Development of special needs classroom prototypes to respond to the sensory needs of students with exceptionalities

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Abstract

Purpose – The observation by the authors, based on their extensive experience working in K-8 public schools in the region showed the special needs classrooms catering to children with exceptionalities such as Autism Spectrum Disorder (ASD), Intellectual Disability (ID) and Emotional Disturbance (ED) are typically makeshift arrangements with no consideration given to students' unseen sensory needs. A thorough literature review indicates that there are no holistic design guidelines in place to meet the sensory needs of students with ASD, ID and ED. This study seeks to address this gap by providing considerations to meet the sensory needs impacting these students' focus, behavior and classroom engagement with course content and peers.

Design/methodology/approach – Sensory design guidelines were established utilizing a qualitative method, providing a foundation for the development of classroom prototypes that address the sensory needs of students with ASD, ID and ED.

Findings – The new guidelines, which correlated interior design strategies with the sensory needs of children with ASD, ID and ED, and the resulting prototypes provide a basis for the further development of design standards and takes designers closer to creating more conducive and inclusive environments.

Practical implications – This study reinforced the belief that these recommendations should be considered in the school-wide design. Many students can be included with their typical peers for all or part of their school day if space has been designed to accommodate their differences.

Originality/value – This study bridges the gap while documenting the correlation between design factors and sensory needs of students with exceptionalities, in this case, ASD, ID and ED.

Keywords Empathy, Inclusivity, Learning spaces, Participatory research, Special need classroom

Paper type Research paper

1. Introduction

Children with disabilities (visible or invisible)/special needs/exceptionalities are typically served in a different classroom in public schools called special needs/alternate classrooms or a classroom for a specialized program. The authors approached the K-8 public schools in the region and were granted permission to observe the physical environment of the special needs classroom. While much work is put into developing a curriculum that is appropriate for these students, little, if any, attention is paid to the physical environment in which the content is delivered. In most cases, these classrooms are typically makeshift arrangements with no consideration given to the sensory needs for children with education and health disparities. Research has shown that in an inclusive classroom structured to address the needs of all children, the best learning results (greater communication skills, higher academic success, larger social networks, fewer behavior issues, meaningful employment as adults) for all students occur (Crosier *et al.*, 2013; Nota *et al.*, 2019; Sheppard-Jones *et al.*, 2021). This not only emphasizes the need for improved special education classroom design, but also for all classrooms to consider sensory preferences. Research also shows that the use of Universal Design principles, a barrier-free design that considers all needs at the beginning of the design process, as the guide for inclusive design, results in benefits of not only the intended few, but also others whose needs have not been identified or observed (Null, 2014). The physical environment comprises the space, shape, form, textures, colors, patterns, acoustics, objects

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and furniture. These elements play an important role in the sensory and cognitive processing of children with exceptionalities (Mostafa, 2008). Although curriculum modifications and adaptations address the needs of students with exceptionalities such as Autism Spectrum Disorder (ASD), Intellectual Disabilities (ID) and Emotional Disturbances (ED), the current physical environment of the classrooms with specialized programs fail to meet these students' sensory needs, which presents learning challenges (Kern and Clemens, 2006). Students' sensory needs must be met in the classroom for them to feel physically comfortable, acquire self-control and focus on their learning tasks. This calls for designers, researchers, educators and the community at large to explore interior design as a tool to understand the education environment and represent all stakeholders (Zingoni, 2019).

By answering the following research questions, this study fills a void in the literature on how to construct inclusive and equitable learning environments that foster learning and individual and social well-being in K-8 schools:

(1) What are the diverse sensory needs of students with ASD, ID and ED?

(2) Which design elements and strategies best meet these sensory needs to promote engaged learning and well-being?

(3) How can the implementation of these new design guidelines within the special needs classroom space positively influence behavior and impact students' learning, educational performance, and individual and social well-being?

(4) How does creating a multidisciplinary partnership inform best practices in learning spatial design?

Capturing perspectives and practical wisdom from intervention specialists is essential to the success of classroom design. An intervention specialist is a licensed special education teacher with at least one additional year in the field. It is a designation that identifies a teacher as equipped to write and implement Individualized Education Plans (IEP), develop curriculum and establish behavior management systems for students with exceptionalities in their classrooms. This cross-institutional and multidisciplinary research study aims to understand the correlation between design factors and sensory needs of students with exceptionalities, in this case, ASD, ID and ED. In partnership with elementary and middle schools in North-East Ohio, this study aims to research, re-examine and design prototypes for special needs learning spaces for students with these exceptionalities to increase their learning and well-being in school.

2. Context

Legislation in the USA dictates that children with disabilities should be educated in the same school environment as children without disabilities if the classroom meets their needs (Individuals with Disabilities Act, 2004). Likewise, the region has identified categories for children with special needs varying from developmental delays, medical conditions, psychiatric conditions and/or congenital conditions. Special needs is a generic term that encompasses a wide range of diagnoses, from those that resolve quickly to those that last for the rest of life and from moderate to chronic. These special needs require accommodations so children can reach their potential. Children with ASD, ID and ED among others fall under the category of special needs. As stated in Diagnostic and statistical manual of mental disorders (Fifth ed.) of American Psychiatric Association (APA), ASD is a common neurodevelopmental disorder that affects a person's ability to socially interact with other people and act in accepted ways of behavior (APA, 2013). Among other difficulties, children with ASD face unique sensory challenges in the environment that affects their behavior (APA, 2013; Dunn, 2008; Whitaker *et al.*, 2001). Children can be hypersensitive and react to

external stimuli that children without ASD may not notice, e.g. smell, noise, texture (APA, 2013; Dunn, 2008; NIMH, 2008). Conversely, children can be hyposensitive with a high tolerance level and not react to external stimuli that children without ASD normally would (Dunn, 2008; NIMH, 2008). According to the APA (2013), the hyper- or hyposensitivity that children with ASD experience are due "to sensory input or unusual interests in sensory aspects of the environment" (p. 50). Students with an ID have below average intellectual functioning affecting logical thinking, problem solving, planning, abstract thinking, academic learning and learning from previous experiences and others, therefore, having an adverse effect on the child's educational performance. Children with ED often have difficulties making appropriate interpersonal relationships and display inappropriate behaviors under typical circumstances (Epstein *et al.*, 2008).

