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TOWARDS INCLUSIVE MULTISENSORY LEARNING SPACES: A CRITERIA-DRIVEN DESIGN FRAMEWORK

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KEYWORDS: *Autism Spectrum Disorder (ASD), Design for All, Inclusive Design, Multisensory classrooms, Sensory regulation, Spatial usability experience*

ABSTRACT

This article examines the issue of Autism Spectrum Disorder (ASD) in childhood, with particular attention to children aged five to ten who attend primary school, a context in which substantial challenges to inclusion and active participation in school life persist. This condition requires a significant paradigm shift in design, orienting it toward negotiable spaces capable of mediating meanings and fostering relationships among diverse forms of cognition. The research question guiding this article is: which design criteria support the development of a multisensory learning environment that is fully accessible to children with ASD and their neurotypical peers? The purpose of this study is to articulate a coherent framework of design criteria capable of guiding the development of a multisensory classroom accessible to both neurodivergent and neurotypical children, together with strategies required to translate these criteria into effective design practice. The research methodology was based on the collection of qualitative data obtained through semi-structured interviews and a structured validation questionnaire distributed to experts across the therapeutic, educational and design domains. The results revealed overwhelming positive feedback concerning the proposed design criteria. These findings contribute to the fulfilment of the initial research objective, demonstrating how a multisensory approach can provide both a theoretical foundation and a practical framework for designing educational environments that embrace neurodiversity.

INTRODUCTION

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterised by persistent difficulties across two primary diagnostic domains: social communication and interaction, and restricted, repetitive patterns of behaviour, activities and interests (Hyman et al., 2020; American Psychiatric Association, 2022). At present, diagnosis is articulated through severity levels, which delineate the intensity of symptoms and the extent of individual impairment across the two core domains, correlating these with adaptive functioning and the level of support required (APA, 2022; Gardner et al., 2024). Importantly, the second diagnostic domain encompasses atypical sensory processing, characterised by symptoms of hyper or hypo-reactivity to sensory stimuli, which may coexist within the same individual, as well as by sensory-seeking behaviours, defined as the active pursuit of sensory experiences in the

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environment (Posar & Visconti, 2018; APA, 2022; Chaxiong et al., 2022). Moreover, research has shown that atypical sensory responses and sensory-seeking behaviours can adversely influence attentional processes, which enable individuals to focus selectively on relevant information. This, in turn, significantly constrains the ability to sustain high levels of attention over extended periods in response to environmental demands (Brandes-Aitken et al., 2024; Salah et al., 2024). In the school context, children who struggle with sensory processing and attentional regulation inevitably experience adverse effects on their concentration and learning outcomes (Mallory & Keehn, 2021; Hill et al., 2023). This perspective is particularly significant in light of the growing prevalence of students with ASD, which has steadily increased over the past twenty-five years, from 1 in 150 children to 1 in 54 or greater (Mallory & Keehn, 2021; Hill et al., 2023). Furthermore, traditional educational settings continue to exhibit structural limitations, as they are rarely designed with consideration for neurodiversity or the integration of Universal Design for Learning (UDL) principles. In this regard, in recent years, there has been a growing awareness within educational debate of the restrictive and detrimental impact of standardisation in school environments. According to Bluteau et al. (2022), students' interaction with space contributes profoundly not only to their learning, but also to their cognitive, emotional and social development. From an interdisciplinary view, the classroom is no longer conceived merely as a place of instruction, but as a dynamic environment in which children and their surroundings mutually influence and shape one another (Bluteau et al., 2022). This condition calls for a significant paradigm shift in design, orienting it toward negotiable spaces capable of mediating meanings and fostering relationships among diverse forms of cognition. To this end, the study seeks to answer the following research question: How is it possible to design a truly inclusive educational environment? To do so, it presents a coherent framework of design criteria derived from a mixed-method approach combining a literature review with in-field data collection carried out through interviews with professionals from diverse disciplines (from the therapeutic, educational and design fields). This framework aims to guide the creation of multisensory classrooms that are accessible to both neurodivergent and neurotypical children. It also outlines strategies for translating these criteria into effective design practice. Subsequently, the same experts completed a structured validation questionnaire, providing their assessments of the proposed design criteria regarding their pedagogical coherence, design relevance and operational effectiveness. Finally, the article presents an initial pilot project in which these design criteria and strategies are applied.

