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The impact of ASPECTSS-based design intervention in autism school design: a case study

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Abstract

Purpose – The objective of this paper is to study the efficacy of the ASPECTSS Design Index's concepts as drivers of design intervention for educational environments for students on the autism spectrum. Based on the seven principles of acoustics, spatial sequencing, escape spaces, compartmentalization, transitions, sensory zoning and safety, ASPECTSS formed the basis for a preliminary post-occupancy evaluation (POE) and survey of an existing school environment.

Design/methodology/approach – Concepts drawn from the review of other strategies for autism spectrum disorder (ASD) friendly design were integrated with the seven ASPECTSS principles to create a design framework and consequent design retro-fit for a Pre-K-12th grade public school for students on the autism spectrum. The following design interventions were proposed: colour-coding based navigation; acoustical treatments in key circulation spaces; introduction of transition alcoves; classroom reorganisation using compartmentalization principles and the introduction of escape spaces for de-escalation. Specifically, a

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Note on language: Throughout this article, identity-first language and the term "autistic individual/person/people" to describe individuals from the autism community are sometimes used. This is based on current literature and preferences of autism self-advocacy groups and autistic individuals with whom the authors work from around the world as communicated to the authors through their work together. There are alternative terminologies that may also be preferred by some individuals and groups, such as "individuals with autism" and "individuals on the autism spectrum". General sentiment in the autistic community seems however to indicate preference of the latter as an alternative to identity-first language. The choice of language here is driven by the preferences of autistic individuals themselves. The National Centre on Disability and Journalism provides additional guidance (NCDJ, 2021).

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classroom template of modules of ASPECTSS-compliant layouts was provided to all staff. The efficacy and impact of these interventions were assessed using a whole campus online staff survey with further probing using classroom observations and subsequent interviews.

Findings – The results show alignment between the implementation of the ASPECTSS informed design interventions and responses to nine of the Likert scale items were all significantly lower than the middle response, indicating a high degree of satisfaction from survey respondents. These questions and responses related to the colour scheme facilitating ease of navigation for visitors of the school, the acoustics of the building successfully mitigating sound magnification and subsequently student distractibility, the organisation of the classrooms enhancing learning and the de-escalation zones allowing improved management of disruptive behaviours in the classroom.

Research limitations/implications – This study focuses primarily on the Autism ASPECTSS Design Index as a framework for assessing classroom efficacy. Other tools and frameworks may produce different insights. A single school site was studied. Validation of these findings in other school environments is necessary before generalising these strategies at scale. The use of qualitative tools, primarily teacher and staff surveys, provides one lens into the efficacy of these design strategies. Further research using measurable biometric indicators such as heart-rate and stress levels measured through wearable technology could provide a first step towards the triangulation of these findings.

Practical implications – These findings could help provide more standardised best practices for designing learning environments for autism, potentially providing supportive strategies with real impact on learning quality, skill development and knowledge acquisition in school environments. This could potentially have economic implications by supporting more efficient progress for autistic students through their school curriculum.

Social implications – Similar to economic impact, if validated and generalised, these findings could help with sense of accomplishment, general mental health improvement, alleviation of family stress and potential reduction of stigma in the autism community.

Originality/value – There is a slowly emerging field of design guidance for autism schools, but very little empirical evidence on the measurable efficacy of these strategies. This research provides one type of such evidence, as measured by the perceived impact from the point of view of staff and teachers at the school.

Keywords Universal design, Autism, Inclusive design, School design

Paper type Research paper

Introduction

The purpose of this paper is to report on the efficacy of ASPECTSS-informed school design on students with autism. This is carried out through a case study review of design interventions generated through an ASPECTSS-informed post-occupancy evaluation (POE) and their subsequent implementation at a K-12 public school for autism. The school is a K-12 charter school for children on the autism spectrum, split into two separate charter schools-one for 3–14 year olds and one for 14–21 year olds. Efficacy of these design interventions was assessed for this paper using staff surveys post-implementation, with classroom observations and subsequent interviews with staff to triangulate and further probe findings, contextualise them and expand understanding of impact.

The original design interventions were a result of a POE conducted in 2018 (Mostafa, 2018). ASPECTSS has been used to assess the performance of learning spaces with studies showing an alignment of its performance criteria with general perceptions of efficacy of space in surveys conducted with school community representatives (Mostafa, 2015). It forms the basis for the preliminary post-occupancy assessment conducted for this paper. In addition to the seven principles outlined by ASPECTSS: acoustics, spatial sequencing, escape spaces, compartmentalisation, transitions, sensory zoning and safety-the design interventions proposed in the original Post-Occupancy were informed by an expanded set of additional concepts, drawn from available literature and subsequent design projects implementing the ASPECTSS Index.

The Autism ASPECTSS Design Index, its criteria first outlined in 2012 (Mostafa, 2012) and later published in 2014 (Mostafa, 2014), is one of the first formal research-based design frameworks for the design of built environments for autism spectrum disorder. The research underpinning its development was first published in 2008 and presented school environment

testing of earlier versions of concepts such as acoustics, escape space, spatial sequencing, compartmentalisation and transitions (Mostafa, 2008). These concepts would later be formalised into the ASPECTSS Index.

The 2008 early research had its limitations-the study sample was small and the teacher-based observations and reporting were inevitably biassed, with teachers being aware of the test and study classroom assignments. Despite this, even its critics have found that although "(the) study is far from perfect, but it represents a paradigm shift in how architects have been studying autism design ... The study is among the first autism design studies to be prospective not retrospective, have a control group, and measure quantifiable factors in a systematic way. This approach is leagues above what most other architects have been doing" (Henry, 2012). Studies such as this current one help expand the understanding of the design-behaviour relationship in autism and provide data related to the further development of tools such as ASPECTSS and others for built environment assessment.