As stated above, children with disabilities in public schools are typically served in different classrooms. This allows the intervention specialist to create a curriculum that is customized to the student's educational requirements. Most public-school environments have not been designed to suit the unique sensory challenges that many children with ASD, ID, and ED experience. Several authors have expressed surprise that little research is available to inform designers how to create supportive environments for them (Irish, 2019; Khare, 2010; Martin, 2014; Shabha and Gaines, 2011). The knowledge can be difficult for designers to find and is often "fragmented and inconclusive" (Shabha and Gaines, 2011, p. 228). If more rigorous research concerning the design of the special needs classrooms for children with ASD, ID, and ED were conducted, published, and made available to designers in an accessible format it could guide them to create supportive educational environments based on empirical evidence (Martin, 2014).

This study aims to bridge the gap through an extensive literature review from the publications on this topic in architecture, interior design, and special education journals to generate a sensory design guideline which correlates interior design strategies with sensory issues of children with ASD, ID and ED. Intervention Specialists from area elementary and middle schools were asked to rank the impact of the sensory design guideline on student learning, which provided a baseline of the important strategies that influence the learning and behavior of children with disabilities. Results from the structured interviews with these specialists helped refine the sensory design guideline for classrooms serving students with the disabilities mentioned above. These results informed the design of a virtual prototype for a special needs classroom. These new guidelines and the prototype provide a basis for the further development of design standards and take designers one step closer to creating more conducive learning environments.

3. Method

Several researchers have adopted a design criteria/checklist approach, sending a questionnaire to caregivers and educators to establish their requirements for an environment that supports children with ASD, and evaluating the responses via a hierarchy of importance (Khare and Mullick, 2008; McAllister, 2010; Mostafa, 2008). Others have taken a case study approach (Pauli, 2006; Scott, 2009). There has been a lack of design standards for sensory requirements in ID and ED. There is a need for a holistic sensory design guideline that meets the sensory requirements of all students in a special needs classroom where children of all abilities are taught together.

This research is more open-ended in both theoretical conception and research design because it typically renounces the notion of a knowable objective reality (Creswell, 2008). This exploratory study follows the qualitative method and is a two-step study. Step one employs community-based participatory methods that seek to actively involve intervention specialists to inform the development of the classroom space (Wallerstein and Duran, 2006).

An extensive literature review was conducted to understand the sensory needs of children with ASD, ID and ED and correlated architectural/interior design elements with sensory issues, which generated the comprehensive design guideline. Intervention Specialists from area K-8 schools were asked to rank these guidelines and based on their responses the research team co-generated the "sensory design guideline' which would correlate architectural elements with sensory issues of children with ASD, ID and ED through participatory research and community wisdom.

These results informed step two of the research process: designing prototypes for a special needs classroom. A prototype is a physical model that tests the designed idea and if the prototype is successful, it is mass-produced. The prototype would assist educators, schools and parents to visualize the space, offer further feedback for refinement, leading to their adoption as design guidelines.

3.1 Physical environment, sensory integration theory and sensory needs of children with exceptionalities

Our senses include sight, hearing, touch (compression, tactility), smell, taste, vestibular movement (bodily movement, balance) and proprioception (coordination of body parts in space) (Park *et al.*, 2020). Sensory Integration (SI) theory was developed from the work of Ayres (1979) and expanded by Fisher and Murray (1991). The foundation of SI theory is that proper integration of the sensory system in the physical environment allows for the development of language, attention, organization, motor abilities, interpersonal relationships and academic learning. Hypo- and hypersensitivities are often used to describe atypical sensory processing in individuals with ASD. Individuals with hyposensitivity have a higher threshold to register a stimulus; thus, they are more likely to miss salient sensory cues (e.g. someone speaking) or need a longer time to respond than neurotypical populations. They are referred to as "sensory seeking," meaning they often create or generate their own sensory experience. Hypersensitivity shows a lower threshold for registration and often results in overstimulation. Children with hypersensitivity can be easily overwhelmed by sensory information in the environment (Jones *et al.*, 2003). The sensory systems of individuals with ASD may become overloaded because they have difficulty filtering stimuli from the environment, causing them to retreat into themselves and not respond to their teachers or classmates (Freed and Parsons, 1997; Hatch-Rasmussen, 1995). According to research by Connolly (2010), altering environmental characteristics such as space organization, illumination and ceiling height can assist children with ASD to accept greater variation in the environment. Unfortunately, very few studies have addressed the relationship between the physical learning environment and the behavior of students with ASD. Beginning in childhood or at birth, ID leads to the inability to be independent and take on responsibilities affecting educational performance (Jebril and Chen, 2020). Like ASD, individuals with ID require higher levels of support and resources in the physical learning environment to address their unique sensory needs. Emotional disturbances lead to inappropriate behavior or feelings under normal circumstances. A child with ED might generally be in a pervasive mood of unhappiness or depression and might tend to develop physical symptoms or fears associated with personal or school problems. Abnormal sensory processing in any or all of the senses may lead to undesirable behavior. It is imperative in a physical setting when all these learners with exceptionalities are in one space to be aware of their sensory needs and provide an environment that responds to these needs.

The manipulation of the physical environment to assist specific functions and elicit desired behavior is the focus of interior design (Nussbaumer, 2018). This physical environment is largely made up of sensory components such as space, shape, color and pattern, as well as textures, colors, lighting and acoustics (Mostafa, 2014). Based on clinical

research first published in 2008, *Sensory Design Theory* presents a flexible and adaptable tool that acts as a catalyst for design criteria development for physical environments based on their sensory qualities, and in response to the sensory needs of diverse users (Mostafa, 2008). Mostafa (2008) further adds that while it appears to be prescriptive, it allows for multiple degrees of application and calls for the creation of a range of stimulation zones to respond to varied activities and skill levels of its users. It addresses generalization of skill, like the neurotypical method, by employing progressive sensory spaces, from highly adapted to typical, to allow for gradual skill development (Mostafa, 2003, 2008). Designers commonly use the sensory cues, i.e. the auditory, visual, tactile, olfactory to convey meaning and messages to users hence facilitating functions and activities within a space, particularly with students with special needs (Malik, 2008). This literature review resulted in a complete sensory design guideline for ASD, ED and ID.