METHODOLOGY

This study adopted a qualitative research approach, articulated through a multi-step process. In the initial phase, relevant literature in the fields of autism studies, environmental psychology, and inclusive educational design was systematically examined, with particular attention to Autism Spectrum Disorder (ASD) in childhood, atypical sensory processing, attentional regulation, and their implications for school participation and learning. Within this body of knowledge, the ASPECTSS™ Design Index (Mostafa, 2014; Mostafa et al., 2024) was identified as a key reference framework and selected as the conceptual starting point of the study, due to its explicit focus on sensory-informed design for autistic users. Building on this theoretical grounding, the second phase involved in-field data collection through semi-structured interviews with professionals from complementary disciplinary backgrounds, including an architect, a primary school support teacher, a director of a non-

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profit organization focused on autism, a cognitive-behavioural psychotherapist, and a behaviour analyst. The interviews aimed to critically interrogate, contextualize, and expand the preliminary design principles emerging from the literature, incorporating practice-based knowledge from therapeutic, educational, and design perspectives. Insights derived from both the theoretical exploration and the expert interviews informed the development of a structured design framework. The framework is articulated into two overarching domains, nine design criteria, and a set of corresponding design strategies intended to support the creation of multisensory, inclusive classroom environments for both neurodivergent and neurotypical children. In a subsequent phase, the proposed framework was subjected to an initial validation process. A structured questionnaire was administered to the same group of professionals to assess the pedagogical coherence, design relevance, and perceived effectiveness of the identified criteria and strategies. The following section presents the resulting framework and summarizes the outcomes of this validation phase. While other components of the research process—such as the full qualitative analysis of interview data and the extended validation of the strategies—are not reported in this article, they remain integral to the broader methodological structure of the study.

RESULTS

For the design of inclusive multisensory environments within the school context, an integrated framework of design criteria has been developed, structured around two interrelated domains: the regulation of sensory stimuli and the spatial accessibility and usability. This articulation arises from the need to integrate factors concerning the perceptual and regulatory quality of the environment with those related to physical and cognitive accessibility, in accordance with the principles of Design for All (DfA). The first design domain (regulation of sensory stimuli) includes all criteria aimed at regulating the intensity, quality and consistency of sensory inputs, including perceptual environmental neutrality, responsive lighting, adaptive acoustics, graduated sensory integration and controlled sensory isolation. The second domain (spatial accessibility and usability) includes all design criteria related to spatial configuration, organization and communication, including dynamic spatial adaptability, sensory zoning, environmental functional capacity and augmentative visual systems. The distinction between the two domains does not imply an operational separation; rather, it constitutes an integrated interpretative framework that highlights a design matrix for an inclusive multisensory classroom, conceived as an adaptive ecosystem supporting and enriching the educational experience. The hierarchical structure of the design framework is shown in Figure 1, illustrating the relationship between domains, criteria and design strategies.