Other researchers have presented alternative frameworks for understanding the relationship between autistic behaviour and the built environment, particularly in learning spaces. McAllister and Li, in their 2012 work, view the school environment as a micro-city and propose the three Vitruvian elements of architecture-*clarity, construct and comfort*- as a linking framework between autistic needs and the built environment. They translated these 3 broad concepts into the ASD (autism spectrum disorder [1]) friendly considerations of: *wayfinding; place, event and legibility; connectivity; accessibility; belonging; atmosphere, resonance and quiet*. Many of these concepts align with criteria proposed in the ASPECTSS Index-place, event and legibility align with spatial sequencing; wayfinding aligns with sensory zoning; atmosphere, resonance and quiet align with acoustics. Their findings support that transferring the three Vitruvian qualities to the ASD friendly constructs is one way of giving users with ASD a voice in the design process when it is hard for them to communicate their needs (Mcallister and Li, 2012).

As one of the most common concerns of autistic users, as well as an important factor in classroom performance of general populations, acoustics is studied with some focus in relation to the role it plays in designing for autism. Kanakri *et al.*, look at the impact of noise on student classroom performance through a survey taken by ninety-five teachers from three schools for children with moderate to high functioning ASD in Houston, Texas. Of the noise sources studied, echoes and air conditioning systems had the most negative impact, with traffic showing moderate impact and operational noise sources such as other children and adjacent classrooms having the least negative impact. Certain specific architectural elements were identified as contributing to these noise sources including hard surfaces, metal furniture and high ceilings. The results also suggest solutions for noise control and general acoustical mitigation including: carpeting, wood furniture, transitional spaces and thick or acoustical walls. A second study by the same authors expands these findings and looks specifically at repetitive behaviours as a performance metric and indicator of behavioural distress in space in children from four classrooms at two schools diagnosed with high functioning autism. Specifically the repetitive behaviours measured included repetitive motor movements, repetitive speech, ear covering, hitting, loud vocalisations, blinking and verbally complaining. The results confirmed that there is a relation between the level of noise and the frequency of behaviours indicating distress. These two studies align with the ASPECTSS concept of acoustics, as well as those of sensory zoning, transitions, escape, compartmentalisation and spatial sequencing given the role they play in acoustical mitigation. It supports the proposed design intervention of general acoustical mitigation, provision of transitions and escape spaces.

Most recently in 2020, Dublin City University (DCU) began developing strategies for the world's first ever Autism Friendly University. This included the development of a design guide which was published in 2021 (Mostafa, 2021). The purpose of the guide is to support facility planning, new builds and design related decision making across the university's multiple campuses. The consequent Autism Friendly University Design Guide outlines a

second iteration of the original Autism ASPECTSS Design Index, titled ASPECTSS 2.0 as well as a formal Autism Friendly Design Audit based on the findings of the research underpinning the guide. The audit is both scalable and translatable across contexts other than university campuses.

ASPECTSS 2.0 expands the original 7 concepts with 8 additional ones. These are: colour; lighting; materiality; furniture; wayfinding and navigation; technology and smart systems; sensory economics; programming and operation. These expanded concepts, as well as the guidance outlined in the guide, are derived from a 3 months participatory research and design process. The study was premised on preliminary data provided by the university which included two primary sources-autistic student sensory audits on campus and a commissioned study conducted in 2016 titled "Living with Autism as a University Student at Dublin City University: Developing an Autism Friendly University". (Burke *et al.*, 2016). In addition to these preliminary findings the study utilised design-thinking based scoping workshops, individual interviews with autistic students; individual design workshops with autistic students and structured design reviews with DCU Autism Friendly leadership and staff as well as DCU Estates and Smart DCU.

There is also emerging literature that supports the value of this type of autism friendly design and its respective concepts, to the neurotypical population. Looking at the impact of the classroom environment more broadly on neurotypical populations, Lorraine E.Maxwell and Emily J. Chmielewski at the Department of Design and Environmental Analysis at Cornell University investigate the role of personalisation displays on kindergarten and first grade children's self -esteem. Although not related specifically to autism, their work partially supported the hypothesis of positive impact as measured by the Self-Esteem Index (SEI) scale and the Children's Inventory of Self-Esteem (CISE) scale. (Maxwell and Chmielewski, 2008). These findings supported the design intervention proposed by the POE which included tackable bulletin boards in the school hallways. This allowed the boards to be used as both acoustical mitigation as well display surfaces for students' work, potentially supporting the fostering of a sense of self-esteem.

Stuart Shell also outlines the positive benefits of a number of design strategies proposed by various autism design researchers for larger groups outside the autism spectrum. These include: spatial configuration; acoustics; lighting; thermal comfort; materials; air quality; and safety (Shell, 2017). Many of these strategies align with recent expanded design indices for increased design performance and indoor comfort for the general population such as the WELL Building Standard [2] and other certification metrics that align with recent Health, Safety and Welfare (HSW) standards outlined by agencies such as the American Institute of Architects (AIA). There is particular alignment in the WELL Comfort Features 72–84 which cover issues of indoor comfort and performance related to acoustical performance, thermal comfort, lighting and olfactory qualities. This emerging literature seems to indicate some alignment between autism specific design criteria and comfort for general populations. Although further research is required, this provides some preliminary indication that at the minimum, the type of design strategies proposed by the various autism design standards reviewed in this study will not conflict with basic needs of comfort for neurotypical users.