3.2 Development of sensory design guideline

The sensory needs of students with ASD, ID and ED can be met by modifying the spatial attributes. These attributes developed from Mostafa's Sensory Design Matrix (Mostafa, 2008), and from Gaines's sensory needs list (Gaines *et al.*, 2014), which exclusively focuses on ASD, and were developed more than six years ago. These frameworks provide the basis for further development of sensory design guidelines for ASD and capturing the needs for broader population in the special needs classroom especially ED and ID. The physical attributes considered for this study are space planning, furniture, shape, and form, lighting, color, texture, and acoustics. A list of strategies or guidelines for each spatial attribute was created from research articles to show how the classroom design can be manipulated to meet the sensory needs of touch, vision, hearing, vestibular and proprioception for both hyper and hypo sensitivities and separately for ID and ED. Tables 1 and 2 elaborate on these, and below are summaries for each section.

3.2.1 Space planning and sensory needs. Large, wide-open areas can be difficult for students with ASD to understand because the environment is not segmented or sequenced functionally (Stokes, 2003). The concept of functional spatial sequencing requires the logical organization of space based on the typical scheduled use (Mostafa, 2008). Mesibov *et al.* (2003) recommended that one side of the room should contain designated quiet areas for individual learning, and group activities should be on the other side of the classroom. This type of space layout has been demonstrated to increase the focus of students in a classroom with varying levels of sensitivity. The user can regulate their emotions in the escape or restorative zone and then rejoin the other students in the shared space (Humphreys, 2005). Empirical research has shown the positive effect of such spaces, particularly in learning environments (Mostafa, 2008). An escape or restorative space may be beneficial for reducing disruptive behaviors when students with ASD and ED experience sensory overload and feel stressed. It would provide respite for the children who are hypersensitive to the overstimulation found in their environment (Mostafa, 2008). Hence, clear functional zoning of designated areas and a clear visual boundary help student understand where each area begins and ends and meet both visual and vestibular needs of children with ASD. The escape and restorative space meet the sensory needs of ASD, ID and ED.

3.2.2 Furniture and objects and sensory needs. Since students with ASD may concentrate on small visual details, clutter can be distracting. Clutter is unsafe for children who are hypersensitive and have impaired vision (Gaines *et al.*, 2014). Visual distractions should be limited, and unnecessary equipment should be stored in another area or in closed storage systems. Color coding, numbers and symbols can be used to teach the students to keep their materials organized (Stokes, 2003; Tufvesson and Tufvesson, 2009). Flexible furniture arrangement would allow movement to permit a variety of teaching strategies.

		Space Planning	Shape and Form	Furniture and Objects
Touch				
		Crawl Spaces, climbing, obstacles		
				Soft edges and materials
Vision		Use of color as a wayfinding device to distinguish classroom zones	Low level curved and horizontal lines Clear display of visual information	Simplify classroom materials and visual information Bean bag chairs Ball pens
			Vertical and diagonal lines	
		Windows above eye level Observation rooms Divide classroom based on lighting and functional zones High ceilings Visual cues and boundary markers for wayfinding	Visual order gives calmness Visual variance energizes	Non glare objects
Hearing				Acoustically sound transition from hallway to classroom
		Soundproof doorways Buffer space between classroom and hallway		Fully furnished rooms Desks placed in groups
Vestibular		Groupings of similar elements and objects		Balanced, repetitive elements Close proximity of similar elements Predictable environment Tactile signs Rocking chairs or hammocks
				Objects contain radial and symmetrical balance Variety in height and volume Unity of odd number elements
		Level flooring and emphasis on balance Functional zoning Separate individual and group learning spaces	Symmetrical visual balance	Reactive displays
Proprioception		Intimate small-scale space		
		Variety in small- and large-scale space		
				Flexible furniture arrangement Use of technology and movement-based interaction
Emotional Disturbance		Variety of teaching equipment Space provides sense of control Room for monitored interaction Integrated classroom within school Private space for restoration		Comfortable seating Objects that promote sharing and cooperation
Intellectual Disability		Kinesthetic form of teaching Proximity to the teacher U shaped desk arrangement Sunspace / outdoor area Quality ventilation Nearby restrooms		Transition space and seating alcoves Folding chairs

Table 1.
Summary of findings from literature review

Using an arrangement with two tables can help children with ASD learn to work and play alongside other students (Mesibov *et al.*, 2003). Bean bag chairs or rockers during the restorative time help children with hypersensitivity, ED and ID (Mesibov *et al.*, 2003; Stokes, 2003). A low-level divider can be used to create structured play zones that are separated from the rest of the room.

3.2.3 Shape and form and sensory needs. No significant strategies were found related to the shape and form of the space to the sensory needs of children with ED and ID. The study conducted by Barakat *et al.* (2019) indicated that the use of curved and horizontal lines that are low to the ground will create a feeling of rest for children with hypersensitivity while the use of diagonal lines would result in an active environment for children with hyposensitivities. The use of symmetrical lines would create a visual balance providing a visual and physical balance to children with ASD.

3.2.4 Lighting and sensory needs. The research on the effects of light and color on children with ASD is limited; nevertheless, the impacts on student behavior and success in the general

		Lighting	Color	Texture	Acoustics
Touch				Soft, padded floor covering Fine textures, smooth objects and smooth walls	
				Providing moments of swaddling, squeezing, and therapeutic brushing Rough surfaces with variety of textured elements	
		Limit glossy surfaces		Use textural changes to designate zones (i.e., fine to coarse)	Objects that give calming noises when touched or played with (i.e., bean bags) Coordinate sounds, rhythms, and beats with vibrations and movement Floor heating to avoid noisy heating equipment Use of soft materials over hard
Vision		Natural and diffused illumination	Avoid high contrast, saturated, bright colors, and overuse of patterns Use saturated colors for priority areas		Average sound level should be kept to 50 dB or below
			High color contrast Use of vivid colors (yellow, red, orange) Complementary color scheme		Varying noises of similar frequencies
		Naturally diffused light without glare LED lighting preferred Color temperature between 300k-3500k Consistent lighting color temperature and even illumination Lighting levels reduced to 25-35 fc Inclusion of task and ambient lighting	Color and pictorial signage for wayfinding Neutral color palette Different color visual cues that reference cardinal directions Color with low reflectance value		Variance in acoustical control for student Higher acoustical control in focus area Acoustically sound private space Environments should progressively have less sound filtration Ambient sound systems that produce calming noises
Hearing					
		Avoid use of fluorescent lighting			
Vestibular					
		Consistent lighting with low contrast			Provide spaces that incorporate sound with body movement
Proprioception					
		Use of unharmful and allergy friendly textures			Interactive screens that make noise to help with motor skills
Emotional Disturbance		Provide control to dim lighting	Provide moments of brighter, uplifting colors Color scheme should reflect a soothing and relaxing environment suited towards all ages		
Intellectual Disability		Promote use of natural lighting Controllable lighting	Colors should evoke a positive, comforting, and calm environment Green, blue, and natural color schemes calm nervousness	Materials that are not slippery to support better movement. Examples include carpet, vinyl, rubber flooring	