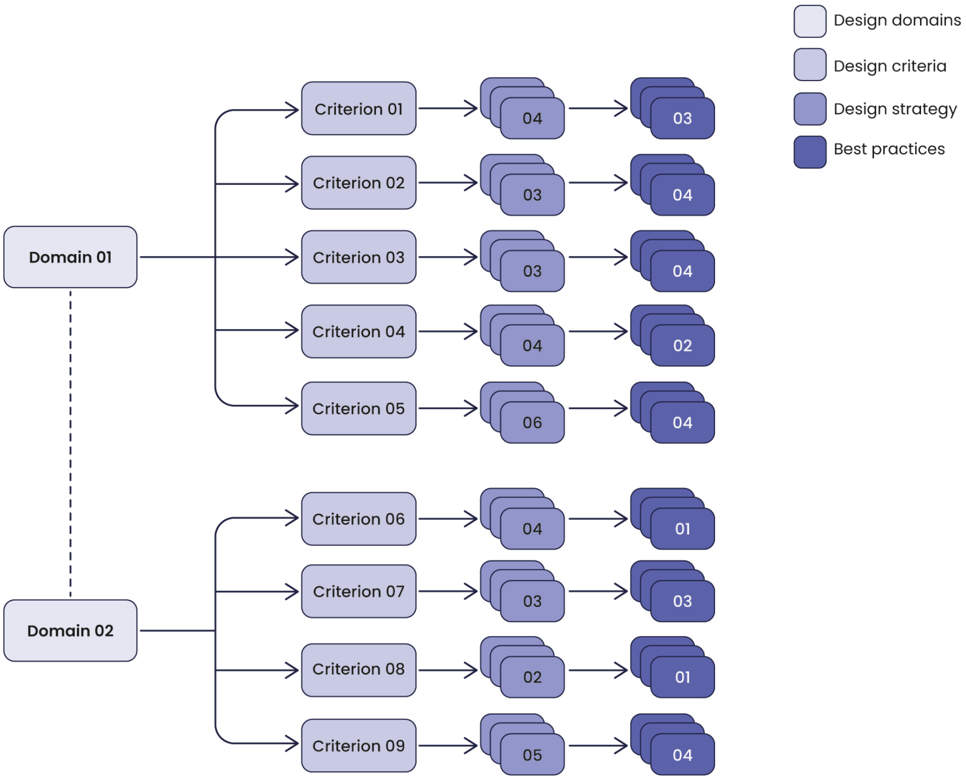

Figure 1. Flowchart of the design framework

Design domain 1 (dd1): regulation of sensory stimuli

The first design criterion (perceptual environmental neutrality) primarily aims to mitigate sensory overstimulation and foster selective attention (Butera et al., 2020; Godwin et al., 2020; Gentil-Gutiérrez et al., 2021). The first design strategy guiding this criterion involves adopting a neutral color palette with low contrast and medium reflectance (Nair et al., 2022; Jiang et al., 2023). A second strategy involves introducing a single accent element within the overall color scheme to provide a visual reference point (Helvacıog˘lu & Olguntürk, 2011; Li et al., 2024). Consequently, perceptual neutrality also extends to the spatial organisation of the classroom, which should be devoid of visual clutter and characterized by an orderly arrangement of materials within designated storage units (Zazzi & Faragher, 2018; Godwin et al., 2020). The final strategy pertains to the tactile and visual quality of surfaces, which should feature uniform textures and be devoid of intricate patterns (Almaz, 2022; Rezaul Karim et al., 2022). The second design criterion (responsive lighting) is conceived as an integrated environmental and educational system in which light plays a central role in shaping a cognitive and relational atmosphere (Mott et al., 2012; Gao et al., 2025). An initial design strategy entails the intentional modulation of light intensity to delineate the different moments of the school routine. In this way, artificial lighting becomes a communicative tool that accompanies and structures the learning process, visually marking the day's phases (Mott et al., 2012; Lech et al., 2023; Gao et al., 2025). A second strategy entails tailoring light intensity and tone to individual sensory profiles. In this context, light functions as a therapeutic and adaptive medium, capable of alleviating sensory overload in children with visual hyper-responsiveness while enhancing stimulation in those exhibiting hypo-responsiveness (Gao et al., 2025; Quiles-Rodríguez et al., 2025). Finally, a third design strategy entails the centralised control of artificial lighting, entrusted to the teacher, to prevent impulsive use or inconsistent stimulation by students (Mott et al., 2012;

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Schledermann et al., 2019). The third design criterion (adaptive acoustics) redefines sound from a potential source of stress into an instrument of educational mediation. An acoustically calibrated environment not only mitigates avoidance and discomfort responses but also becomes an integral component of the pedagogical framework, conveying coherent and measurable sensory cues (Danesh et al., 2021; Williams et al., 2021). The first design strategy entails conducting a preliminary acoustic assessment of the classroom to identify potential sources of disturbance such as reverberation, echo or background noise (Williams et al., 2021; Mealings, 2023). The second strategy involves defining calibrated and customisable auditory stimulus gradients across the classroom's functional areas, intending to mitigate sensory overload through spatial sound modulation (Williams et al., 2021; Mealings, 2023). Finally, a third design strategy concerns the optional and adjustable nature of sound stimulation, which should be capable of being activated, modulated or deactivated by the teacher in accordance with the specific sensory needs of the students (Danesh et al., 2021; Williams et al., 2021). The fourth design criterion (graduated sensory integration) advances a relational and adaptive design model whose primary objective is to support the child's autonomous re-engagement with their learning context, enabling the recovery from sensory overload in a regulated yet spontaneous manner (Pfeiffer et al., 2021; Hutson & Hutson, 2024). An initial design strategy involves providing a sensory toolkit[1] calibrated across multiple perceptual channels, enabling interventions to be tailored to individual sensory needs while fostering choice and autonomy within the self-regulation process. A second design strategy concerns the selection of sensory materials within the toolkit, which should be neutral, adaptable and age-appropriate for the students. The third design strategy involves regularly maintaining and monitoring the sensory inserts within the toolkit (Fan et al., 2024; Hutson & Hutson, 2024). The fourth design strategy seeks to ensure educational and sensory continuity between school and home environments using familiar materials from the child's everyday life, thereby promoting the generalisation (Pfeiffer et al., 2011; Jones et al., 2020; Hutson & Hutson, 2024). The final criterion within the DD1 is controlled sensory isolation, which defines a model of adaptive pedagogical architecture wherein the decompression space functions as a diffuse therapeutic environment (Clément et al., 2022; Marwati et al., 2023; Finnigan, 2024). A first strategy concerns adherence to the minimum ergonomic dimensions of the decompression corner, approximately 4,58 m2, sufficient to allow the child to adopt relaxed postures, perform small movements and engage in self-regulatory activities while avoiding any sense of physical constraint (Clément et al., 2022; Marwati et al., 2023). The second design strategy entails providing clearly identifiable and easily accessible decompression zones within the classroom, positioned near the most stimulating areas, ensuring students can easily reach them when needed (Clément et al., 2022; Unwin et al., 2022; Marwati et al., 2023; Finnigan, 2024). As a third design strategy, decompression areas should be positioned laterally to the main space, thereby preventing interference with circulation routes and ongoing teaching activities (Clément et al., 2022; Unwin et al., 2022; Finnigan, 2024). A fourth design strategy entails the functional differentiation of decompression zones within the classroom, calibrated according to their intended purpose and degree of sensory isolation (Marwati et al., 2023; Finnigan, 2024). Furthermore, decompression zones should be modular and upholstered, allowing adaptation to diverse methods of emotional self-regulation. This flexibility enables both students and teachers to adjust the configuration of the area in response to specific emotional and sensory needs. A final design strategy entails the integration of clear visual signals indicating