Most seminal in relation to effects of the built environment on student learning perhaps in the current literature is the work of Barrett *et al.* (2015). In a study of 3766 student's learning across 27 schools, the paper suggests that school design accounts for 716% of pupil's learning. It concludes seven key parameters that contribute to this impact, grouped across three categories: naturalness (light, temperature, air quality); individuality (ownership, flexibility); and stimulation (complexity, colour). The concepts of light, ownership, flexibility, complexity and color align with the ASPECTSS and ASPECTSS 2.0 concepts of spatial sequencing, escape, compartmentalisation, transition, sensory zoning and color and lighting respectively.

We also find alignment with the Lackney's (2000) principles of school design. Of particular alignment are the notions of: safety; clustering of instructional areas; creation of activity pockets; privacy niches; natural and full-spectrum lighting; healthy buildings and appropriate acoustics. These align with the ASPECTSS and ASPECTSS 2.0 notions of: safety, compartmentalisation; spatial sequencing; escape spaces; lighting; and acoustics respectively.

A comparative alignment assessment of the most relevant literature findings reviewed here is illustrated in Figure 1.

The ASPECTSS Design Index, with additional features from the literature reviewed-primarily color and wayfinding-was developed as the framework by which to perform a POE of the PreK-8 case study school in 2018 (Mostafa, 2018). The alignments found in the literature reviewed here further support this expansion of criteria and the consequent identification of priority design interventions.

The resultant POE concluded the following design interventions which were subsequently implemented in the school: colour-coding based navigation; acoustical treatments in key circulation spaces; introduction of transition alcoves (Plate 1); classroom reorganisation using compartmentalization principles; the introduction of escape spaces for de-escalation both in-class and at the whole-school level.

This original POE was limited in that it was only based on ASPECTSS principles, which did not at the time expand to include concepts related to materiality and operation, such as colour and wayfinding. These concepts were included in the design guidance as a result of user-engagement and feedback through the original POE, as well as the literature reviewed here. The index has since been formally expanded through further autism user-centred research to create an ASPECTSS 2.0 Design Index, which includes the following 8 additional concepts: colour; lighting; materials; furniture; wayfinding and navigation; technology; sensory economics; programming and operation (Mostafa, 2021). The literature reviewed here and its alignment with ASPECTSS and ASPECTSS 2.0 principles supports these expanded criteria.

This paper sets out to assess the impact of the resultant design interventions on students and staff of the schools.

Methodology

Three primary tools were used to measure the efficacy of the design interventions: observations, interviews and a survey of staff and teachers.

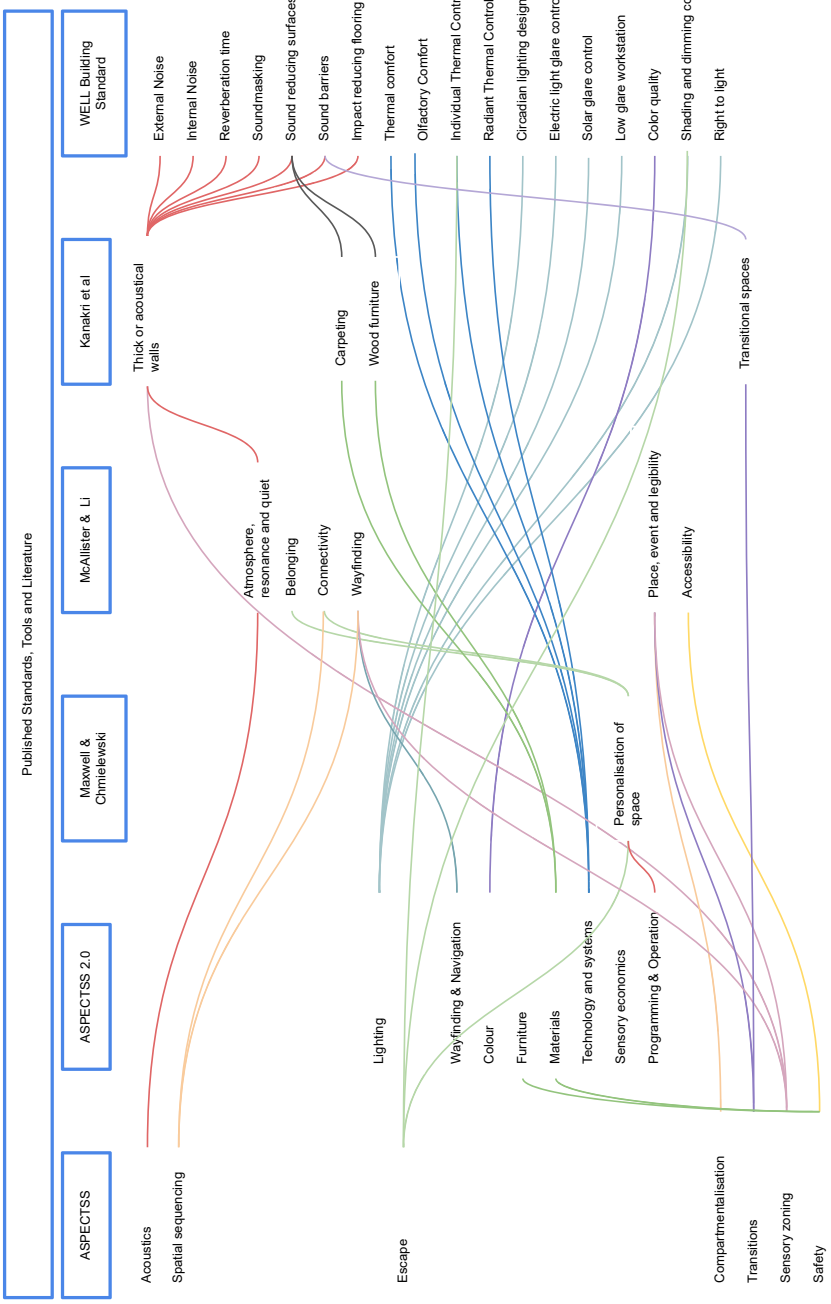
Observation and interviews

In order to facilitate a greater understanding of the impact of the design interventions, structured observations and interviews with key stakeholders were conducted 18 months after the design interventions were implemented. The data collected in the observations included: student make-up; scheduled activity type; space utilisation including escape space; behaviours exhibited by students and teacher response, particularly vis a vis spatial utilisation.