Table 2.
Summary of findings from literature review cont

population have been well established. Daylighting, the illuminating of a space using natural light, has been demonstrated to help students perform better in school (Fielding, 2006). Clerestory windows (windows placed above the students' sightline) can be installed to reduce distractions from outside (Benya, 2001; Humphreys, 2005; Tufvesson and Tufvesson, 2009). Fluorescent lighting commonly used in classrooms causes flicker as well as hum from the ballast used in their design (Winterbottom and Wilkins, 2009). Studies have noted visual hypersensitivity and repetitive behaviors in areas with fluorescent lighting (Boyce, 2010). Individuals who are hypersensitive are bothered by bright lights, easily distracted by movement and may stare at certain objects. Other common stereotypical behaviors displayed by individuals with visual hypersensitivity or hyposensitivity include staring at lights, repetitive blinking, moving one's fingers in front of the eyes and hand-flapping (Gaines *et al.*, 2014). All light fixtures should have lens coverings, louvers, or baffles and should have a color

temperature between 300 and 3,500 Kelvin, with light levels that should be reduced to 25–35-foot candles to ease anxiety and frustration in children with ASD (Long, 2010). For ED and ID, the student should be able to dim the lights if they are distressed (Flannery, 2019).

3.2.5 Color and sensory needs. Color preferences for children with developmental disabilities include a wide range of studies and literature, some of which are not empirical. Imhof (2004), Kennedy and Banks (2002), and Zentall and Dwyer (1989) contend that color stimulation in the learning environment improves attention and motor processes, resulting in better academic performance in general. However, Clay (2004), Myler *et al.* (2003), and Stokes (2003) claim that a subdued color scheme in warm neutral colors with low reflectance value is necessary to prevent overstimulation. They encourage a low contrast in wall and flooring colors, avoiding complex shapes and patterns, and using saturated colors for areas that require the attention of children with hypersensitivity. One study found that lower functioning students with ASD preferred red, and higher-functioning students preferred blue (Woodcock *et al.*, 2009). According to research on color and wayfinding, color and pictorial signs are used to help navigation, and distinct color visual cues are used to identify cardinal directions in school (Barakat *et al.*, 2019). A soothing and relaxing color scheme would help children with ED (Flannery, 2019).

3.2.6 Texture and sensory needs. The research on the link between texture and sensory needs in children with ASD is limited and non-empirical. Some of the findings indicate that using textural changes to designate different functional zones is helpful. Children who are hypersensitive prefer soft and cushioned floor coverings with fine and smooth textures, whereas children who are hyposensitive prefer rough surfaces with a variety of tactile components. They further prefer swaddling, holding, stroking, hugging, squeezing and therapeutic brushing (Barakat *et al.*, 2019).

3.2.7 Acoustics and sensory needs. Children with ASD attention spans, response times and behavioral temperament, as assessed by occurrences of self-stimulatory behavior, are all enhanced when noise levels and echo are reduced in educational environments, according to empirical study. This improvement resulted in a doubling of attention span, a 60% reduction in reaction time and a 60% reduction in self-stimulatory behavior in some cases (Mostafa, 2008). Activities that require higher focus (often in low stimulus zones) require a higher level of acoustical control to keep background noise, echo and reverberation to a minimum. Soundproof doors are recommended for a smooth transition from noisy halls to classrooms. Calming noises are desirable for hypersensitive children and changing noises of comparable frequency can help identify sounds (Barakat *et al.*, 2019).

3.3 Structured interviews

The researchers conducted structured interviews with intervention specialists working with children with ASD, ED and ID in K-8 public schools in the region to validate the effectiveness of the design guidelines. After receiving clearance from the institutional review board, participants were requested to share the contact information of their acquaintances with the researchers through snowball recruiting. A total of five intervention specialists volunteered to take part in this study. The demographic data requested from participants included their education qualification, and year(s) of employment at the school. The participants were asked not to disclose their age and gender as it had no bearing on the outcomes of this study. Out of five, four intervention specialists had 10–15 years' experience and one had over 15 years of experience in the special education area, teaching students with ASD, ID and ED in special needs classrooms in a public K-8 setting. All of them had their master's in special education.

They were first asked the question of the classroom's capacity. Participants were provided with the design guidelines as shown in Tables 1 and 2 two weeks before the interview. They were then asked to rank the design strategies corresponding to the sensory needs based

on the impact on students with special needs learning and behavior. They were asked to write additional suggestions of design and sensory elements not included in the guideline. The interviews were completed in two weeks and each interview took approximately 45 min to an hour. The interview was guided by a moderator who asked the participants why and how they prioritized various strategies. We also discussed with the interviewees how these design strategies impact student's attention, behavior and temperament in the classroom. Following this, the interviewees were asked to list any other applicable design strategies that were not included that they would find beneficial with respect to space planning for the special needs classroom.

3.4 Revised sensory design guideline based on feedback from structured interviews

Grounded theory, one of the strategies of qualitative research methodology, is applied in this study as a method for analyzing the data. Strauss and Corbin (1998), describe data analysis from a grounded theory perspective as the process of breaking down, conceptualizing and putting back together data in new ways to develop a different understanding of phenomena. All the open-ended interview responses were thoroughly analyzed and then broken down into phrases and sentences, representing the main idea (Strauss and Corbin, 1998). They were arranged into similar groups and main ideas of space like space planning, furniture and objects, etc. were derived from them. Tables 3 and 4, reflects the holistic guideline based on the input from the intervention specialists and below is the summary of the findings:

Space Planning: According to all the interviewees, space should be well-defined. The classroom should provide different areas for independent work, group work and leisure (Mesibov *et al.*, 2004). Screens, bookcases and other dividers can be used to divide the classroom, or carpet squares can be utilized to delineate different zones within a space. To satisfy the requirements of children with ASD and ED, it is critical to provide a space for a private restorative or escape space while still providing the intervention specialist with the ability to have visual access from the classroom. Some new information revealed during this discussion included finding ways to provide the students with ASD a sense of ownership and self-control. One method recommended by three specialists is to provide focus rooms with visual barriers, escape and restorative spaces, sit-to-stand desks and small collaborative spaces within the classroom.

