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Classroom Design and its Influence on Students' Performance Within the Autism Spectrum Diagnosis

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by

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Chapter 1: Introduction

As special education teachers, our responsibilities are great and ever reaching. We work tirelessly to ensure the children on our case load have the tools and resources they need to be successful in the classroom each day. No 2 days are the same; our students have good days and bad days just like us. Their emotions are vast and sometimes excessive, but each behavior they present means something. It serves a purpose, whether it is to communicate with us, a way of expressing emotions they are feeling, or just to have someone pay attention to them in a positive or negative manner. We spend our days focusing so much on the individual that I contemplate how much time we truly assess and manipulate the environment. The majority of our time is fixated on the individual and how to make them more successful through the elimination of behaviors or through academic support. We tirelessly dedicate vast amounts of time toward shaping their attitudes and making routines identical each and every day in hopes of getting ahead of any behaviors or instabilities that may affect their day. Do not misinterpret what I am saying, most special education teachers look at the whole being and the whole environment. Sometimes in our haste to correct behaviors and get a child to do necessary tasks or function for the maximum amount of time in the least restrictive environment, we forget to take a step back and gauge the environmental factors that could be contributing to an individual's frustration or even temperament. Such things as lack of focus or emotional state can be a function of their environment. We get wrapped up in the moment, have constraints with our available time, and therefore do not conduct daily observations and reflection on our students' daily, hourly, educational settings. How stark walls, ambient light, and hard surfaces might be contributing to behaviors, and even their ability to learn effectively. This is the "silent curriculum" (Mcallister & Sloan, 2016) or the other teacher. In a recent year-long study conducted by Agron (2013) and

the University of Salford, in partnership with Nightingale Associates Architects, 751 students in 34 classrooms were tracked. This study evaluated various parameters such as classroom orientation, acoustics, natural light, temperature, indoor air quality, flexibility, organization, and color. The findings suggest placing an average student in one of the best designed classroom environments, compared with one of the worst designed classroom environments, equates to a year of academic progress (Agron, 2013). Therefore, creating not just a community but an environment, creates lifelong learners.

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) affects one in every 68 U.S. children. Autism spectrum disorder has been described as neurological and development disorders that can cause significant social, communication, and behavioral challenges that affect academic achievement (CDC: Center for Disease Control and Prevention, 2016). An autism spectrum disorder is a developmental disability caused by differences in how the brain functions. People with ASD may communicate, interact, behave, and learn in different ways. Signs of ASD begin during early childhood and usually last throughout a person's lifetime. The Community Report on Autism released by the CDC (2016) estimated that the percentage of children identified with ASD remains high, but has not changed significantly. Boys are 4.5 times more likely to be identified with ASD than girls. White children were more likely to be identified with ASD than black or Hispanic children. Black children were more likely to be identified with ASD than Hispanic children. When it comes to looking at intellectual capabilities among the ASD demographic, 44% of these individuals have average or above- average intellectual ability, 24% are in the borderline range of intellectual ability, and 32% are diagnosed with an intellectual disability.

In the Arcs Autism Now Center (2015):

> social issues that may present themselves in the education community are: the preference towards solitary activities, problems with group work and interactive lessons, and trouble making friends. Behavioral issues that also present in an educational setting are: strong and inflexible adherence to rules, rituals and preoccupation with preferred topics or objects, and easily being overwhelmed by minimal change.

Unstructured times are most difficult for these children because they are unpredictable. From a transitional standpoint, they bring too much ambiguity to the moment. Students also face challenges during recess, lunch, physical education, and busing. Additional challenges present themselves in the secondary setting due to the additional changes of classes quarterly or on a semester basis.

Academic issues may include but are not limited to: “variable skill ability across academic areas, concrete/literal thinkers, these students may develop expertise in an area of interest, have difficulty making connections, shifting attention, and respond atypically to sensory input like lights, sounds or touch” (Erlauer, 2003).

Communication issues within the educational setting are as follows: direct individuals, they say it like it is with little to no filter for social norms, trouble following directions, difficulty interpreting or understanding jokes or idioms, sarcasm, and figurative language. Their written and oral responses may not reflect their true knowledge and understanding due to communication deficiencies. Frequently they do not know how to ask for help or self-advocate for themselves, even in dangerous situations. They sometimes lack basic social communication norms and take longer amounts of time for processing of verbal information and instructions.

It is important to note that for every challenge, there is an equal and complementing strength within the individual and educational setting. It is not uncommon to find students who prove all of the above stated challenges as strengths. Strengths like attention to detail, having deep passions and intense interests, being highly skilled in a particular area, logical, less concern for what peers think, and excellent abilities as independent thinkers. These strengths result in novel "big picture" insights that result in a different way of thinking. These insights provide a different way of looking at things, ideas, and concepts. Rarely do they have hidden agendas and they will follow schedules concretely. They possess incredible levels of loyalty, honesty, and non-judgmental listening capabilities. "Finally, as stated above, the vast number of children diagnosed with an autism spectrum disorder possess average to above average intelligence scores, which tend to serve them well in all educational settings" (Arcs Autism Now Center, 2015).

The Learning Process

During the learning process three components exist: visual, motor, and cognitive. All three of these components are needed for active learning to occur. These three components interact to produce a complex pattern between learning and attention. When these components are not synchronized or are compromised, it affects the student's learning process. To take this one step further, it is important to include the three main sensory systems that learning is typically categorized into and labeled as "learning styles." Typical student demographics are represented by auditory learners, visual learners, and kinesthetic learners; where one is representing as their dominant learning style. Generally, most people learn using two or more learning styles. Interestingly, autistic children are more likely to rely on only one style of learning (Arcs Autism Now Center, 2015). Therefore, it is important that educators assess

learning styles and adapt and methodically control the learning environment for these children to be successful.

Another area that is typically categorized within this same area of learning process is engagement. While comprehensive reviews elucidate slightly, there are different definitions of what engagement is and how it should be measured. The literature generally identifies four components of engagement: "cognitive, affective, behavioral, and academic" (Appleton, Christenson, & Furlong, 2008). "There are also varied perspectives through which student engagement is studied: behavioral, psychological, socio-cultural, and holistic; each of which places emphasis on a different facet of the metaconstruct" (Kahu, 2011). Our assumptions have always been that the problem of engagement is student-based yet we now know they are important factors in the learning continuum. We need to be aware of the small changes we can make in the educational environment to make all children effective in learning. The ability to capitalize upon boosting students' confidence and skill-sets through better prepared classrooms and more active student participation will only result in a richer learning climate, better knowledge, and acquisition of skills, taught at all levels of education.

My Research Question

Can classroom design influence students' performance in the classroom within the autism spectrum diagnosis? Branigan-Pipe (2016) found that "being sensory sensitive and unable to integrate or communicate fully with others means that those with ASD can find the classroom a disorienting and even frightening place." For school children this is especially damaging. Any unwanted distraction can impact a child's ability to learn. The background and surrounding environment that most of us are able to ignore or cope with will actually act as a barrier between the child and teacher, further hampering the child's development. Throughout my research, I

want to take a step back from all the behaviors, emotions, and autism spectrum characteristics. This will allow me to see how and to what extent the child's school environment and classroom design play a significant role on their moods, engagement, emotions, and behaviors. In a recent survey conducted by Tech Learning (2015), "92% of teachers believe classroom design has an impact on student learning." These teachers believe there is a direct link between classroom design and student performance and engagement. This survey also revealed that 79% of respondents believe it is important for student attendance. Ninety-nine percent of the teachers surveyed, which is a staggering number, believe that school design is important for creating a good learning environment. These same teachers also believe that the classroom environment can affect a child's academics and behaviors over a single year's progress by as much 25%. This statistic alone gives us reason for pause and reflection. If a single school environment or classroom can change a student's performance and behavior by as much as 25%, imagine what this could do for student engagement, student morale, and the stability we can bring to their learning just by being aware of classroom design. We need to be mindful in the area of classroom design and not just our content teaching or state-mandated standards, but how we create and include conducive, cognitive, social, emotional, and sensory modulated classroom environments. Recent research has begun to focus on how "space design impacts student engagement and behaviors," with one study showing that "creative spaces featuring flexibility, a unique atmosphere, and inspiring aesthetics led to more engagement and less resulting behavioral needs" (Jankowska, & Atlay, 2007). As of recent, students have begun to have access to stand-up and flexible desks, bungee or wiggle chairs, integration of soft surfaces, private nooks, and sensory mindfulness, all contributing to higher engagement.