Two sets of interviews were conducted. The first set of interviews were conducted by the design architect and informed by the structured observation of classrooms and the general school environment. This first set of interviews was with the foundation chief operating officer (COO), observed classroom teachers, an early intervention teacher and the foundation's behaviour services manager. The primary framing question of this set of interviews was the impact of the changes on student behaviour and teacher experiences in the school. Further probing questions were asked as follow-up based on the responses.

The second set of interviews were conducted by the design architect with the school and foundation staff-namely the schools' principals and foundation COO.

Interviews were assessed using thematic content analysis. All interviews were prompted by the framing question "what is the impact of the changes made to the design of the school



Source(s): Figure created by author

Figure 1.
A diagram mapping the alignment of architectural concepts and criteria across ASPECTSS, other autism design literature and comfort criteria of the WELL Building Standard, showing overlaps and gaps in concepts across the tools

Plate 1.
Image showing the "purple pod" transition alcoves used for sensory regulation when moving from high stimulation activities to low stimulation, high focus activities in the classroom and vice-versa. Subsequent to their installation, they were used as student-requested reward time in support of positive reinforcement

Source(s): Figure created by author

spaces?". Further questions helped probe responses deeper as well as solicit suggestions for further design interventions catalysed by the design changes.

Observations were conducted by the design architect over a two-day site visit to the school. Data were collected during observations of two classrooms within the school in order to have a better understanding of the impact of the classroom layout. Classrooms were selected in order to evaluate the impact of the design features within a classroom that was fully compliant. A comparative observation of modified classrooms that were fully compliant with the proposed redesign strategy vs unmodified classrooms was conducted (Plates 2, 3, and 4). Observations were conducted through one-way glass partitions from an observation room to avoid disturbance or influence on the behaviour of students, teachers and aids. The observer was supervised and escorted by school staff at all times. Teachers were informed of the site visit but were not made aware of the specific observation time. Observations were conducted in 15 min samples randomly throughout the typical school day. The site visit was scheduled in the second week of the beginning of the Fall semester, to allow for accommodation and settling of students in the first week.

Survey instrument

The survey was developed by the design architect, the Foundation COO and the school principal. It consisted of 20 questions in 5 categories. The first category, navigation and way-finding, addressed issues related to design elements aimed at supporting transition. The second category, acoustics, addressed issues related to the impact of added noise reduction features. The third, classroom spatial reorganisation, addressed the impact of suggested classroom layout and organisation. Finally, questions related to escape and de-escalation spaces, addressed the addition and availability of dedicated deescalation spaces.

Source(s): Figure created by author

Plate 2.
Image of the ASPECTSS compliant classroom layout showing the group activity space

Additionally, one of the open-ended questions was included to gather perceptions of the impact of the design changes.

Overall, twelve of the questions measured the respondents agreement with position statements related to each area on a 5-point Likert scale, ranging from strongly agree to strongly disagree. In addition, the survey included five multiple choice questions as well as three yes/no questions (Table 1).

Survey analysis

The survey was disseminated via email and responses were collected through the online survey tool SurveyMonkey.The responses to the survey were then exported into a de-identified dataset within IBM SPSS version 28. This platform was also used for data analysis. For the 12 Likert scale items the responses were coded as follows; "strongly agree" = 1, "somewhat agree" = 2, "neither agree nor disagree" = 3, "somewhat disagree" = 4 and "strongly disagree" = 5. A series of one-sample *t*-test analyses were then conducted to determine whether the average responses to each of the 12 items were significantly different from a value of 3, signifying that responses were either significantly favourable or unfavourable for a given item. An additional one-sample *t*-test was conducted comparing the overall mean across all 12 items to the middle score of 3 ("neither agree nor disagree"). The results of the yes/no and multiple choice questions were also discussed.

Survey participants

The survey was sent to 91 staff at the elementary school including teachers, teacher assistants, speech therapists, occupational therapists, administrative staff and board chairs.

Plate 3.
Image of the ASPECTSS compliant classroom illustrating one of the individual work and small group compartmentalised spaces

Source(s): Figure created by author

Plate 4.
A panoramic view of the ASPECTSS compliant classroom

Source(s): Figure created by author

Additionally the survey was sent to a total of 34 individuals from the Foundation, who were familiar and occupied and treated clients within the building. The survey was sent to a total of 125 individuals which yielded 45 responses, a response rate of 36%.

Participating classrooms

The modified and fully compliant study classroom was an elementary class, with students ranging from 5-6 years old. The class composition consisted of 8 students (6 male and 2 female) with one teacher and 3 aids. The observation period was during first period at which time students were doing the good morning routine with a "days of the week" and "months of the year" exercise using the smart board.

The control sample class was an elementary class of students ranging in age between 6 and 8 years old. The class composition consisted of 9 students, all male, 1 teacher and 3 aids.

The observation period was during the second half of the first period during the good morning routine and days of the week activity. Upon concluding the activity students were first given a break before leaving the classroom for a walk.