Furniture and Objects: Furniture arrangement flexibility is vital, according to the interviewees, and furniture should be scaled suitably for the user (Jacobs and Baker, 2002). Floor rockers, cocoon swings, pedal chairs, bouncing balls, wiggle pads, bean bags and sit and spin are ideal seating options and allow for flexibility. Teachers prefer chair legs with horizontal bars for foot support, and they generally use workout or non-latex bands to compensate for the lack of a horizontal bar. The workout bands also provide a flexible footrest that permits movement without disturbing other class members while providing a needed stimulus for a hyposensitive student. Horseshoe tables and tables for group work with individual sliding panels are preferred. The teachers typically put VELCRO® on the undersides of desks to meet a sensory need and help students regain control in their environment. The VELCRO® provides a rough texture that can be rubbed against the forearm to provide the opportunity for self-stimulation, which can calm students. Individual desks need an organization system to provide cues for tasks that need to be completed. Lastly, teachers would prefer a cart filled with books or heavy items as a storage option which the child can push to expend energy, refocus and calm down.

Shape and Form: According to the interviewees, symmetrical spaces and simple shapes are preferred especially for assistance in walking. Lines on the floor are desired for body awareness. Diagonal lines present skewed perspectives to children with ASD hence, should

Table 3.
Summary of findings from focus group interviews

	Preferences	New information
Space planning	Separate classroom into different functional zones – instruction, reading, sensory and escape. Using physical structures for boundaries for clear distinction between rooms and their function	Hallways should not be used as escape spaces as they are typically stigmatized and lack privacy. It is best if the escape space is still integrated within the classroom for children who cannot focus
	Minimize clutter and number of items within the classroom. This can be contained within storage that is accessible only to teachers, not students	Use focus spaces for one-on-one instruction. Focus is strengthened through visual barriers
	Promote control and privacy while still maintaining visual access in the sensory heads down or escape space	Give students a way to understand what their body and minds need and how to prepare for that, hence providing a sense of ownership and self-control
	Sensory space should be self-regulated and customizable. Teachers should always have visual access to the sensory space	Observation rooms with windows are not preferred
	Use focus spaces for one-on-one instruction focus is strengthened through visual barriers to avoid distractions	Include vocational spaces in classrooms to learn jobs and recreational spaces to release energy (i.e. pushing a book cart)
	Reflection and restoration within the classroom. One example for how this could be achieved is by creating a designated space for children to retreat to when they feel overwhelmed. This space could be defined by a boundary such as a curtain, partition, rug, carpet tiles, or furniture	Escape spaces should not have windows as this suggests a lack of privacy (ED especially). A mobile escape space could be helpful so that it can be accessible in many locations, including the hallway
Shape and form	Symmetrical spaces and simple shapes are preferred especially for assistance in walking	Sensory rooms – No corners in this space
	Lines on the floor are desired for body awareness. Diagonal lines present different perspectives	Dividers allow for a visual block using moveable pieces. These dividers could be constructed from PVC pipes for a lightweight and flexible design
	Nooks permit small group instruction	Students enjoy curbed or circular shaped areas due to the softness in play, but they are accustomed to the square and traditional structure of walls
	Provide visual boundaries for group learning and workspace	Pull out rooms are ideal for make-up work or individual instruction. By making this space accessible for multiple classrooms, it promotes sharing, collaboration, and a more economical use of space
		Racket ball – A program that some schools have adopted to help students focus, concentrate and develop body awareness. The routine involves bounce, clap and bounce, which can be completed alone or with a partner. A designated space for this activity to be included in the classroom
		Diagonal lines are not preferred as they skew perspective
Furniture and objects	Rocking chairs, floor rockers, cocoon swings, pedal chairs, bouncing balls, wiggle pads, workout bands on chairs, bean bags, sit and spin and Rifton chairs are all ideal seating options and allow for flexibility	Cover and hide outlets to only allow access to teachers
		Cubbies and cabinets are important. Proximity and mobility are key for this item. Slots can represent the next step to task and allow the student to complete each step independently
	Carts in the room allow weighted blanket storage	
	Chair legs should have exercise or resistance bands. Teachers often use latex bands, but some schools are completely latex free	Carts filled with books or heavy items – the child can push the cart to expand energy, refocus and calm down
	Stand to sit tables, horseshoes tables and tables for group work with individual sliding panels are preferred desk styles. There should not be any attached seats or hard edges on the desks. Lips on the sides of desks and padded edges are preferred. Velcro on the undersides of desks meet a sensory need and help students regain control in their environment. Individual desks need an organization system to provide cues for tasks that need to be completed	Reduce the glare of screens
	Preference of rockers over exercise balls	

Table 4. Summary of findings from focus group interviews cont

	Preferences	New information
Lighting	Dimmers are highly preferred Fluorescent lighting is the least preferred type of lighting. Use covering devices when applicable Incandescent and natural, diffused lighting is preferred Matte surfaces are preferred to reduce glare Consider sight lines from the window as this can lead to visual distractions	Currently, classrooms are almost always too bright Blue and purple light covers are used by teachers on fluorescent lights There is a need for light covers that are fire retardant
Color	Think about the colors of all pictorial materials displayed on walls for information as this leads to visual clutter Colors with a low reflectance are preferred Neutral tones and calming colors are preferred (i.e. warm or cool tones) Strategic use of colors allows for wayfinding and fading	Red and yellow are less desired colors. Purple, blue and green are preferred Clothing and hairstyles are also impactful uses of color in the classroom and can lead to distraction
Texture	Strategic use of textural zoning can accommodate sensory needs such as touch, i.e. fine, coarse and smooth textures Carpet is ideal for sitting and stretching (yoga) Students enjoy pressure of certain textures (i.e. swings, mattress, weighted stuffed animals)	Picture frames with different textures allow for exposure to new materials. Include these pieces on sliding or removable panels to hide textures from children with hypersensitivity Some items to possibly include are teepees with rubberized mat on the inside, textured toys within color coated boxes, brushing options, bean bag chairs, couch, swing, pillows, weighted blankets, fidgets Texture boards in hallways, specifically on lockers, for students to drag hands and shoulders across. This assists in wayfinding and adds a sensory comfort in crowded hallways
Acoustics	Use sound dampening surfaces such as dividers with acoustical properties Background/white noise is good but can distract hypersensitive children Fluorescent lights distract and overstimulate children High ceilings and open areas can be acoustically challenging	The PA system, lunchrooms, gyms and auditoriums can be overstimulating Quiet closing doors and cabinets (padding) help lessen noise

not be used. Teachers preferred playing with the scale of the space and creating reading and individual small-scale nooks. For group learning and workspace, they also favored visual boundaries.

