.
• Individuals with ASD can have weakened immune defenses toward existing infections (Rossignol & Frye, 2012).	➡ Ventilation / Cleanness / Furniture.

V. ASD's Design Guidelines and Strategies for LE

After translating key facts into design problems, a design guidelines and strategies for learning environment that accommodate ASD needs were represented in the tables below.

Table 6: Demonstrating ASD design guidelines and strategies

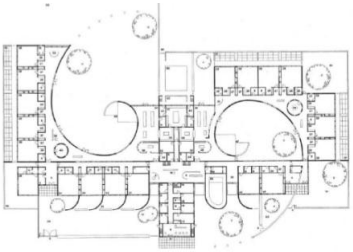
Thresholds		
Design a combination of physical and virtual boundaries that boost security, allow individuals to observe proximity and preserve personal space, which provide a visual relation between areas of activity. Barriers, boundaries and borders in different degrees, dimensions and materials can have a specific effect on people behavior interactions inside space. A barrier is any physical feature that is enabled by sight, sound, touch, or scent to hold people together or hold them apart (Zeisel, 2006).		
Fence Physical boundaries that promote security 	**Social Cushion** Counter-top acts as social cushion 	**Permeable Boundary** Allow individuals to observe beyond activity before interact 
Partial Height Wall Partial height wall & attached bench divide space 	**Lite Window** To observe events in room before entering 	**Screen Barrier** Views can be screened off if outside became stimulus 
Transition		
For ASDs individuals It can be disturbing and distressing to have a setting that has a sudden shift between different tasks (e.g. switching from one activity to another). So an easy transition has to be provided among various spaces. If various tasks are included in classrooms, ensure smooth transition from one task zone to another (Mostafa, 2008).		

Buffer Zone Prepare them for the new environment. Walls or floor may have same coloring of the space 	**Lite Window** Windows in doors or a lite close to doors to enable students to observe before entering 
Spatial Sequence of Classroom Area enclosed by removable partitions. If teacher notes that pupil mastered tasks' order then the temporary partitions can be removed. 	**Visual Illustration** A visual illustration of the planned activities inside and outside classroom 

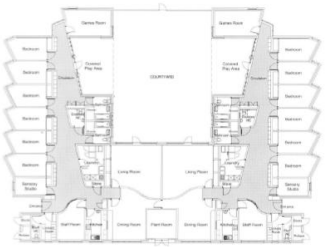
Predictable Way-finding

Way-finding would be challenging if the direction to the destination lacks visual cues (e.g. landmarks) and if those cues are visually separated from each other (i.e. directly after accessing a cue A, one does not access a cue B) (Baumers and Heylighen, 2010).

Curved and Rounded Walls
Walk around space more smoothly than right-angle edges



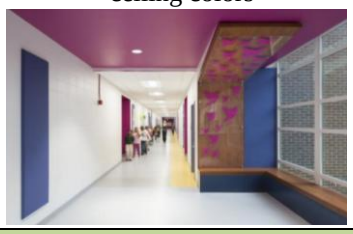
One Way Path
Emphasize consistency and predictably that limited anxiety



Configuration around Central Area with Window Wall
Avoid disorderly circulation and minimize visual stimuli

Color-Coded and Visual Cues
To indicate the right way and nodes on student's route

Distinct Spaces Visually
Provide distinct floor or wall or ceiling colors



Linked Function Visually
Construct concept of "studying" by table and chairs

Acoustical Boundary

Acoustic dampening is an effective strategy to discourage the transfer of sound in order to create a more supportive environment that facilitates comfort, improves social control and decreases behavioral outbursts for the ASD individuals (Canter, 1975).

Acoustical Ceiling Cavity
Ceiling cavities where sound absorbed and captured

Acoustical Cushion Rooms
Place quite room as a cavity to hinder the sound transmission

Mirrored Distribution
Doors should be opposite or rather as far apart as possible

Heavily Massed Walls
Exterior envelope of the building to block outside noise

Acoustical Wall Panels
Reduce sound transfer between spaces and do not affect the auditory environment

Light Diffusion

Variation of light creates shadows and over stimulation; that may disturb ASD individuals. Repeated shadows can contribute to fixed glares which promote confusion and distraction; although fluorescent lamps are seriously frustrating for ASD individuals because of the flickering rate (Humphreys, 2008).