Chapter 2: Review of the Literature

Ten studies were chosen for review that evaluated how classroom design influences educational performance for students with an autism spectrum diagnosis. Architecture is the science of environment creation and the manipulation of spatial organizations to fit the needs of its users. Architects commonly use the sensory environment, i.e., the auditory, visual, tactile, and air quality characteristics of space to convey meaning and messages to users. Hence, facilitating functions and activities within a space, particularly in the case of special needs users. (Malik, 2005).

In Chapter 2, I will look at the three key components my research indicated as the most influential on students' behaviors and academic performance within the ASD designation; they are light, noise, and overall design elements.

Light

Light plays a significant and fundamental role in our society. Our position to the sun plays a key role in our ability to survive on earth. For each of us, light plays a vital role in our daily lives through our house lighting, computer, phone, and TV; all light-based items we use each and every day. "According to researchers Dr. L.D. Rosenblum, Dr. Harold Stolovitch, and Dr. Erica Keeps, each of our senses processes a different amount of environmental components, as compared to our other senses" (Hurt, 2012).

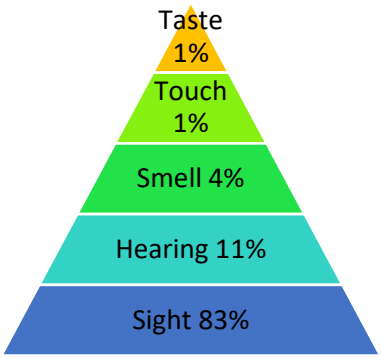

Figure 1: Natural Sensory Preference (adapted from Hurt, 2012)

Our brains give significant preference to processing vision as compared to our other senses. Stolovitch and Keeps used the following examples to help us understand their research better: Imagine you are in an open field. How far can you see? About 50 miles. How far can you hear? Maybe a mile or two. How about smell? 10-20 yards. How about touch? Just an arm's length. Taste? A couple of inches.

Sight is our bodies preferred sense for interpreting our surroundings, so the influence light can have on students' learning abilities is significant too. Hearing is also crucial because we acquire our language skills through this sense. Language gives us the ability to verbalize our knowledge and experiences. Together, sight and hearing help us perceive much of the world around us. "The more our senses are engaged in meaningful and structured methods, the more easily learning can occur. Ultimately, our senses act as learning portals. All raw information enters our brains through those learning portals" (Hurt, 2012).

Students diagnosed with an autism spectrum disorder frequently suffer from some level of sensory sensitivity. This inability to correctly process sensory interaction within an environment can cause many difficulties for individuals. Sensory overload can be caused in lighting by bright lights, fluorescent lights, and sunlight. Lighting can be disturbing for students

with ASD, and this results in a magnitude of undesirable behaviors in an effort to filter out the light. Some of their physical signals and behaviors may be poor eye contact, anxiety, fidgeting, and/or headaches. As articulation of emotions is challenging for most students with ASD, consequently, they communicate their preference through their actions in the form of behaviors. Recognizing this sensitivity and the affect it can have on these individuals neurologically is meaningful and essential. Children with ASD commonly have sensitivities, especially with temporal modulation of light, which in turn has a profound effect on mood and body regulation. Studies and research behind the cognitive regulation between light and its effect on humans are significant and far reaching.

To explain its effect, the following research study is used to demonstrate the cognitive regulation between light and emotional behavior. The cited results are from a study of 17 healthy volunteers who assessed the spectral quality of light modulation on the emotional brain responses in humans. The study focused on light therapy as a form of treatment for individuals with seasonal affective disorder (SAD). The study suggests that light can modulate emotional behavior, mood, and even its influence on mood disorders. The first assessment was to determine whether "light can acutely influence normal brain emotion processing" (Vandewalle et al., 2010, p. 19549). Acute physiological changes were noted in this study; for example, ambient light significantly modulates ongoing cognitive brain function, including attention, working memory, updating, and sensory processing within a few tens of seconds. The amygdala, a core component of the emotional brain that receives sparse direction projections from it, is one of the brain areas acutely affected by changes in ambient light. This result raises the intriguing possibility that ambient light directly influences emotional brain processing. However, non-classical responses to ambient light significantly modulate ongoing cognitive brain function

including attention, working memory, updating, and sensory processing, within a few tenths of a second (Vandewalle et al., 2010). The results demonstrate the influence of light and its spectral quality on emotional brain processing and identifies a unique connection between the effects of ambient light versus natural light. The findings "also suggest the possibility that ambient light directly influences emotional brain processing" (Vandewalle et al., 2010, p. 19549).

A study conducted in 2009 looked at a plethora of light studies and summarized their findings. Vandewalle, Marqeut, and Dijk (2009) showed the relationship between light and cognitive brain function in a study titled "Light as a Modulator of Cognitive Brain Function." In this study light emerges as an important modulator of brain function and cognition. Light, however, does not only provide visual information, but also constitutes a powerful modulator of non-visual functions including improvement of alertness and performance on several cognitive tasks.

Vandewalle et al. (2009) summarized recent neuroimaging data that reveal some of the brain responses involved in the effects of light on cognition. The data indicate that ambient light and its physical characteristics are major modulators of brain function and cognition. Light-induced modulations of brain activity while participants are engaged in non-visual cognitive task are detected in numerous areas including alertness-related subcortical structures such as the brainstem in a location compatible with the Locus Coeruleus (LC).

Published in the March issue of *Brain Research Reviews*, "autism is a developmental disorder caused by impaired regulation of the locus coeruleus, a bundle of neurons in the brain stem that processes sensory signals from all areas of the body." In addition to the influence of the locus coeruleus, this study summarized the available data into a visual pattern of how, in humans, non-visual effects of light spread from the retina to various brain structures and

ultimately modulate cognition. Neuroimaging results were used to guide and conduct the neuroanatomical data.

The data used in this study conclusively suggest that the modulation of behavioral changes can be influenced through the use of light. This study suggests and demonstrates the significance of light and its ability to modulate the cognitive response of the brain depending upon the strength and duration of light exposure. "All populations could greatly benefit from a better understanding of the cognitive impact of light" (Vandewalle et al., 2009, p. 435). Artificial light sources cannot replicate nor account for the spectral sensitivity of ASD students when compared with natural daylight. Artificially lit environments may leave our students with behavioral regulation and cognitive deficits without even realizing their impact on this sensory vulnerable student population.

Another study that suggests the importance of lighting within our education system was done by Sleegers et al. (2012) titled "*Lighting Affects Students' Concentrations Positively: Findings from Three Dutch Studies.*" This study assessed the correlation between lighting conditions within classrooms and its effects on concentration for elementary school children. In the first two experiments a "dynamic and flexible lighting system" was used in a quasi-experimental field study. They used data from 89 students from two schools. Thirty-seven students from two classrooms participated in the field study. The second phase included one randomized laboratory experiment which evaluated two lighting settings within a school-simulated, windowless, laboratory setting. The goal of the study was to better understand to what extent classroom lighting conditions in elementary schools affect children's concentration.

The words “dynamic lighting” are used in the study to describe the lighting system that provides different lighting settings, versus the traditional on/off (static) lighting system. Specific combinations of illuminance and CCTs (Correlated Color Temperature) were used and can range from the higher end of the light spectrum known as “neutral white” to the lower end of the spectrum knows as a “warm white” source. The variability of the CCT and dynamic lighting system was applied to the classroom environment and then assessed for its effectiveness on students’ visual performance, arousal, and well-being. “The dynamic lighting system was found to improve both pupils’ performance, which was assessed by increased reading speed, and pupils’ behavior, in terms of restlessness and aggressive behavior” (Sleegers et al., 2012, p. 160). The methodology employed for the dynamic lighting system, settings, and conditions was designed to support the rhythm of activity in the classroom through the use of four different lighting settings. The teacher is able to select the most appropriate setting via a five-button, wall-mounted control panel located in the classroom. The system has four preset lighting settings:

- Energy Setting. This setting is intended to be used to activate the pupils at the start of the day or after lunch (a ‘cold,’ blue-rich white light).
- Focus Setting. This setting aids concentration during challenging tasks such as exams and tests (a bright white light).
- Calm Setting. This setting brings a relaxing ambience to support independent and collaborative learning (white light with a warm, red color tone).
- Standard Setting. This lighting setting is used for regular classroom activities. (standard white light as commonly used in indoor workplaces) (Sleegers et al., 2012, p. 161)

Once the classrooms were established, they first administered a pre-test with no dynamics lighting. They followed this with a post-test with dynamic lighting, and a secondary post-test with dynamic lighting. All were administered within 2 weeks of one another; all conditions were equivalent. To assess concentration, the study used the d2-test developed by Brickenkamp (1981). This test has been used in other research studies that have looked at the effect of lighting conditions on students' concentration.