Lighting: The interviewees reported that the intensity of light, source of light and presence of windows can trigger sensory hypersensitivity. Natural light was favored over fluorescent lighting by the participants; however, windows were also considered as a source of distraction for children with ASD. One teacher commented that she covered the bottom half of the windows in her classroom to prevent distractions but left the top half open to let in light. Teachers reported problems associated with fluorescent lights due to their brightness, flicker, glare and noise. They all covered these lights in their classroom with a fire-retardant colored cloth in cool blues or purples for their calming effect. Most teachers appreciated control dimmer switches and they typically turn off the lights on one side of the classroom to minimize the intensity.

Color: The interviewees unanimously believed that students with ASD and ED prefer soft, natural, cool colors, such as blues and greens. They preferred colors with low reflectance values. Color may be utilized to help students with wayfinding. One intervention specialist shared that her students with ASD and ED perceive desaturated blue, purple and green as calming colors whereas red and yellow are less desired colors in the classroom. In addition, educators noted that they planned the colors of their wardrobe as well as their hairstyles to withhold any visual sensory distraction.

Texture: The interviewees unanimously agreed on the benefits of textural zoning (fine to smooth or coarse) inside the classroom to meet the sensory needs of students with ASD, ED and ID. The intervention specialists further added that the students with hypo sensitivities enjoy the pressure of certain textures (i.e. swings, a mattress, weighted stuffed animals). One intervention specialist added that texture boards in hallways, specifically on lockers, for students with hyposensitivity to drag hands and shoulders across would be beneficial to meet their sensory needs. Additionally, the educators found that teepees with a rubberized mat on the interior for hypersensitive students and ED provided a good escape space. Also recommended to include in the classroom were tactile toys within color-coded boxes, textured surfaces such as hairbrushes, beanbag chairs, couches, swings, cushions, weighted blankets and fidgets. Having these items readily available provides the student with a level of agency in the classroom to control their personal sensory needs.

Acoustics: According to the interviewees, the buzzing and flickering sound from the fluorescent lights is both distracting and overstimulating for children with hypersensitivity and ID. These intervention specialists have typically used white noise on their phones to help with this. The overall recommendation aligning with the findings was to use sound-dampening surfaces such as dividers with acoustical properties, carpet on the floor, and acoustically sound doors.

4. Development of prototype

The interviewees unanimously supported that design of the built environment through space planning, appropriate use of furniture and objects, manipulation of space, form, lighting, color, texture and acoustics play a key role in meeting the sensory needs of students with ASD, ED and ID in K-8 public school system. Based on the established design guidelines, the learning environment should reduce the impact of visual changes and clutter, undefined space, and poor lighting and acoustics. Typically, such research leads to the creation and refinement of design standards; however, the researchers wish to expand on these findings and apply the guidelines to the development of the three prototypes. The detailed design guidelines developed through the above studies serve as the foundation for creating a prototype for an inclusive special needs classroom that satisfies the sensory demands of

children with exceptionalities such as ASD, ED and ID. A prototype, by definition, is a first, typical, or preliminary model of something from which subsequent forms are formed or replicated. These prototypes will act as models for receiving feedback from intervention specialists, parents, students, educators and designers before being developed and implemented into a design-build project.

The three prototypes evolved after multiple iterations, evaluation of precedents and thorough reflection of the design guidelines. These prototypes are not intended to be the only solutions; rather, they are intended to demonstrate many ways in which the classroom could be organized to accommodate the requirements of children with special needs. These will serve to assist the community in visualizing and providing more feedback to refine the design guidelines further. These three configurations offer flexibility, adaptability and options which school districts can include in their future design guidelines. The question of the classroom's capacity was posed to the five intervention specialists. They all agreed that in a public-school system, a special needs classroom generally has 6 to 8 children at any one time. The prototypes are in response to the proposed class size.