Results

Observation

Study sample (modified fully compliant classroom). The classroom was set up using the template provided (Plate 1). It was well-organised, with materials stored or stacked in a

Navigation and finding your way:

2. In the post-occupancy evaluation commissioned by the school it was found that the symmetrical configuration of the school (i.e the similarity of the corridors on either side of the building) may lead to occasional disorientation in navigating around the school. It was proposed that visual aids may allow for better orientation throughout the school building. Consequently, to assist students' ability to navigate throughout the school each of the east and west wing corridors of the school were given a distinct color-blue and green respectively. Accordingly please answer the following questions

The color scheme adopted in the hallways is used as a prompt to facilitate independent navigation for **students**- for example "head to the blue hallway …"

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	N/A
○	○	○	○	○	○

3. The color scheme adopted in the hallways is used as a prompt to facilitate independent navigation for **visitors**- for example "head to the blue hallway …"

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	N/A
○	○	○	○	○	○

4. For staff who joined the school prior to February 2015, please answer the following:

The color scheme adopted in the hallways has been effective in improving independent way-finding and navigation for **students**

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
○	○	○	○	○	○

5. For staff who joined the school prior to February 2015, please answer the following:

The color scheme adopted in the hallways has been effective in improving way-finding and navigation for **staff**

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
○	○	○	○	○	○

(*continued*)

Table 1.
School Design Performance Survey

Acoustics

6. Based on the recommendations, acoustic ceiling panels were installed in the main school entrance foyer, found immediately after the double doors from the school lobby as you enter the main school hallway.

For staff at the school prior to February 2015:

The acoustics of the main school entrance foyer no longer creates an echo and sound trap

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
◯	◯	◯	◯	◯	◯

7. For all staff

Students do not exhibit behaviors that indicate an acoustical distraction in the main school entrance foyer. For example: clap their hands or make other forms of noise to hear an echo/ cover their ears when they are in the space/ avoid the space/ seem agitated when they are in the space

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
◯	◯	◯	◯	◯	◯

8. Additionally it was recommended that the bulletin boards installed in the hallways have acoustical properties to reduce echoes and general noise levels.

For staff at the school prior to February 2015

The acoustic panels installed in the hallways have reduced noise

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
◯	◯	◯	◯	◯	◯

9. For all staff:

The acoustic panels installed in the hallways have improved the behavior of the students when moving from one room to another- for example they are less distracted, move more efficiently, are able to move more independently:

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
◯	◯	◯	◯	◯	◯

Table 1. (*continued*)

10. Which improvements are you seeing specifically. Select all the apply:

- ☐ Students are less distracted
- ☐ Students are able to move more independently
- ☐ Students move more efficiently
- ☐ Other (please specify)

11. The purple pods (acoustical pods) introduced throughout the school are intended to create quiet, semi-isolated spaces that have less sensory stimulation.

The purple pods (acoustical pods) are used by students

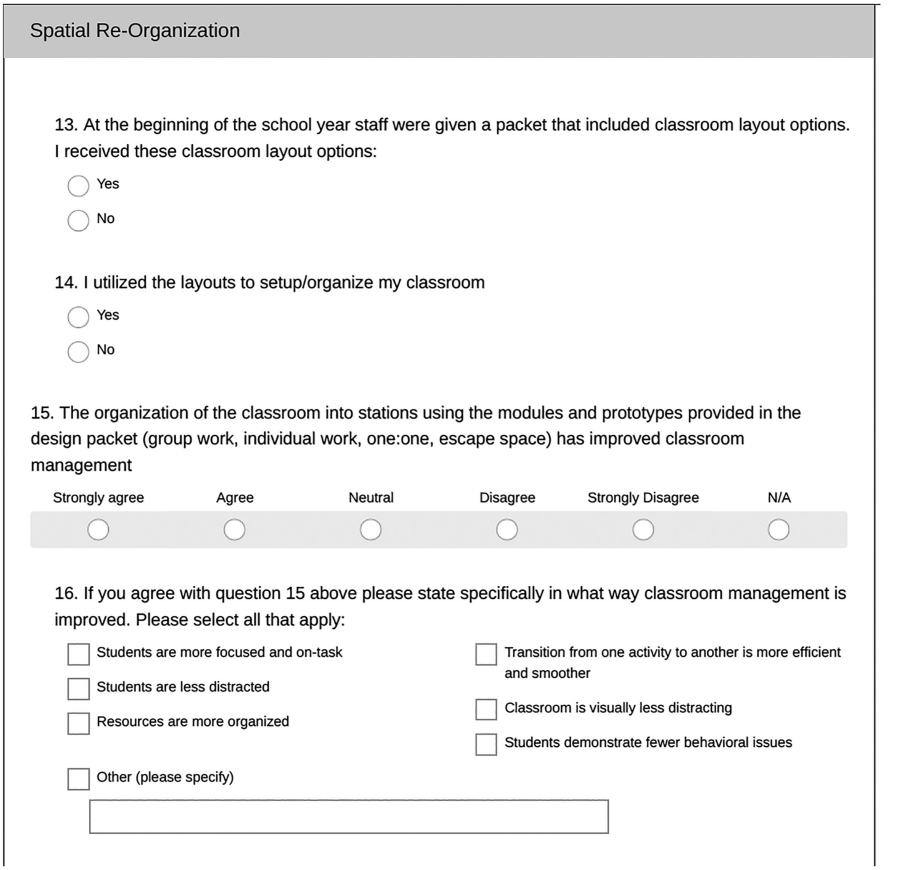
Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
○	○	○	○	○	○

12. When used, the purple pods are used for (select all that apply):

- ☐ Transitioning from high stimulation to low stimulation- for example when students move from the playground to the classroom
- ☐ Escape from sensory overload
- ☐ Social interaction
- ☐ Positive reinforcement i.e. reward time
- ☐ Other (please specify)

(*continued*)

Table 1.