This particular test consists of 14 lines with each line containing 47 symbols. The symbols are either the letter d or the letter p. Students are directed to mark each letter d that has a total of two lines above and below the letter. The test is timed to allow for 20 seconds to complete each line and the student must then move to the next line at the end of the 20-second period. Therefore, both accuracy and speed are elements of concentration that are assessed on this test. Concentration performance (CP) and the total number of errors € made by the students is calculated by the number of errors made by failing to identify a correct d2 symbol, plus the number of errors made by incorrectly marking symbols that are not d2 (Sleegers et al., 2012).

The results showed a significant effect on CP. On average, students in the control school performed better on CP than their peers in the experimental school. This indicates that although the performance of students in both sample schools increased, this increase is more pronounced for pupils of the experimental school. The findings indicated significant interactions when comparing CP scores of students across schools on the second post-test with the pre-test. The results suggest that in addition to an overall learning effect for pupils in both schools, the focus light setting had a positive effect on students' concentration in the experimental school. The

findings underline the importance of lighting in educational setting as well as the effect it can have on students' concentration and learning performance.

Classroom lighting can improve student attention and create comfort while in the learning environment. Fluorescent lights, although energy efficient, do not provide the best quality of light for learning due to their unnatural color and discontinuous spectrum. Students diagnosed with ASD typically have some level of sensitivity to visual light extremes. In the graphic below, provided by the DIY Decorator's Eco-Friendly Lighting Dilemma (2015), we see the discontinuation of the light continuum sometimes associated with the different types of artificial light options compared to natural daylight.

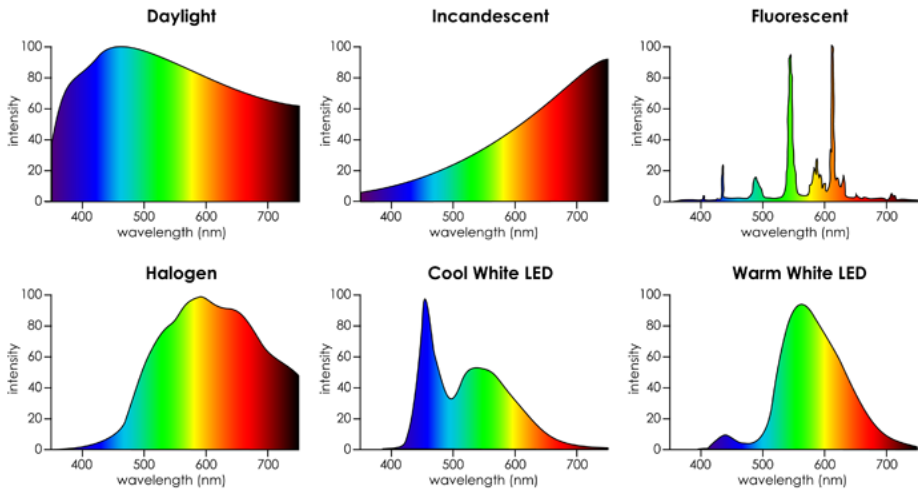

Figure 2: Discontinuation of the Light Continuum

As you can see in the graphic above, fluorescent lights have the greatest amount of light spectrum missing and it also shows the instability of light that is emanated from the bulb. This helps us to understand the behavioral challenges for students, when the majority of schools in the United States have this as their primary light source in the

classroom. This type of lighting has been associated with; increased student stress which may negatively affect students' learning, behavior, and comfort while in school. "Students in school environments that incorporate full-spectrum lighting experience less stress and anxiety which results in improved behavior, attitudes, health, attendance, performance, and academic achievement" (Martel, 2003, p. 1).

Students with autism are often sensitive to light and some lighting may be painful to them, especially bright and flickering lights. Research has suggested that children with autism exhibit increased repetitive behavior when exposed to fluorescent lights (Kuller & Laike, 1998). Friedlander (2010) suggested that some people with autism can see the "60-cycle flicker" associated with fluorescent lighting resulting in headaches, eyestrain, or even the perception of a pulsating room. "In contrast, halogen lighting is soft, producing a golden-white light, with continuous spectral distribution that looks and feels like sunlight" (Lorelei, 2003).

A study was conducted by Kinnealey et al. (2012) with a mixed-method, multiple single-subject AB (C + D) design. This study included the installation of halogen lightings as one of the phases of their study. Participants were four male students ranging in age from 13 to 20 years old. Three of the students were diagnosed with ASD and one was diagnosed with Dyspraxia. This group would receive design modifications to improve the students' sensory environment. The study took place over 6 weeks and included three phases: a 2-week (BE), before the environmental changes, 2 weeks after the installation of sound-absorbing walls (WI), and 2 weeks after installation of halogen lighting (HL). Classroom physical layout, white walls, curriculum, routines, and activities were unchanged and uninterrupted during the course of the study.

After halogen lighting installation, three of the four students mentioned positive improvements, one of whom also mentioned light sounds (i.e., the absence of the buzzing of the fluorescent lights): “Much more calmer than when the big lights are on” (P2); “Yes, I really like the lights” (P3); and “New lights made calmer days” (P4). A theme of positive emotional response to the environment after the installations was noted among three of four students: “I’m really happy, very happy that I have finally come in a nice quiet room” (P2); “Yes, I really like the lights” (P3); and “I love to hear now” (P4). (Kinnealey et al., 2012, p. 517)

These types of results provide evidence for the use of alternative lighting. Students with sensory hypersensitivity benefit with improved comfort and reduced anxiety and overall attention. The statements made by participants only strengthens the data provided in this study. The improvements in attention, engagement, mood, and performance were all from the perspective of the students. Although this study does have limitations due to its small sample size and single location, the data and results are suggestive of the influence light can have on students within the ASD designation while in the classroom environment.

With a plethora of studies indicating the significant role that light has on our cognitive functions such as: attention, behavioral regulation, focus, and emotional response, we need to further our understanding and awareness of these implications. Making dedicated, thoughtful consideration to the lighting environment will optimize brain function and create greater success for our students long-term. Items to consider while addressing sources of light in our classrooms include but are not limited to correct strength and duration of natural light, to the utmost. These studies have shown that light influences and regulates our emotions as well as attention. Which, for students, can have far reaching implications for their long-term educational success, thereby

influencing life-long achievements. Typically, our classrooms are brimming with bright, harsh, fluorescent lights the entire length of the classroom. This works wonderfully for having a brightly lit working area, but is it providing the best environmental and lighting conditions to help regulate students? Ambient blue light, which is found in most florescent lights, promotes arousal and associated mnemonic processing, which may favor a rapid turnover of the limbic system. The limbic system is reactive to emotional challenges and thus could contribute in a rapid behavioral adaptation to the environment. I think it is important to note here that the limbic system is a complex system of nerves and networks in the brain, which involve several areas near the edge of the cerebral cortex concerned with instinct and mood. It controls basic emotions of fear, pleasure, and anger. So, when this system is stimulated or over-stimulated, the resulting behavior may include any of the emotions listed above, without the student even being aware of their reason for the reaction or behavior.

Summary

Light plays an important role in our society. Through the analysis of these studies, we see the greater impact it can have on students' education through the inability to concentrate, focus, hyper- and hypo-sensitivity, and regulation. All of these challenges can contribute to an increase in behaviors for special education students.

Table 1

Summary of Studies Regarding Light

AUTHOR(S)	STUDY DESIGN	PARTICIPANTS	PROCEDURE	FINDINGS
Vandewalle, Schwartz, Grandjean, Wuilaume, Balteau, Degueldre, Schabus, Phillips, Luxen, Dijk, & Maquet (2010)	Qualitative Experimental Design	17 Individuals	fMRI-considered brain responses associated with specific time point (events) corresponding to light onset (12 light exposures) Impact of the wavelength of the ambient illumination context on the brain processing of emotional auditory stimuli	The task thus allowed us to separate the known effect of ambient light on attention from its potential to influence on emotion processing. Results demonstrate that ambient light and its spectral quality influences the brain processing of emotional stimuli.
Vandewalle, Maquet, & Dijk (2009)	Quantitative Review of Usable Statistics		Considered three aspects of cognition: auditory, perception, attention as well as executive function, and specifically working memory and updating.	The data indicates that ambient light and its physical characteristics are major modulators of brain function and cognition. Compared with natural daylight, our artificially lit environments may leave us "deprived." Exposure to blue-enriched white light during daytime hours improves subject alertness and performance.
Sleegers, Moolenaar, Galetzka, Pruyn, Sarroukh, & Van Der Zande (2012)	Quantitative Experiments	89 Pupils from two schools (elementary). And 37 pupils from two classrooms (elementary).	Evaluate the effect of lighting conditions on the concentration of elementary school children.	The results indicate a positive influence of the lighting system on pupils' concentration. The findings underline the importance of lighting for learning

AUTHOR(S)	STUDY DESIGN	PARTICIPANTS	PROCEDURE	• FINDINGS
Kinnealey, Pfeiffer, Miller, Roan, Shoener, & Ellner (2012)	Quantitative Mixed Method Design, AB(B+C)	4 male students, ages 13-20	Evaluate whether attention and engagement increased after the installation of (a) sound-absorbing walls, and (b) halogen lights.	Results included increased frequency and stability of attention and engagement. As well as improved classroom performance, comfort and mood.