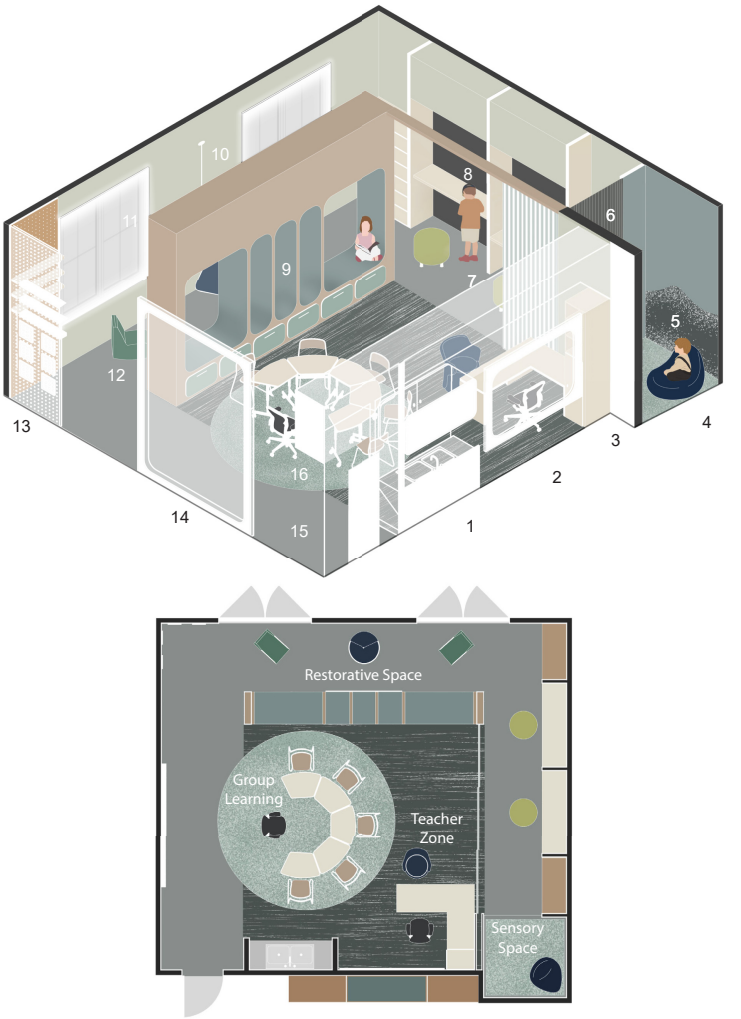
The first prototype reflects a centripetal spatial organization, with group learning happening in the center with a smartboard and designated teacher's zone. The choice of appropriate furniture and flooring distinguishes these zones from each other. Sensory and restorative space is provided in the quietest corners of the classroom, with positive distractions on the wall, for children with ED, ID and ASD. The peripheral spaces accommodate sit and stand desks with an organization system to provide cues for tasks, reading zones and small collaboration spaces to meet the needs of these students with diverse learning abilities. These spaces can be visually separated from the centripetal learning space through a sliding panel system or simply by drapes. The entrance cubbies with textural surfaces and peripheral storage/sink space act as transitional spaces to these zones. Figure 1 shows a more detailed version of this prototype with annotated design guidelines.

Figure 2 shows the second prototype, which divides the classroom space into four quadrants. The first quadrant acts as a transitional zone, with cubbies and storage for learning objects and materials and breakout space for small groups. This transition into the main learning space which contains a variety of areas including group learning design, individual sit-to-stand workspaces, reading zones, rockers and bean bags. The sensory and restorative zone is once again located in the quietest part of the classroom, giving students control while also providing teachers visual access.

The final prototype divides the classroom into two quadrants. For children who are hypersensitive or have ID or ED, the first quadrant is an active learning environment. The second quadrant contains one-on-one or small group learning activities and restorative space for children with ASD, ED and ID. This prototype is elaborated in Figure 3.

5. Reflection, discussion and future implications of the study

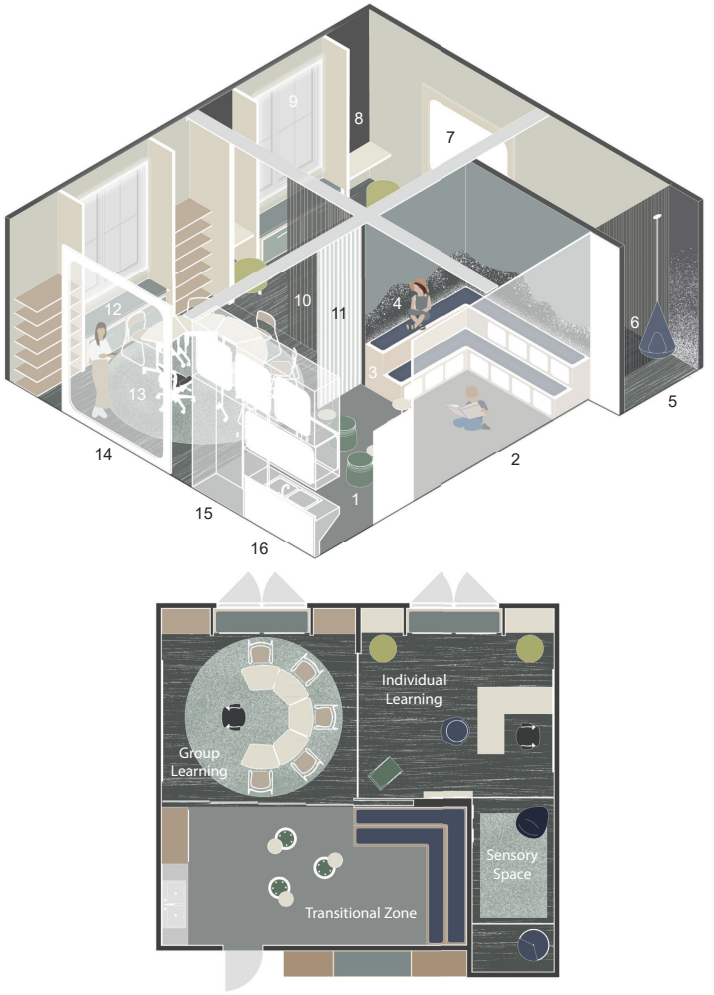
A survey of K-8 school environments in the region shows that the special needs classrooms have not been designed to suit the unique sensory challenges that many children with ASD, ID and ED experience. This study aimed to bridge the gap by generating a sensory design guideline which correlated interior design strategies with the sensory needs of children with ASD, ID and ED and implemented these guidelines in the prototypes. The two-part study consisted of an extensive literature review of sensory needs of children with ASD, ID and ED and physical attributes of the interiors of the classroom environment which correlate with these needs. The outcome of this literature review was a preliminary sensory design guideline for the special needs classroom. The literature review was followed by interviews with



1 Inclusive Sink with Above Cabinetry
2 Individual Teaching Area with White Board
3 Teacher Storage
4 Escape Space / Darker, Enclosed, Comfortable Seating, Acoustically Sound
5 Textural Application with Acoustical Properties
6 Slightly Transparent Curtains
7 Sliding Panels / Classroom Division, Privacy, Acoustical Application
8 Chalkboard Wall with Task Organization and Sit Stand Desk
9 Cubbies and Colorful Storage to Assist with Wayfinding
10 Hanging Swing
11 Adjustable Shades / Provides Partial Lighting
12 Private Zone with Rocker and Rubber Flooring
13 Adjustable Peg Board for Shelves, Lap Desks, and Technology Storage
14 White Board for Group Learning
15 Encouragement Wall (Magnetic Chalkboard)
16 Group Learning Defined by Area Rug and Classic Carpet