Clerestory Windows
Provide natural light with high-placed windows lights

Brise-Soleil
Help diffuse light of clerestory

Sky light
Skylight in corridor for natural light and ventilation

Spatial Volumes

Designers must apply a range of small and wide spaces. A variation of volumes helps people with ASDs and their families to select the right condition for their personal mood. Unfortunately, it may cause fear for most people with ASDs. Variation and flexibility in configuration lead to a lack of predictability and regulation associated with behavioral outbursts, thus, predictability and consistency must consider. (Henry, 2011).

Large Spaces
ASDs may feel more comfortable in large spaces with higher ceilings where it is less like to be invaded

Small Spaces
Effective in LE that provide privacy, limit sensory overload, and promote one-on-one conversation

Recalibration Spaces

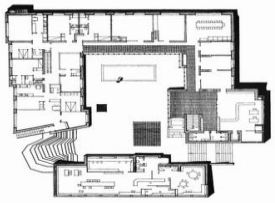
The choice to withdraw from an active zone increases human control on over sensory stimuli and social interactions. ASD individuals usually need to avoid maladjusted sensory stimuli and re-calibrate in a private zone (Mostafa, 2008).

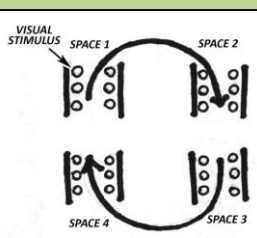
Quiet Room
ASDs need immediate access to quiet space, whether inside the classroom or near it.

Sensory Room
Used to stimulate the senses

Outdoor Escape Space
For who find running and jumping a way to cool down

Configuration around Central Area





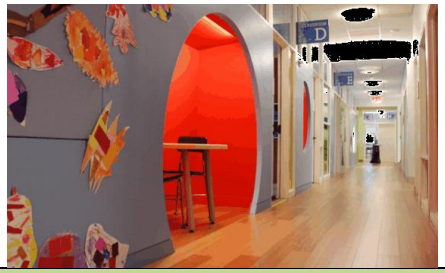
- Providing simple and easy access where the activity takes place. This should avoid disorderly circulation through the learning environment and minimize visual stimuli.
- The creation of a one-way flow (i.e. a one-way path that connects main activities).

Areas within Circulation

It allows intimate social communication, offers a distant refuge for silent social involvement,
The niche room should be intimately sized, visually related to the circulation corridor and any correspondin g social areas, ideally shaped for acoustic efficiency and visually identified by textures, light and colour fro m the surrounding (Henry, 2011).

Niche Space or Cubby Hole

Encourage socialization in small intimate spaces for who are intimidated in large open spaces.



Alcove Bench

Open to wide corridor lack the spatial value required for intimate social interaction

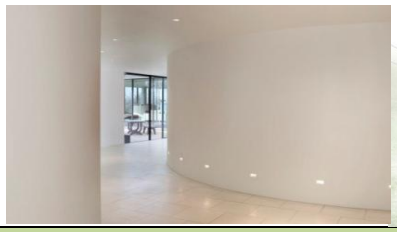
Maximize Nature Views through Circulation

Ideal place for viewing nature without distraction that affect learning environment

- Benefit of viewing nature and health restoration.
- Benefit from improved way-finding through memorable signs.
- Increased independence through staff monitoring without interference.
- Views can be screened if the external visual stimuli are distracting.

Curved and Rounded Corners of Circulation

Help individuals walk around space more smoothly than right-angle (blind corner) edges, so there are no unexpected corners to turn around. Blind corner or sudden social encounter cause fear and anxiety (Beaver, 2010).



Proxemics

Proxemics concerns with personal area; it is the area people believe they need to set up, particularly for security, among themselves and others. For an individual with ASD who is different of other, they need more area for social relations; thus, this should be taken into account in the design process in order to minimize any burden on them generated by a sense of perceived risk (Humphreys, 2008). In contrast ASD individuals are less respectful of others' actions that lead to unwelcome interactions with other people (Mottron, 2011).

Wide Circulation paths, Entrances and Doors

ASDs needs to feel relaxed in order to face social demands, since they are very worried of their personal space

Additional Assistance

Provide enough space for aid in teaching methods in a variety of tasks, such as dining, using the toilet and academics

Furniture

Unsteady objects will become a significant safety threaten. Also Features with several details can enhance the local processing bias (LPB). This will decrease focus and contribute to distraction (Mottron et al., 2012).