Noise

Let us go back to one of the figures raised earlier in the section on lighting. According to researchers Dr. L.D. Rosenblum, Dr. Harold Stolovitch, and Dr. Erica Keeps, noise represents the second largest amount of information our senses process simultaneously, at 11% (Hurt, 2012).

Our sense of hearing is the second most influential sense in our body and therefore strongly influences our ability to acclimate to the environment we are in. According to Autism Speaks (2012), sensory processing characteristics of kids with ASD include kids having the ability of "super" hearing. Having provisions available for both quiet spaces and sensory sensitivities are imperative. Noise, consequently, is undoubtedly influential on these students. "With 'super' hearing ability they need to be able to escape noise. Students suggest that all general education classrooms should have quiet rooms where students can withdraw, if needed" (Reed, 2011). Areas that are normally classified as noisy to these students include, but are not limited to: gymnasiums, dining halls, drama classrooms, music/band classrooms, and theatre halls. These areas should always be away from general education classrooms, as well as any specific resource classrooms for students with ASD. In the research study titled "*Design by the Pupils, for the Pupils: An Autism-Friendly School*" students noted:

> The need for additional space to be designated outside the dining hall and physical education environments; which are full of noise, smells and bustle. This will provide reassurance of predictability and routine, which students within this diagnosis, often require. In terms of proxemics, students indicate a desire and need for additional space in shared areas which provides comfort and security. (Mcallister & Sloan, 2016, p. 345)

In this study titled; "*Design by the Pupils, for the Pupils: An Autism-Friendly School*," they first outline some of the challenges faced by students with ASD in trying to cope with their noisy learning environments. Next, they outlined the development of a simple school design through the use of a "jigsaw" kit that allows students with ASD to communicate and display their ideas for their perfectly designed school. The methodology employed was through the use of *School Building Design Handbooks,* therefore acting as a template for what would "normally" be included in a primary or secondary school design. Then they comprised a hypothetical, new, small, secondary school that included provisions for an ASD resource base. This base is a classroom specifically designed for students with ASD within the mainstream school. The jigsaw kit included a quiet room and suites for drama, home economics, science, music, art, and technology. Other areas included four general classrooms, two junior classrooms, a library, staff room, health office, dining hall, social concourses, gym, hallways, playgrounds, green house, and toilet facilities. Employing a workshop methodology, 13 male and four female students, ages 11-18 years old, were included from a mainstream, secondary-level school.

Throughout the workshop, noise was always mentioned as being important and concerning to the participants. As the study noted:

> Hence, a number of the designs grouped together the elements of the school that the pupils categorized as being noisy and then purposely distanced them away from the

> position of their own ASD Resource Base. Eddie (H3) was succinct, but direct, in his judgement, simply stating that accommodations classified as noisy included the dining hall, drama and music classrooms. Mark, Nigel, and Oscar (C2) went further by stipulating that all music rooms must be 'soundproofed' and that all of the general classrooms should have quiet rooms, where pupils could withdraw to if they needed. Generally, as a place of calm and respite, pupils wanted a quiet room in close proximity to their ASD Resource Base. Also suggested, was that it be alternatively positioned centrally in the school so that it could be easily accessed from all areas. Paul, Quinn, and Ray (C3) even went as far as suggesting that there should be no school bells in the school, but instead a sound-system speaker in classrooms that could announce the end of a timetabled period in each school room at a reduced volume to that of the normal school bell. (Mcallister & Sloan, 2016. p. 340)

The recurrence of noise is a major concern for the students with ASD. "An inability to filter out, or being highly sensitive to, unwanted noise is a challenge faced by many people with ASD" (Stiegler & Davis, 2010). Therefore, unwanted external stimuli can have negative effects on students with ASD. Due to this inability to filter, the results are feelings of unease with an inability to engage fully in all aspects of school life. Hall's (1992) assertion that "space perception is not only a matter of what can be perceived but what can be screened out" puts a voice to the prevalence of students' concerns. Many students try to find a way to cope with unwanted noise, and their designs demonstrated this during the workshop. The importance of noise was demonstrated by the students in major design considerations, across the entire school layout, with detailed placement of quiet rooms in all areas of the school, even the class level.

"The message from the workshops is very clear. Noise is a very important concern for pupils with ASD" (Mcallister & Sloan, 2016, p. 341).

Another study that cited many of the same results as conducted in June of 2016 is titled *"Noise and autism spectrum disorder in children: An exploratory survey."* This study focused on the fact that more student than ever before, with ASD are being educated in the public-school system. This study looks at what considerations from an architectural and design element need to be considered and modified to enhance the academic and social success of students with autism in school.

Ninety-five teachers from three schools for children with moderate to high-functioning ASD in Houston, Texas, were approached to participate in this study. The schools used research sites coded as: School 1, School 2, and School 3. Twenty-six out of 30 teachers at School 1 responded (87%), 25 out of 40 teachers at School 2 responded (65%), and 24 out of 25 teachers at School 3 responded (96%). In total, 74 teachers completed surveys and the overall response rate for instructors across the three schools was 79%. Specific grade levels taught were preschool (17%), pre-kindergarten (3%), kindergarten (7%), lower elementary (10%), upper elementary (6%), middle school (17%), and high school (2%), with 38% of teachers teaching multiple grade levels. The most common types of classrooms reported by teachers were general education (48%), special education (8%), and specific subject or service classes (56%). Teachers reported spending an average of 30.28 hours with their students each week (SD = 8.41). Most teachers reported having between 1 and 10 students in their class. Teachers reported working with children with autism an average of 106.48 (SD = 84.72) months.

The survey, which addressed the impact of architectural design elements on autism-related behavior, was developed for teachers of students with ASD. The purpose of the survey

was to determine if the instructors believed there was a connection between disruptive behaviors and noise levels. The study sought to find if they (the teachers) perceived elements of the environment, like the classroom, as influencing noise levels.

The teacher survey used a 5-point Likert Scale (1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, 5 = strongly agree) and open-ended questions. In addition to demographic questions about the teachers and their classrooms, a total of seven items addressed the following:

1. In addition to air conditioner sounds, echoes, sounds from children in the classroom, sounds from other classrooms, and traffic noise, are there other acoustical environmental conditions that you feel negatively affect children with autism?
2. Please rank the following regarding how negatively they impact the children's behavior: air conditioner, echoes, sounds from children in the classroom, sounds from other classrooms and traffic noise.
3. Are there aspects of the physical environment that you believe reduce the noise levels?
4. Describe the positive and negative acoustical qualities of the following types of rooms: classroom, common area, art room, computer lab and library, music and drama rooms, PE room.
5. As a teacher for children with autism, please evaluate the importance of carpet, wood panels, wood chairs, and soundproofing as aspects of the learning environment.
6. What types of behaviors do you see children doing that indicate that they are impacted by noise?

7. Do the children in the class ever attempt to reduce the noise by covering their ears or using ‘ear defenders? (Kanakri, Shepley, Tassinary, Varni, & Fawaz, 2016, pp. 89-90)

Results of the survey are as follows: nearly all (95.77%) of the teachers surveyed observed children covering their ears (in reference to loud noises that were overstimulating to them and which they could not filter out). Most teachers indicated they strongly agree that noise control is an important issue for children with autism (79%), followed by somewhat agree (14%), strongly disagree (4%), neither agree nor disagree (1%), and somewhat disagree (1%).