Spatial Re-Organization

13. At the beginning of the school year staff were given a packet that included classroom layout options. I received these classroom layout options:

- ◯ Yes
- ◯ No

14. I utilized the layouts to setup/organize my classroom

- ◯ Yes
- ◯ No

15. The organization of the classroom into stations using the modules and prototypes provided in the design packet (group work, individual work, one:one, escape space) has improved classroom management

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
◯	◯	◯	◯	◯	◯

16. If you agree with question 15 above please state specifically in what way classroom management is improved. Please select all that apply:

- ☐ Students are more focused and on-task
- ☐ Students are less distracted
- ☐ Resources are more organized
- ☐ Transition from one activity to another is more efficient and smoother
- ☐ Classroom is visually less distracting
- ☐ Students demonstrate fewer behavioral issues
- ☐ Other (please specify)

Table 1. (*continued*)

De-Escalation Spaces

17. One of the recommendations was to introduce dedicated de-escalation spaces to be used when behaviors occur in students at varying degrees that cannot be managed within the classroom.

The availability of de-escalation rooms have helped in managing student's challenging behaviors

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
○	○	○	○	○	○

18. The availability of de-escalation rooms have helped reduce the number of severe behavior incidents in students

Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
○	○	○	○	○	○

19. In what ways are the de-escalation spaces used? Please select all that apply

- ☐ For full physical management of students
- ☐ For temporary removal from over-stimulating situations to avoid appearance or escalation of behaviors
- ☐ For independent access for students to remove themselves from an over-stimulating situation
- ☐ Other (please specify)

20. Are there any other observations about the recommended changes outlined above and their impact on students? If so please elaborate

Source(s): Table created by Author

Table 1.

manner to avoid distraction- storage shelves faced outwards from the escape space and the trampoline was folded up and stored in the kitchenette corner out of sight.

During the observation period, 2 instances of self-stimulatory behaviours were observed. In 2 students over the 30-min span. The first student was verbalising repetitively, rocking and then crying. Consequently they were moved by an aid to the teacher area to sit on a bouncy ball. One other student was also rocking in their chair, but was managed by the aid in the seat.. Both students remained engaged and on task with their peers, and their behaviours were managed within the activity space.

The observation of the participating study classroom demonstrated a sample of use aligned with the intent of the modified classroom arrangement. Examples of this alignment include:

(1) Appropriate use of storage to make supports readily available without distraction. Specifically a bounce ball chair was stored in the wall cupboard of the teacher area,

out of sight of students when not in use to avoid distraction, but accessible for use in a seamless transition of a student from the main group table to teacher space when needed. This demonstrated the spatial provision for a form of tertiary escape and de-escalation. The teacher space is compartmentalised yet visually accessible to the main teaching space, allowing the removed student to de-escalate while remaining engaged.

(2) The u-shaped table organisation proposed in the classroom template was used as intended, with students centred to their desks and at their seats, with the teacher at the board in the centre of the U, and teacher aids distributed at almost equal distances behind the students. The teacher appeared to have excellent control over the classroom, with the attention of all students. Instruction continued almost seamlessly when behaviours happened.

(3) One of the 2 challenging behaviours observed was resolved at the group table, with the second resolved in the teacher area which had been designated as a tertiary escape space with a bouncy ball, without the need to use the formal escape space. This showed an agile use of the classroom modular layout, allowing full utilisation of all compartments of space in parallel to one another, with minimal disruption to the classroom activity. The introduction of the teacher area as an alternative and informal escape space illustrates the affordances made by the design template and suggests perhaps that the multiple compartments were being used flexibly and that the formal escape space was reserved for more acute needs for de-escalation. This was confirmed in the follow-up interview with the class teacher.

Control sample (unmodified classroom). The control classroom did not adhere to the proposed classroom template and several limitations and challenges were subsequently noted during the observation period.

Two of the students were identified as having elopement tendencies and were assigned seats at adjacent tables, farthest from the classroom door, with 2 of the teachers' aides seated slightly to their left and behind them. One of them was engaged in one-to-one occupational therapy (OT) feeding support.

During the observation period of 30 min, 2 of the students were in the classroom escape space and not engaged in the group activity. In addition, challenging behaviour in one student was observed, with that student exhibiting increasing distress and lack of participation. In response to this behaviour, the first action was an attempt to manage the behaviour at the group table. When this did not resolve the behaviour, the student was invited to exit the classroom by one of the teacher aids for 3 min in the newly installed transition pod outside of the classroom as escape and for an opportunity to de-escalate and engage in more prosocial behaviours. The in-class escape space was occupied by 2 other students at that time and therefore not available for use. When the student rejoined the class the group was taken for a walk to transition prior to the next activity.

Further limitations in the classroom setting were noted including:

(1) Although modular arrangements were used to achieve compartmentalisation, the central group arrangement was in three clusters of three desks each. This left two of the students with their backs to the teacher while she was speaking and an inability to remain on task with any work on the desk while simultaneously paying attention to the teacher.

(2) Storage bins and other teaching materials were not stored in designated and closed storage, but rather some were in bins and on table tops. This is potentially distracting.

(3) The use of the escape space by two students early in the day suggests perhaps a need for additional transition to get on morning tasks, or the need for escape due to overstimulation so early in the day.

(4) Being occupied by two students, the third student requiring escape was escorted outside the classroom to the transition pod. This suggests that either a single escape space was insufficient for a class of 9 students or that perhaps students had a higher need for escape. Observation of the study class seems to support the latter interpretation.

(5) The designated teacher space was also setup with an additional screen and desk which during the interview with the teacher was revealed to be used for individual screen time. It was unclear if this was for classroom activities or as a form of reward, reaffirming the earlier observed benefits of the teacher space as a tertiary escape space for de-escalation and recalibration when students exhibit behaviours.

Interviews

The exploratory thematic analysis revealed 3 patterns across the 7 interviews conducted. These are summarised as follows.