Dull and Non-scratch

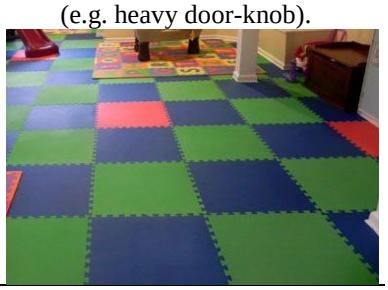
Reflective surfaces reflect the surrounding environment and contribute to distracting attention. Scratches and dust create a texture that can be distracting for ASDs

Un-detailed and Simple

Avoid detailed mechanical and electrical structures.

Soft and Durable

lined both floor and lower wall part of the room. Covered sharp and hard.Using soft objects that don't need a strong physical effort (e.g. heavy door-knob).



Steady and Un-bulky

To enable students to adjust by themselves to avoid clutter and to be managed independently

Storage and Removable Panels

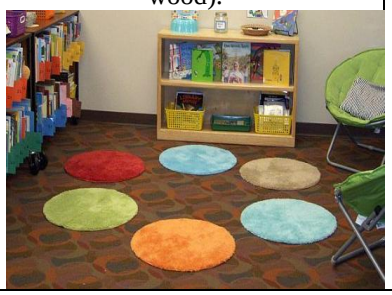
Providing cabinets and boxes for storage at each area. movable panels or text-boards to transfer the information

Safety Consideration

Tiny obstacles on the edges of shelves to avoid falling off by mistake.

Tactile

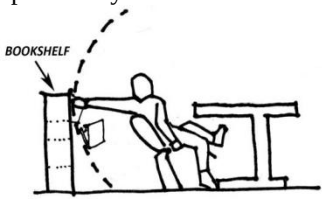
Offer fluffy pillows and rugs to curl around their body. Prevent rough material that may harm Optimize the use of materials of low thermal conductivities (like, wood).



Respecting children's body size

The height of all usable surfaces (writing surface height, seat surface height, etc.) should be calibrated according to child's body.

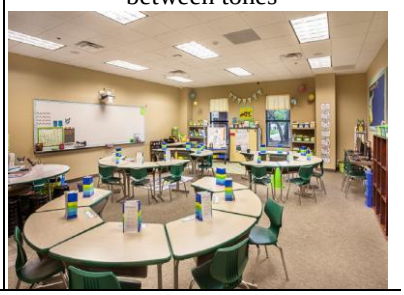
Do not create obstacles to practically relevant motions



Colours

Soft coloring and subdued tones should be considered

For walls and floor finishing, strive not using more than three colors. Subduing the contrast between tones



VI. DISCUSSION AND CONCLUSION

It is clear that there are several design considerations that must be taken into account in order to meet ASDs' needs. These considerations are formulated in tables that explain guidelines and strategies with recommended solutions, which include: 1) Threshold, 2) Transition, 3) Predictable way-finding, 4) Acoustical boundary, 5) Light diffusion, 6) Spatial volumes, 7) Recalibration spaces, 8) Configuration around central area, 9) Areas within circulation, 10) Maximize nature views through Circulation, 11) Curved and round corners, 12) Proxemics, 13) Furniture.

From the previous design strategies we can deduct design principles that concern the design for ASD to fulfill their needs and enhance their well-being. The design principles concluded that learning environments for ASDs have to provide five goals: 1) Social control, 2) Safety, 3) Predictability and consistency, 4) Stimulation control, 5) Specific materials.

For further study, these strategies have to be developed to accommodate experience from stakeholders and other domains to improve and enhance design recommendations.

The architects' role is to create equitable environments that will fulfill the needs of ASD individuals However, design for ASD population requires a comprehensive knowledge about their characteristics; how ASD communicate with others, perceive their worlds and interact with events. Considering the lack of scientific information to form appropriate design guidelines, this study developed recommendations for design of learning environments for ASD children. The recommendations were based on an extensive scientific literature review. A conceptual framework of design strategies was developed to accommodate ASD needs.

The study was based on a five stages to translate scientific information into design strategies. A significant part of this method is a set of design problems interpreting the scientific information facts. Design Guidelines and Strategies present suggested solutions to the Problems. The Strategies were analyzed and the most important principles regarded designing for the ASD were extracted from them.

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