Teachers were also asked to identify specific aspects of the physical environment they believed would reduce noise levels. Most teachers indicated they strongly agree that thick or sound-proofed walls are an important issue for children with autism (45.2%), followed by somewhat agree (42.4%). There was a significant relationship between teacher observation of behavior change and belief that thick walls are an important issue for children with autism, $X2 = (10, N = 74) = 26.642$, $p = 0.003$. The majority of teachers also indicated they strongly agree (34.7%) or somewhat agree (34.7%) having carpet on the floor of the classroom is an important component for children with autism. There was a significant relationship between observance of behavior change and belief that use of carpet is an important issue, $X2 = (10, N = 74) = 30.450$, $p = 0.001$. Most teachers also reported they neither agree nor disagree that using wood chairs and tables rather than steel chairs and tables is an important issue for children with autism (52.1%), followed by somewhat agree (31.5%). There was a significant relationship between teacher observation of behavior change and belief that wood tables and chairs is an important issue $X2 = (10, N = 74) = 33.205$, $p = 0.001$.

Suggestions for improved classroom environment and the items teachers felt would be most impactful included carpeting (20.3%), wood furniture (17.7%), transitional spaces (12.2%), and thick or acoustical walls (4.3%). In addition, the survey asked teachers to identify the positive and negative acoustical aspects of various environments in their school, including the classroom, corridors, art room, computer room/library, music room, and physical education room. In general, positive acoustical aspects of the various school spaces included having a transitional space, multi-zoning, large spaces, and thick walls. Negative acoustical aspects in the school settings included echoes, hard floors, metal furniture, light walls, high ceilings, and no carpet.

Overall this survey indicates both from a student perspective and teacher perspective the important role that noise plays in influencing the behaviors and academic performance for students with autism. They demonstrated through actions, behaviors, and sometimes verbal communication their frustrations in trying to regulate themselves in educational environments. Too frequently, these classrooms and buildings provide a consistent and frustrating level of noise which intern creates an over stimulation of their senses. This over-stimulation creates a sense of hypersensitivity to the environment. Through simple, calculated modifications to our educational environment, we can foster greater learning and less frustration for all students, especially those diagnosed with ASD. By making simple changes to the classroom for students with ASD, we can create a learning environment similar to their non-disabled peers, which allows them to focus on the task of becoming the best student they can be. "By modifying the built environment in acoustically friendly ways, the treatment and education of children with autism maybe greatly enhanced" (Kanakri, et al., 2016, pp. 89-90).

The final research study titled: *"An Observational Study of Classroom Acoustical Design and Repetitive Behaviors in Children with Autism"* explored, through empirical research, how we as educators can best support the learning and developmental needs of children with autism using interior school space features and spatial environment characteristics (Kanarkri et al., 2016).

Research suggests that there is an inverse relationship with noise level and memory, auditory discrimination, speech perception, and school performance (WHO: World Health Organization, 2016). The WHO also acknowledged that children are especially vulnerable to noise pollution and that schools, in particular, have increased susceptibility to noise effects.

In this study, behavioral observations took place in four classrooms—two classrooms from each of two schools. These classrooms were separated into quiet and noisy according to decibel guidelines defined by WHO and the American National Standards Institute (ANSI). Classrooms with an average of 35 dB or greater, while unoccupied, were considered noisy. Those with an average of less than 35 dB, while unoccupied, were considered quiet.

School 1 contained two classrooms; the first with a playground area outside, the second was adjacent to a small wooded area. Each classroom had one door that led outdoors, and one entrance door that served as the main classroom door from the hallway. School 2 also had two different classrooms selected for the study; a quiet room and a loud room were compared.

Participants consisted of children with high-functioning autism in the second- and third-grades from two schools for autism. Two classrooms of children from each school participated in the study. For this study students ranged from 6-9 years of age. Twenty high-functioning children with autism (16 males) and (four females) were included in this study from two classrooms in School 1. Sixteen had no intellectual impairment (IQ > 85), three had mild

intellectual impairment (IQ between 50 and 70), and one had severe intellectual impairment (IQ from 41 to 49). Twenty-two high functioning children with autism (21 males) and (1 female) were included in this study from two classrooms in School 2. Fifteen had no intellectual impairment (IQ $\geq$ 85), five had mild intellectual impairment (IQ between 50 and 70), and one had severe intellectual impairment (IQ from 41 to 49).

The study used video cameras to capture data. Observations ran from 8:30 am to 2:30 pm for 48 days. On an average week, 20 hours of observational footage was recorded. Collected was 64 hours of data from each classroom, so in total the completed observational period was 7 weeks.

The following behaviors were the focus of this study: covering ears, producing sounds, hitting in response to a sound, blinking eyes in response to a sound, complaining, repetitive motor movement, and repetitive speech. To create a form of measurement for the behaviors, researchers would record a mark every 30 seconds when any of the above listed reactions was exhibited. In addition to this behavior tracking, a decibel meter was recorded every 10 seconds to link the activities with sound levels inside each classroom.

As the study progressed, a significant relationship between decibel level and behaviors began to develop. The following results were cited: at School 1 there was a significant, positive correlation, between decibel level and behaviors of complaints, repetitive speech, producing loud sounds, repetitive motor movements, and covering ears, indicating that as the decibel level increased, the occurrence of these behaviors increased. At School 2, there was a significant, positive correlation between decibel level and the behaviors of; complaints, repetitive speech, hitting, producing loud sounds, and repetitive motor movements, indicating that as the decibel level increased, the occurrence of these behaviors also increased.

Independent sample t tests were also conducted for the overall data (School 1 and School 2 combined) to analyze the difference between the loud and quiet classrooms in terms of observances each of the seven behaviors were recorded during 15-minute intervals. Levene's (1960) test was significant for complaints, repetitive speech, hitting, produce loud sounds, repetitive motor movements, and covering ears; therefore, equal variances are not assumed and adjusted t values are reported. The loud classrooms had significantly more observances of complaining, repetitive speech, producing loud sounds, repetitive motor movements, and covering ears than the quiet classrooms. The loud classrooms also had more observances of hitting compared with the quiet classroom. No other significant results were found. An independent-sample t test was also conducted for the overall data without the child who had ear-covering habits unrelated to noise. Levene's test was significant, therefore equal variances were not assumed and adjusted t values are reported. The loud classrooms ($M = 13.52$, $SD = 26.23$) still had significantly more observances of covering ears than the quiet classrooms ($M = 4.64$, $SD = 11.85$). Considering his data likely skewed the results, the findings without his data may more accurately depict the relationship between loudness and ear-covering behaviors in the classroom (Kanakri, Shepley, Varni, & Tassinary, 2017).

The findings suggest that while acoustical design and modification to existing educational classrooms provides benefits for all students overall, it becomes important and statistically significant for students within the ASD diagnosis. There was a positive correlation between noise levels and repetitive behaviors. Making a concerned-effort of simple and easy modifications to address noise levels in the classroom, will provide a more supportive, educational environment, and experience, for students with autism. For students with heightened sensory perception, these design changes have demonstrated a significant impact on their

learning and educational success within the classroom environment. This study specifically identified the need for sound levels to remain at or below the 50-decibel level to aid in the reduction of what the study identified as behavioral problems for students with ASD.

Summary

"It remains though, that acoustics appear to be one of, if not the most important factor, in a well-designed environment for individuals with autism" (Kanakri et al., 2016, p. 92).

Table 2

Summary of Studies Regarding Noise

AUTHOR(S)	STUDY DESIGN	PARTICIPANTS	PROCEDURE	FINDINGS
McAllister & Sloan (2016)	Quantitative Workshop	.2 schools secondary level 20 students ages 11-18 Resource based classrooms for ASD	4 workshop sessions 2 in each school Visuals created and presented to students on suggested ASD classroom design. A kit was developed and given to each student. Students designed their own classrooms	7 key design considerations were determined by the students Playground provision Sense of security Internal circulation space Noise & comfort ASD resource base Wider school environment Legibility–structure and rationale
Kanakri, Shepley, Varni, & Tassinary (2017)	Quantitative Survey	95 teachers from three schools with moderate to high-functioning ASD in Houston, Texas. (School 1 = 26/30 teachers responded) (School 2 = 25/40 responded) (School 3 = 24/25 responded)	Survey which addressed the impact of architectural design elements on autism-related behaviors, for teachers of ASD kids. Survey to determine if the instructors believed there was a connection between disruptive behaviors and noise levels. Did elements of the environment were influential in noise levels.	.79% of teachers indicated they strongly agree that noise control is an important issue for children with ASD. Most teachers agreed that the air conditioner and echoes had the most negative impact on behaviors. Specifics included the importance of carpet and wood furniture, transitional spaced, multi-zoning and thick walls.