(1) Transition spaces, which were primarily designed to support sensory adjustment, had expanded in their use. They were being used by students as occasional social spaces, as well as for student-requested positive reinforcement for tasks in the classrooms. They were being used by foundation staff and teachers for short span work spaces for note-taking, preparation and orientation between tasks (noted in 4 out of 7 interviews).

(2) The modular classroom prototypes provided allowed for individual therapies to be brought into the classrooms for push-in interventions. This provided an operational infrastructure that could be expanded to support parent/child training in early intervention classes (noted in 3 out of 7 interviews).

(3) There was an observed sense that students generally demonstrated slightly more independence, particularly as related to less distracted wayfinding and on-task activities in template-compliant classrooms (Noted in 2 out of 7 interviews).

The following elaborations were shared through probing for further design guidance catalysed by the design changes.

(1) For future iterations of design, a distinction between *intended sensory levels* (high stimulation/low stimulation needed) and *operational sensory levels* (high stimulation/low stimulation generated) may be helpful to provide a more nuanced spatial organisation and sensory zoning, particularly with early intervention students.

(2) Access to the outdoors could be made available, particularly for proprioceptive and vestibular needs that require space to move

(3) Furniture typologies should expand to include proprioception stimulation, such as bounce chairs, swings and yoga slings for hammocks

Survey

The average response across the 12 Likert scale items was 2.34 (SD = 0.52), which was significantly lower than the middle response of "satisfactory" in this sample, $t(36) = -7.63$, $p < 0.001$, indicating an overall general agreement with the statements from respondents.

Additionally, the average responses to questions 3 (M = 2.63, SD = 1.09), 4 (M = 2.74, SD = 1.37), 5 (M = 2.52, SD = 1.17), 6 (M = 1.87, SD = 0.69), 7 (M = 2.48, SD = 0.62), 8 (M = 2.32, SD = 0.67), 9 (M = 2.89, SD = 0.88) 11 (M = 1.59, SD = 0.56), 15 (M = 2.0, SD = 0.63), 17 (M = 1.70, SD = 0.65) and 18 (M = 2.11, SD = 0.77) indicated favorable agreement to the respective statements. Responses to question 6 were significantly different from the middle response of "satisfactory", $t(22) = -7.80$, $p < 0.001$. This was also the case for responses to question 7 ($t(32) = -4.78$, $p < 0.001$), question 8 ($t(18) = -4.44$, $p < 0.001$), question 11 ($t(33) = -14.98$, $p < 0.001$), question 15 ($t(15) = -6.33$, $p < 0.001$), question 17 ($t(29) = -10.93$, $p < 0.001$) and question 18 ($t(36) = -4.78$, $p < 0.001$). See table (1) for the specific content of the questions.

Only the average response to question 2 ("The color scheme adopted in the hallways is used as a prompt to facilitate independent navigation for students-for example "head to the blue hallway . . .") which was a 3.50 (SD = 0.62), was significantly greater than the middle response of "satisfactory" in this sample, $t(17) = 3.43$, $p = 0.003$, indicating a trend of disagreement with the prompt.

Responses to question 1, which was "I have read the statement above and agree to participate in this survey" reflected unanimous agreement (100%). Responses to question 13, "At the beginning of the school year staff were given a packet that included classroom layout options; I received these classroom layout options" included 14 "yes" responses and 13 "no" responses. The responses to question 14, "I utilized the layouts to setup/organize my classroom" consisted of 13 "yes" responses and 14 "no" responses.

In response to "Which improvements are you seeing specifically", the most common response was "students are moving more efficiently and independently".

In response to "When used, the purple pods are used for" the most common answer was "Transitioning from high stimulation to low stimulation-for example when students move from the playground to the classroom".

In response to "Please indicate in which way classroom management was improved" the most common reply was "Students are more focused and on-task", "Resources are more organized", and "transition from one task to the next is smoother and more efficient".

In response to "In what ways are the de-escalation spaces used"? The most common reply was "For temporary removal from over-stimulating situations to avoid appearance or escalation of behaviors".

Lastly, in response to "Are there any other observations about the recommended changes outlined above and their impact on students"? The most common response was "For independent access for students to remove themselves from an over-stimulating situation".

Discussion

The purpose of this project was to study the efficacy of the ASPECTSS Design Index concepts as drivers of design intervention for educational environments for students on the autism spectrum. Further, the seven principles of this index (acoustics, spatial sequencing, escape spaces, compartmentalization, transitions, sensory zoning and safety) were evaluated through interview, observation and survey responses in a participating autism preschool environment. Overall, there was converging evidence from these instruments -observation, interview and survey-to support the utility of the ASPECTSS Design Index for creating effective environments for students with autism.

Through observation measurements it was revealed that the classroom design allowed for numerous benefits in the context of learning within a classroom of a school for autism and other developmental delays. Primarily, the use of storage and de-escalation space enabled a swift and seamless transition of a student from the main class group to an alternative space when needed. The U-shape distribution allowed for excellent classroom control and created a

situation where classroom aids could provide equivalent degrees of assistance to each student. Lastly, the designated tertiary area with a bouncy ball provided the teachers and aids with the tools necessary to quickly resolve situations involving challenging behaviours.

In comparison, the control classroom did not comply with the principles of the ASPECTSS Design Index. Observations of this condition revealed several noteworthy results.The central classroom group arrangement was in three clusters of three desks each. This setup left two of the students facing away from their teacher, making it extremely challenging for sustained focus and activity engagement. Further, the lack of storage bins for materials lead to increased distractibility and the absence of a designated therapy/de-escalation space hindered the staff's ability to promptly curtail difficult behaviours.