Figure 1.
Prototype 1, with centripetal learning zone

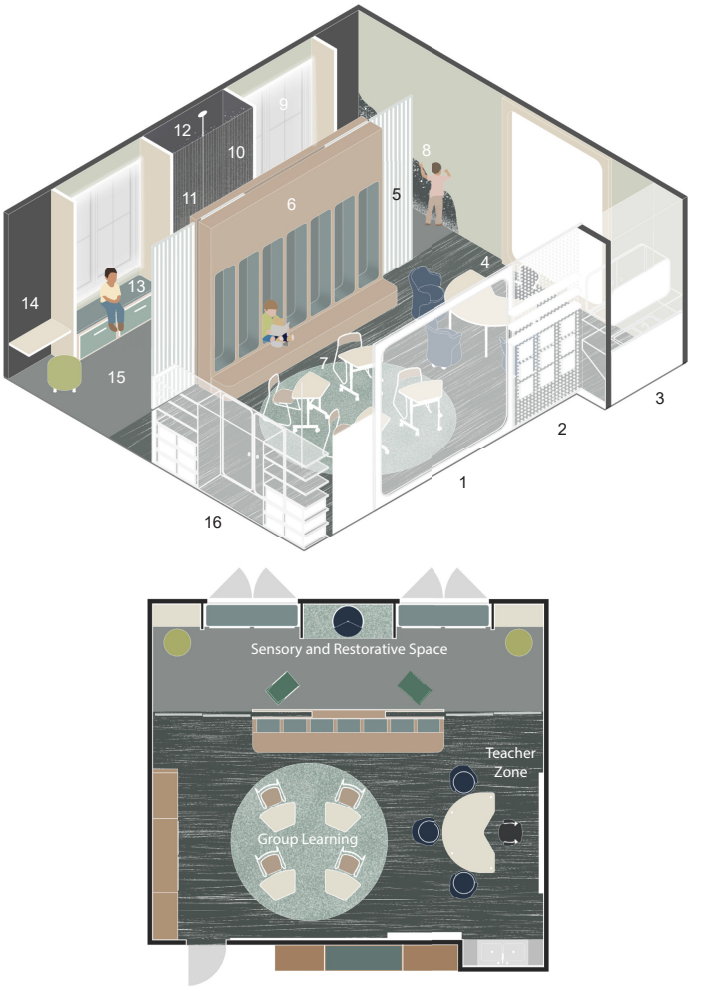
Intervention Specialists from area elementary and middle schools who were asked to rank the impact of the sensory design guideline on student learning. The intervention specialists mentioned their rooms had been initially designed for other purposes, from one that was for a Family and Consumer Science curriculum to a repurposed standard classroom. As a result, these creative educators had taken it upon themselves to recreate the spaces to work for their students and their sensory needs: blocking windows to eliminate outside distractions,



1 Play Area / Writing Stools and Rubber Flooring
2 Encouragement Wall (Magnetic Chalkboard)
3 Student Cubbies and Cushioned Bench
4 Textural Application with Acoustical Properties
5 Escape Space / Darker, Enclosed, Comfortable Seating, Acoustically Sound
6 Hanging Swing
7 Individual Teaching Area with White Board
8 Chalkboard Wall with Task Organization and Sit Stand Desk
9 Adjustable Shades / Provides Partial Lighting
10 Slightly Transparent Curtains
11 Sliding Panels / Classroom Division, Privacy, Acoustical Application
12 Window Seat with Colorful Storage Cubbies
13 Group Learning Defined by Area Rug and Classic Carpet
14 White Board for Group Learning
15 Teacher Storage
16 Inclusive Sink with Above Cabinetry

Figure 2.
Prototype 2, divided into four quadrants

adding rugs to soften the sound, re-designing chairs with a stimulating exercise band as a footrest, using white noise apps on their phones, softening the lighting with fabric and even "re-designing" themselves through their choice of wardrobe colors, hair color and accessories. While all these efforts were admirable, they reinforced the researchers' hypothesis in the need to consider these issues before the design of the space. It is essential to consider students' sensory needs as part of the inclusive design of classroom spaces. The information gained from this study shows the potential that an appropriately designed educational environment



1 White Board for Group Learning
2 Adjustable Peg Board for Shelves, Lap Desks, and Technology Storage
3 Inclusive Sink with Above Cabinetry
4 Individual Teaching Area with White Board
5 Sliding Panels / Classroom Division, Privacy, Acoustical Application
6 Student Cubbies and Bench
7 Group Learning Defined by Area Rug and Classic Carpet
8 Textural Application with Acoustical Properties
9 Adjustable Shades / Provides Partial Lighting
10 Slightly Transparent Curtains
11 Hanging Swing
12 Escape Space / Darker, Acoustically Sound
13 Window Seat with Colorful Storage Cubbies to Assist with Wayfinding
14 Chalkboard Wall with Task Organization and Sit Stand Desk
15 Private Area with Rubber Flooring. Encouragement wall Located on Back Side of Cubbies
16 Teacher Storage

Figure 3.
Prototype 3, divided into two quadrants

can help reduce undesirable behaviors in students with ASD, ID and ED and contribute to a positive learning experience. The interviews provided a baseline of the most important design strategies that influence the learning and behavior of children with exceptionalities. The refined sensory design guideline informed the design of virtual prototypes for a special needs classroom. These potential options can only be validated after the design is implemented, occupied and then data is gathered after occupancy of what potential works and what were some of the drawbacks.

The new guidelines and the prototype provide a basis for the further development of design standards and take designers one step closer to creating more conducive and inclusive environments. This research also reinforces the belief that these recommendations should be considered in the design of all classroom spaces. Many students can be included with their typical peers for all or part of their school day. Often this is complicated by the space not being designed to accommodate their difference. While the researchers are not advocating that all classrooms have sensory considerations but proposing the prototypes for designated special needs spaces, certainly many of the suggestions would work in a school-wide design. For example, clerestory windows do cut down on distractions for students with ASD, ED and ID, but they also cut down distractions for the typical student.

The relevance of adding sensory considerations to the design/planning process goes beyond just the accessibility considerations (ramps, wider doorways) currently used in the design of all spaces. It is hoped that these guidelines and prototype options will motivate the designers, educators and facility managers to develop the knowledge to design an inclusive classroom. Through integrating research-based solutions and the community, this study addresses the grand challenge of the achievement gap, promotes student learning, enhances practice and informs policies that positively influence 21st-century children's different sensory needs.

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