Table 2 (continued)

AUTHOR(S)	STUDY DESIGN	PARTICIPANTS	PROCEDURE	FINDINGS
Kanakri, Shepley, Tassinary, Varni, & Fawaz 2016	Qualitative Empirical Research	Behavioral observations, 2 classrooms in 2 schools. Students ASD high-functioning, 2nd & 3rd grades School 1 = 20 students School 2 = 22 students	Classrooms were separated into quiet and Noisy according to decibel guidelines by WHO and ANSI.	School 1 & 2 had a positive correlation between decibel level and the 7 behaviors being observed. Study suggests there is a direct relationship between repetitive behaviors and auditory processing.

Overall Design

Schools are to our children what a house, a neighborhood, or community, is to us. This is their world. It is like a micro-city within a greater city. It is the core of their education but also the majority of their social interaction, sports, activities, and learning experiences. The importance of the school environment to student relationships is substantiated when we consider that "96% of school teachers agree that the school environment has an influence on pupil behavior" (Kumar, Omalley, & Johnston, 2008, p. 457).

When contemplating the considerations of overall design, I return to a study cited earlier, "*Design by the Pupils, for the Pupils: An Autism-Friendly School*." This research study, through the use of a jigsaw kit, allowed students with ASD to create their own optimal learning environment from a building design perspective. Seven design considerations were ultimately identified as the most important considerations for classrooms. They included provisions for playgrounds, a sense of security, noise and comfort, internal circulation spaces, legibility, a wider school environment, and finally, their own ASD Resource Base. I would like to explore each of the seven design considerations in depth from content cited in the study.

- *Playgrounds:* Primarily cited for elementary schools, students with ASD wanted direct access from their ASD Resource Base to an external play area that was separate from the main, larger, school-wide playground.

As stated by many of the participants of this study, being able to choose between alternative playgrounds was voiced as important by a number of pupils. Jack, one of the pupils stated "playgrounds can be territorial...so you need lots. It is good to have alternative places to go." Dan (H2) echoed this, stating "having a number of different playgrounds gives more choice for places to go." That need for choice and variety was further exemplified by Mark (C2) who recommended that "Playgrounds need to be divided into different areas for different play." Being able to avoid potential conflict or large numbers of pupils was also noted by Eddie (H3) as important, evidenced when he stated that he wanted his "own playground ...with not too much people to walk into."

- *Security:* Another area frequently brought up by study participants was a need for feeling safe.

Participants made statements like the following during their workshop day while designing their own environment "knowing where the staffrooms were and where staff could be contacted was often emphasized as important." Creating a sense of safety and security, is not only important for students with ASD, it is imperative in a school setting. This concern is recognized by Cannon Design (2010) in their statement that: "Children are only ready to learn when they are safe and secure, so address those needs before considering any other aspect of a child's learning environment." However, it is striking that students with ASD were so aware of this design consideration.

- *Noise and Comfort*: This area was explored in great detail in the section on noise, so please defer to that sections as needed.
- *Circulation*: This area of design is focused on the movement of students. The transitional times between classes, the hallways, stairwells, and corridors.

As cited by the study, it is unsurprising to see an emphasis on trying to deal with circulation spaces by the students in their designs. That might be another reason why all of the designs included direct access from the ASD Resource Base to an external play area, therefore making the need to negotiate shared corridors redundant by the students with ASD when wanting to go outside. Dan (H2) stated "Schools are too squashed. I get squashed in the corridors, in the hallways and the lunch room. It's ... like.... claustrophobia," before adding that, "you should bevel corners so that would give more room to walk and not get squashed and pushed and shoved." Clearly Dan wanted more space throughout all of the school circulation areas. This same sentiment was expressed, this need for circulation in reference to a particular space (and time) to prepare for entering places like the dining and physical education (PE) halls. Students made this design change by purposely distancing the ASD Resource Base away from large hall areas. In the design by Adam, Ben, and Cate (A1), they stated their reason as "that gives you time to prepare for the different activities that happen there." or as noted by providing extra circulation space alongside the dining hall to give pupils time to "line up" and ready themselves mentally before entering "the noisy dining hall" (C2).

- *Legibility:* The need for order, structure and predictability is a common shared trait of students with ASD. So, the need for legibility is not surprising.

Unsurprisingly, then, the PE hall was always positioned alongside the gymnasium. Alongside these, the health office was commonly added because the students reasoned that it

would be those with PE who would most likely get injured and need help from the health office. Other students cited the need for order and consistency as the reason for grouping in their designs art, drama, music, and technology together. They classified these classrooms as the "creative" classrooms. This idea of making sense in the design was echoed by Mark, Nigel, and Oscar (C2) who, having arranged their jigsaw accommodation around a central organizing interior court, explained this would not only "look good on the inside ...it should make sense on the inside." Finally Karen, working alongside Lewis (C1), positioned the ASD Resource Base close to the main school entrance on purpose so that, as she explained 'The first classroom you come to should be the ASD Resource Base. Then you can check your timetables, get told about changes and prepare for the rest of the day." This sense of predictability and notice of change is a trait that many students with ASD possess. The preference for wanting to know what was potentially changing in their daily routine led to reduced stress and anxiety by avoiding unexpected surprises that can occur during the school day. Knowing what to expect will help all students successfully navigate their way through the school day.

- *ASD Resource Base:* This is the central home-base for many students. It is their safe place where they share the room with other students who are just like them. It is a place to relax, have meltdowns, express emotions, and integrate or segregate themselves form others based on their hyper or hypo sensorial needs.

Helen (H3) reiterated the need for an ASD Resource Base, but went further in her specification by not wanting the classroom to stand out, stating "You need a room at break time and lunchtime with fun stuff. But it should look like a mainstream classroom." This would imply that for Helen, as well as many other students with autism, the desire to not stand-out within the body of the school. It is also important for the design and expression of the ASD

Resource Base to look and feel like a normal classroom. Eddie (H3) agreed with Helen but elaborated, stating that the ASD Resource Base "needs to be quiet to focus on work." Another student did not want his base on the edge of the school by itself. It was noted that all students expressed a desire from a design layout perspective that they wanted and preferred to be an integral part of the wider school demographic and environment. Having a well-considered ASD Resource Base is critical in making the previous statement work. As it is for all of us, having a place to go that is familiar and safe, ultimately provides us with a space that supports our needs from a learning perspective.

- *The Wider School:* This portion of the study focused on the unique and differentiating ideas proposed by students.

Adam, Ben, and Cate (H1) said that "as sustainability today is important, any 'perfect school' would therefore need to be sustainable." Similarly, Mark, Nigel, and Oscar (C2) stated that, "because 'fresh air is good,' all classrooms throughout the school should have direct-door access to the exterior." Perhaps the most descriptive request came from Adam (H1) who stated: "It is important how it [the school] looks. Gates and small windows are scary" before also requesting that the school instead "should be colorful."

The seven design principles collected from the students' jigsaw kits that became the basis for overall school design, provide an excellent overview of the simple yet functional design all schools should have, benefitting all students as well as students with ASD. These students also noted that the majority of the time they were accepting and welcoming of their integration into the mainstream learning environment. School is important to them, as with most students. It is not just as a venue, it is a micro-city for them so how it looks and operates is important. "If we are truly to provide more inclusive school design for pupils with autism and opportunities to

avoid noise, this might well mean providing more time and space in which to feel comfortable" (Mcallister & Sloan, 2016, p. 341).

"Architects commonly use the sensory environment, i.e., the auditory, visual, tactile, and air quality characteristics of space to convey meaning and messages to users hence facilitating functions and activities within a space, particularly in the case of special needs users" (Malik, 2005).

In the next study, published in March of 2014, conducted by Magda Mostafa, a Cairo professor, suggested an Autism ASPECTSS™ Design Index and illustrated the use of the index and its seven principles of design for students with ASD.

"Despite the apparent possibilities of designing favorable architectural environments for autistic users, autism has generally been excluded from architectural design codes and guidelines" (Mostafa, 2014). The United Nations is the first to address these design considerations by issuing a mandate, although not legally binding, with a moral commitment to provide equal opportunities for persons with disabilities, including access to built environments. Yet…no specific references are made in the mandate regarding individuals with developmental disorders or even autism. It has also been noted that individuals with developmental and psychosocial disorders, of which autism is one, have been overlooked. So, in the year of 2018 we still see a lack of understanding and consideration for students with disabilities from a far-reaching organization like The United Nations.