Secondly, the feedback trends derived from the informal interviews suggested the partial success of a number of the design interventions, particularly the transition pods. The pods were originally intended to be used as a space for sensory recalibration and preparation prior to beginning class, particularly for children returning from a high-stimulation activity; however, numerous additional uses and potentials also emerged. These included 1) the use of the transition space for additional escape space from classrooms, particularly when disruption to class is an issue or if the in-class escape spaces are occupied and 2) the use of the transition space as part of the behaviour incentive system adopted in the curriculum. Further, transition pods were used by students for positive reinforcement, at times initiated by the student. Two of the interviewees even shared that students would request time in the transition pod as reward for tasks achieved or positive behaviour.

Notably, transition pods also were being used for the various neurotypical communities of the school. These included teachers, administrators, foundation staff, parents and visitors. Functions ranged from temporary work spaces between tasks, particularly for note taking during after classroom observations in the observation rooms, or as preparation prior to activities such as training, orientation, events and visits to the school. Transition pods were also used as social spaces for more than one individual to conduct semi-private conversations. These had the potential to occur between teachers, students, staff and external community members visiting the school. Of particular interest, as shared in one of the interviews, were emerging patterns in older students who would occasionally initiate conversation with familiar staff members in the hallways while seated in the transition pod. It was noted that this was less common prior to installation of the pods, or perhaps demonstrated by students who had social challenges and were perhaps less likely to initiate such conversations. This could be interpreted as the transition pods affording a safe space and sensory comfort zone that would allow for a more conducive social environment. This would potentially allow the interstitial spaces such as hallways and lobbies where such transition pods are located, to support social opportunities and life skills curriculum, allowing the whole school environment to be holistically supportive of the students' comprehensive development-beyond just the academic. Further study of the potential of such spaces would be useful to better understand their use.

The survey results further illustrated the impact of the recommended classroom design on the learning environment. Overall, there was a high degree of agreement in the responses across the 20 survey questions, suggesting that perceptions of the classroom design were favourable and that targeted goals were met from the design team. Responses to nine of the Likert scale items were all significantly lower than the middle response, indicating a high degree of satisfaction from survey respondents. These questions and responses related to the colour scheme facilitating ease of navigation for visitors of the school, the acoustics of the building successfully mitigating sound magnification and by way student distractibility, the organisation of the classrooms enhancing learning and the de-escalation zones allowing improved management of disruptive behaviours in the classroom.

The one item that did not receive favourable perceptions was question 2, "The colour scheme adopted in the hallways is used as a prompt to facilitate independent navigation for

students" It is possible that students did not have sufficient opportunities to navigate the hallways independently from the perspective of the respondent.

Triangulation (three outcome measures) was used to analyse efficacy in this study for three key purposes. (1) To increase the reliability of the results by deploying a robust combination of measures. (2) To ensure that faculty perceptions are aligned with the observations of the research team. This is critical because staff needs to be pleased with the design in order to maximise its utility. (3) To better recognize the gaps that still need to be better researched on this topic. From the results, it could be concluded that the design led to numerous positive changes in the classroom setting. Future research is still warranted using larger samples and longer observation periods. It is likely that the impacts of such a design continue to compile throughout the duration of the school year.

Conclusion

A review of the available autism design guidelines and literature revealed some growing patterns of alignment across various concepts. Six guidelines derived from other literature in the field were assessed, with all criteria of the ASPECTSS and ASPECTSS 2.0 collective set of guidelines aligned with concepts in at least one other set.

Across the measures of evaluation there was evidence to show a positive perception of this design implementation from teachers, aids and other staff members. The colour scheme, classroom organisation, designated de-escalation space and use of storage bins were particularly advantageous for enhancing learning and allowing distracting situations to be well managed.

There is also preliminary evidence that autism design strategies may provide affordances for other unintended and unexpected activities. This allows these design interventions to be appropriated for organic uses outside their intended function, not only for intended purposes of transition or escape for example, but for important life skill development such as social engagement and verbal communication. The hypothesis here is that the sensory reprieve these spaces provide allow for a window of opportunity to be made available, one which is not usually available due to surrounding sensory stimulation. This window, when made consistently available, may help generalise these social skills perhaps to other environments outside of the school structure.

Additionally, there was preliminary evidence that autism design strategies may provide benefits to neurotypical users and at the minimum not create barriers of use. This supports the consideration of codification of these strategies and their more widespread use as part of inclusive and universal design approaches.

Further, we recommend that individuals with autism in addition to staff members be included in future studies evaluating the impact of design modifications. These individuals have an important voice in this discussion and their opinions will be instrumental in allowing further advancement of this research.

Finally the evidence collected through this research seems to support the success of the 5 design interventions proposed as a result of the post-occupancy design assessment: colour-coding based navigation; acoustical treatments in key circulation spaces; introduction of transition alcoves; classroom reorganisation using compartmentalization principles; and the introduction of escape spaces for de-escalation both in-class and at the whole-school level.

Further study

The diverse literature demonstrates a need for a comprehensive tool to assess performance and catalyse design solutions for more effective classroom design and whole school strategies for impactful learning for ASD students within the larger and more intersectional construct of

mainstream users. Currently, tools provide conceptual frameworks across the following categories of design constructs: sensory environments, spatial organisation, materiality and operation. Prior to constructing this comprehensive tool, the assessment of the efficacy of each of these frameworks individually in guiding design could be constructive. This assessment should be based on performative metrics such as: increased independence; increased focus and minimised distraction; improved socialisation opportunities improved comfort and minimised distress.

This form of evidence-based investigation will hopefully provide designers with more reliable frameworks to responsibly design and assess effective environments for individuals on the autism spectrum. This need not be limited to K-12 educational typologies but can extend to higher education, workplace environments, recreational spaces, commercial projects, public spaces and cities.

Notes

1. This is the language used in the literature at the time. The authors of this paper would like to note that other less medicalised, more inclusive terminology is often used and perhaps preferable.
2. https://www.wellcertified.com/certification/v1/standard

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