The Sensory Design Model is a set of criteria that highlights two specific areas of design consideration. First, it addresses the various sensory areas involved in perceiving the physical environment, they are listed as: (a) auditory, (b) visual, (c) tactile, (d) olfactory, and

(e) proprioceptive. Second, it addresses the integration of the architectural attributes that may be manipulated to accommodate various sensory needs in autism students, they are listed as: (a) structure, (b) balance, (c) quality, and (d) dynamic.

Next, The Autism ASPECTSS™ Design Index was created. "By looking at these common sensory environment problems, such as acoustics, texture, lighting, etc., a group of design principles were generated through the matrix. Some of these suggested guidelines were empirically evaluated in a school environment and indicated promising results" (Mostafa, 2003; Mostafa, 2006; Mostafa, 2008). These principles are summarized in the following proposed Autism ASPECTSS™ Index, and "were used as a basis for the development and design of the Advance School for Autism in Egypt" (Mostafa, 2014).

- *Acoustics:* This criterion proposes that the acoustical environment be controlled to minimize background noise, echo, and reverberation within spaces used by individuals with ASD. The level of such acoustical control should vary according to the level of focus required in the activity at hand within the space, as well as the skill level and consequently severity of the autism of its users.
- *Spatial Sequencing:* Spatial Sequencing requires that areas be organized in a logical order, based on the typical scheduled use of such spaces. Spaces should flow as seamlessly as possible from one activity to the next through one-way circulation whenever possible, with minimal disruption and distraction, using Transition Zones.
- *Escape Space:* The objective of such spaces is to provide respite for the autistic user from the overstimulation found in their environment. Such spaces may include a small partitioned area or crawl space in a quiet section of a room, or throughout a building in the form of quiet corners. These spaces should provide a neutral sensory

environment with minimal stimulation that can be customized by the user to provide the necessary sensory input.

- *Compartmentalization*: The philosophy behind this criterion is to define and limit the sensory environment of each activity, organizing a classroom or even an entire building into compartments. The sensory qualities of each space should be used to define its function and separate it from its neighboring compartment. This will help provide sensory cues as to what is expected of the user in each space, with minimal ambiguity.
- *Transitional Zones:* Working to facilitate both Spatial Sequencing and Sensory Zoning, the presence of transition zones helps the user recalibrate their senses as they move from one level of stimulus to the next. Such zones can take on a variety of forms and may be anything from a distinct node that indicates a shift in circulation to a full sensory room that allows the user to re-calibrate their sensory stimulation level before transitioning from an area of high-stimulus to one of low-stimulus.
- *Sensory Zoning:* This criterion proposes that when designing for autism, spaces should be organized in accordance to their sensory quality, rather than the typical architectural approach of functional zoning. Grouping spaces according to their allowable stimulus level, spaces are organized into zones of "high-stimulus" and "low stimulus." The former could include areas requiring high alertness and physical activity such as physical therapy and gross motor skill building spaces. The latter could include spaces for speech therapy, computer skills, and libraries. Transition zones are used to shift from one zone to the next.

- *Safety:* A point never to be overlooked when designing learning environments, safety is even more of a concern for children with autism who may have an altered sense of their environment. Fittings to protect from hot water and an avoidance of sharp edges and corners are examples of some of these considerations.

It is proposed by this study "that this Autism ASPECTSS™ Design Index may further be used to develop designs for other building typologies such as assisted living communities and respite centers" (Mostafa, 2014). Other suggestions included it be used as a framework to facilitate inclusion in any public structure as well as services. Another application could be to act as an audit index. If buildings needed to be rated or have an index score, this design would help rate the appropriateness of an environment for autistic users. If such a scenario were to occur, it would encourage employers, building/architectural designers, and public facilities to create inclusion and integration for individuals with disabilities like ASD into society and the community at large by creating a healthier, more conducive environment for all.

In a study conducted by McAllister and Maguire (2012) on the "*Design Considerations for the Autism Spectrum Disorder-Friendly Key Stage 1 Classroom,*" a study was carried out in three stages over a 2-year period. The study took 10 different classrooms in 10 different schools and converted and refurbished them into specifically designed ASD classrooms. The refurbishment took place in 2005 and 2006.

One of the main challenges in this study was the ability and methodology that would be employed to best enable the teaching staff to pass their knowledge to the researchers and design teams. They decided to use scalable, three dimensional models of various colors, facilitating the recognition of the incorporation of these elements. In essence, a kit was developed for teachers to use to aid in conveying their design ideas. They established what components were likely to

be needed through the review of existing literature. This would allow them to establish the challenges students with ASD face in a traditional educational setting, as well as challenges presented in a custom-built environment for students with ASD. Teachers then ranked the available design elements suggested through their research studies and 16 design criteria were compiled. These 16 chosen criteria were then placed into four categories: (a) control and safety, (b) classroom character, (c) classroom usage, and (d) classroom physical factors.

The following are the 16 design considerations with reasoning for consideration:

- *Threshold and Entrance:* Having a transitional buffer for pupils before entering the teaching areas of the classroom helps maintain the quiet and calm of the classroom.
- *Coatroom Provision:* Having a designated coatroom area with seating, shelving, and coat storage helps each pupil prepare and ready themselves for change.
- *Sight Lines Entering the Classroom:* Give consideration to students with ASD by creating sight lines that focus on the learning area when entering the classroom. Curtail views to the exterior from the classroom entrance.
- *Visual Timetable:* Make provision for the positioning of the visual timetable in its own designated zone in the classroom.
- *High-level Gazing:* Provide high-level windows to the exterior. Be mindful of orientation, glare and possible solar gain.
- *Volumetric Expression:* If possible, consider volumetric changes in height and character in conjunction with different teaching zones requiring different characters.
- *Control:* Ensure clear sight lines from the teaching areas to other areas of the classroom.

- *Access to Classroom External Play:* Ensure direct access from the classroom to a dedicated external classroom play area. The play area must be secure.
- *Access to School Playground:* Provide access from the classroom external play area to a larger school play area.
- *Quiet Room:* Provide a quiet room. Give consideration to the materiality of the quiet room. This should be different from the classroom, thereby helping make it a separate identifiable area. Consider employing a sliding door or screen to the quiet room if applicable.
- *Toilet Provision:* Provide two toilets, two wash hand basins and corresponding changing space directly off the classroom.
- *Kitchen:* Provide a kitchen area for the classroom. Decide if this is best within the classroom or in a separate room adjoining the classroom. Give consideration to the kitchen area supporting other class activities such as art.
- *Floor Area:* Provide additional area for the ASD classroom in comparison to mainstream classrooms.
- *Storage:* Maximize available storage accessed from the classroom. This should cater for small- and large-scale items.
- *Computer Provision:* Make provision for two computer workstations. These need to be carefully positioned to minimize distraction for non-users.
- *Workstations:* Make provision for a minimum of three workstations. These need to be positioned carefully to allow access to pupils' work baskets and away from potential sources of distraction.

Again, with this study we see the important design elements that go into designing a classroom learning environment free from distractions for students with ASD. The classroom is an important place within the larger school environment where the students with ASD will spend most of their time and the one location within the school where they can feel comfortable, relaxed, and even secure. These simple design considerations can make what would otherwise be a terrible and mood-altering place, become a safe, emotionally regulated, and successful learning environment for even the most challenging of students.

Summary

Students with ASD have shown to be sensitive to many stimuli in their environments, lighting being one of major concern. Students with autism have also shown struggles within the area of hypersensitivity to extremely bright rooms which can influence and deter a successful transition back into a normal classroom routine. Harsh lighting environments can present their own set of challenges for regular students, without any other factors being considered or present. We no longer need to imagine the implications for students with ASD and sensitivities, each study solidified one another.

Table 3

Summary of Studies Regarding Overall Design

AUTHOR(S)	STUDY DESIGN	PARTICIPANTS	PROCEDURE	FINDINGS
McAllister & Sloan (2016)	Quantitative	.2 schools secondary level 20 students ages 11-18 Resource based classrooms for ASD	4 workshop sessions 2 in each school Visuals created and presented to students on suggested ASD classroom design. A kit was developed and given to each student. Students designed their own classrooms	.7 key design considerations were determined by the students Playground provision Sense of security Internal circulation space Noise & comfort ASD resource base Wider school environment Legibility–structure and rationale
Mostafa (2014)	Qualitative		Illustrate the use of ASPECTSS™ Design Index	Seven design principles, acoustics, spatial sequencing, escape, compartmentalization, transition spaces, sensory zoning, and safety. Paper summarizes the impact of these design principles.
McAllister & Maguire (2012)	Quantitative 2-year study	9 ASD friendly classrooms were visited and surveyed	Surveys were completed on specific design elements targeting sensitivities for persons with ASD.	16 Chosen criteria were broken down in to four category bands that were identified for an ASD friendly classroom design as key elements. Control and safety Classroom character Classroom usage Classroom physical factors.

Chapter 3: Conclusions and Recommendations

According to recent literature, the key to designing for autism seems to revolve around the issue of the sensory environment, design, and its relationship to autistic behavior. "This role of the sensory environment in autistic behavior has been an issue of debate since Leo Kanner first defined the disorder in 1943" (Kanner, 1943). From the early works of Rimland and his discussion of sensory stimulation and its relationship to autistic behavior (Brittannica, 2006), to Delacato and his discussion of "sensoryisms" (Delacato, 1974), the sensory environment has been part of the autism dialogue. Simply stated, this dialogue, hypothesizes that autistic behavior—which is characterized by repetitive behavior, limited communication skills, challenges in social interaction, and introversion—may be a result of a hyper- or hypo-sensory perception. This may take the form of hyper-sensitivity or hypo-sensitivity, in its various degrees and across the scope of all the senses, leaving individuals with autism with an altered sensitivity to touch, sound, smell, light, color, texture etc. "In other words, this leaves them with an altered sense of the world around them" (Mostafa, 2014).

Little attention has been given to understanding how our environment and classrooms affects students' psychological and physiological systems. In education, we are dealing with the smallest and most sensitive of our human population. They deserve better thought, research, and attention to be given to the environment in which they spend 6-plus hours a day eating, playing, learning, and developing. The goal should be to have a classroom environment that can bring comfort and warmth to our children's lives. This will help regulate their psychological and physiological systems and create smoother days not only for special education teachers, but for all educators in general.

> The Sensory Design Theory, which stipulates that favorably altering the sensory environment can be conducive to positive and constructive autistic behavior, particularly in learning environments. Based on clinical research first published in 2008, Sensory Design Theory presents a flexible and adaptable tool which acts as a catalyst for architectural design criteria development for architectural environments based on their sensory qualities, and in response to autistic sensory needs. (Mostafa, 2008)

There are two main conditions which contribute to how students with ASD process information. Patients with ASD will either experience a "hyper-" or "hypo-" sensitivity to their environment. The prefix "hyper" suggests an over sensitivity to stimuli. The brain picks up more information from the environment than necessary and becomes overwhelmed when processing information. The prefix "hypo" means just the opposite; the brain cannot make the connections to correctly interpret information and it becomes lost in the brain and develops little or no reaction. As research has shown, "there is no predictable pattern of which stimuli will invoke a 'hyper' or 'hypo' reaction" (Autism Society, 2008). Because the brain of a patient with ASD does not consistently have a cohesive path of neuron connections for interpretations, the information is scattered into various parts of the brain to try and formulate a reaction. The reaction is then commonly displayed as confusion, frustration, withdrawal, or repetitive behaviors. If stimuli from the environment are intentionally limited, a student with ASD may be better able to make clearer connections between neurons in the brain. Students with ASD cannot always differentiate between what is socially important and something that is visually or audibly distracting. They may focus their attention to extraneous sights and sounds and be unable to engage in classroom activities and instruction. Fluorescent lighting is a common source for

distracting stimuli. "Fluorescent fixtures are traditionally and still currently the most popular fixture in classroom design because it is able to fulfill the recommendations for quality and efficiency, while still maintaining a reasonable budget" (Rea, 2000).

When considering the influence of noise in our educational environment, persistent or loud noises have a universal impact in the form of stress to the physiological system. The possibility that repetitive behaviors may be markers of physiological distress caused by noise in the environment is an important consideration. According to the American National Standards Institute [ANSI]/Acoustical Society of America [ASA] (2012), exposure at a level greater than 85 dBA may lead to hearing loss. Lower levels of continuous or disruptive noise can have other damaging impacts. They include, but are not limited to: "increases in blood pressure, appearance of muscle reflexes, and sleeping disorders may also be among the physiological effects of continuous and extensive noise" (ANSI/ASA, 2012). Physiological responses to low and high frequency noise can include changes in cardiac rhythm and respiration rate (measured by electrocardiogram [EKG] recordings, pulse counts, and impedance anemography), change of systolic rhythm, blood and endocrine changes, and disturbances to the central nervous system, as well as subjective responses.

HVAC equipment is a major source of background noise in learning environments, but it is not the only source. Simply moving the Heating, Ventilation, and Air Conditioning (HVAC) system or electing to install more expensive centralized systems may not reduce noise enough to adhere to ANSI standards. "Architects must also take into consideration the classroom size, properties, and sound absorption" (TRANE, 2003).

For overall design considerations, we, as a society usually rely on architects. These same people can help people with autism by designing appropriate interior and exterior environments

that help them use the space appropriately and comfortably. "Guidelines generated by research include specific design criteria concepts such as sensory zoning, use of transition spaces between zones, adoption of escape spaces, and the use of visual clues to enhance way finding" (McAllister & Maguire, 2012). In addition to providing spatial cues for activities, offering and including a quiet space for children to take assigned or self-selected time out to regulate within the school environment is critical. These areas are found to significantly affect well-being, even if the escape space is only a reminder that brief escapes are an option for the sensorially overwhelmed child. However, limited recommendations have been made about improving the acoustic design of school interiors. In the United Kingdom, the National Autistic Society has published guidelines for architects and builders, but these guidelines have not yet been adapted.

As of recent, the focus on classroom design has been centered on the need to experience "hands-on learning," with a primary focus on STEM (science, technology, engineering, and math). With the spotlight on STEM and the incorporation of kinesthetic experiences for our student, we need to ensure we are connecting the practices of how we design spaces for *all* learning types.

More often than not, our school infrastructure is old and outdated. Rarely have I experienced the physical space and classroom make-up replicating and connecting to the pedagogy design and development that has been encouraged during my advanced degree. For most classrooms in the United States, students generally sit in chairs at a desk. Years of statistically significant research suggests this is not conducive to learning, yet nothing has changed. In the private sector, many facilities have implemented sit/stand desks and alternative working environment for their employees. Why has this same application not been carried over to our school environment?

Isolation is another factor that is present in most learning environment. A dedicated classroom for each subject is present and shared learning spaces are non-existent. Students do not have the opportunity to collaborate outside of their designated classroom. This type of open, collaborative, visual workspace would provide for more sharing and more communal education experiences. Using a classroom with this type of design provides benefits in two significant ways for students with ASD. First it breaks down the large, noise ridden, brightly lit, classroom environment and segments it into learning spaces that have a dedicated purpose with a small group learning atmosphere. Second, it would provide additional space away from larger groups for students who tend to think or work better independently by retreating to a smaller more enclosed space similar to a cubicle. This enclosed, secure, quiet space would provide students with many different diagnoses, a space that they desperately need to retreat to during times of over stimulation or sensory input. The feeling of being overwhelmed and faced with anxiety while in the classroom is a common denominator most students with ASD share.

Teachers should always have a quiet study or relaxation area available within their classroom setting for any student who needs the opportunity to get away, this is important even for students without a disability. Dedicating a space within the classroom allows for greater usability and also maintains a presence within the learning environment. A simple suggestion would be to include a few comfy chairs set up in the back of the room or off to one side, indicating to students this area is for a specific purpose. Within my ASD classroom I am lucky to have two dedicated safe spaces for students. One has a door and two large windows so I can view the students while using, the other is a rectangular room (approximately 10’ x 6’) with two bungee chairs and sensory fidgets. Students are aware that when another student is utilizing one of these “safe spaces” they are off-limits to other students. They are not allowed to enter or

engage with the student who has chosen to be in that room or area within my classroom. The most important part of creating this space is allowing the student to choose this adaptation. It is important to note that the space should never be used as a form of punishment or punitive area that would defeat the purpose of the design.

Summary

Classroom design for students with ASD is not commonly addressed in initial education facility design; yet, we as teachers, can make small changes that can have an enormous impact on the children we serve. The impacts cited in this paper, are far reaching and include improvements in attention, mood, engagement, and increased body regulation and less sensory hyper or hypo stimulation. As a teacher, the classroom environment is one area we have control over. We need to look at creating an optimal, holistic, ASD classroom environment, which in turn will increase student engagement and learning.

It is a hope of mine that the design considerations, thoughts, and study-based conclusions presented in this paper will begin to move more teachers, parents, employers, and political figures toward listening with all of our senses to the needs of individuals with ASD. The over-reaching consideration and motivation would be for administrators and school districts in the United States to develop the knowledge to design more appropriate architecture to better serve all students, especially those with ASD.

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