[1] A set of sensory tools designed and calibrated to operate in a coordinated way across multiple perceptual channels, including the visual, auditory, tactile, olfactory, proprioceptive and vestibular systems.

the status of the decompression space, whether available or occupied, thereby promoting self-regulation and facilitating rotation among students (Unwin et al., 2022; Marwati et al., 2023; Finnigan, 2024).

Design domain 2 (dd2): accessibility and spatial usability

The DD2 is framed by an initial criterion of dynamic spatial adaptability, referring to the environment's capacity to respond flexibly to diverse individual sensory profiles and personalised education plans (Bluteau et al., 2022; Baars et al., 2023; Morris & Imms, 2025). An initial design strategy involves conceiving the classroom as a modular system, wherein spatial components and furniture can be reconfigured, allowing for partial or complete transformations of the environment (Baars et al., 2023; Larose et al., 2024; Morris & Imms, 2025). A second strategy entails the use of mobile, interchangeable and lightweight equipment, enabling periodic reconfigurations of the multisensory classroom to experiment with various perceptual arrangements and assess students' sensory responses (Bluteau et al., 2022; Baars et al., 2023; Morris & Imms, 2025). Another design strategy establishes transition zones between the classroom's primary functions, characterised by mobile and reconfigurable elements that facilitate a gradual and controlled progression between activities. Finally, the fourth design strategy entails the creation of dedicated teacher zones designed to facilitate discrete support and guidance for students (Mallory & Keehn, 2021; Baars et al., 2023; Morris & Imms, 2025). The second design criterion (sensory zoning) addresses the need to minimise spatial ambiguity and facilitate sensory regulation during transitions between different educational and recreational activities (Tola et al., 2021; Habbak & Khodeir, 2023; Al Qutub et al., 2024). A first strategy involves scaling the criterion to the structural conditions of the space: in large environments, a clearly defined functional compartmentalisation may be adopted, whereas in smaller settings, spatial fluidity should be prioritised (Tola et al., 2021; Habbak & Khodeir, 2023). A second strategy entails defining intelligible and predictable micro-spaces, ensuring that each area of the classroom clearly conveys the activity intended to occur within it (Tola et al., 2021; Llorens-Gámez et al., 2022; Habbak & Khodeir, 2023). A final strategy involves designing a unidirectional path that gradually guides students through varying levels of sensory intensity, sequencing areas from the calmest to the most stimulating and back again (Tola et al., 2021; Habbak & Khodeir, 2023). The third design criterion (environmental functional capacity) seeks to regulate social and sensory interaction within the school environment, helping to avoid overstimulation states commonly preceding dysfunctional behaviors in children with ASD (Gentil-Gutiérrez et al., 2021; Al Qutub et al., 2024; Mills et al., 2025). The first design strategy entails configuring the classroom to accommodate small groups of students, intentionally limiting its functional capacity to facilitate closer teacher observation (Banire et al., 2021; Al Qutub et al., 2024; Mills et al., 2025). A second strategy involves setting a maximum number of children per functional area, thereby ensuring a balanced and controlled distribution of students throughout the classroom (Gentil-Gutiérrez et al., 2021; Al Qutub et al., 2024; Mills et al., 2025). The final design criterion addresses augmentative visual systems, aimed at enhancing engagement and fostering active participation among children with ASD (Meadan et al., 2011; Rutherford et al., 2020; Bateman et al., 2023). A first strategy entails the implementation of a structured wayfinding system that facilitates orientation and smooth transitions between the classroom's diverse functional areas and activities (Meadan et al., 2011; Rutherford et al., 2020; Liang et al., 2024). A second

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design strategy involves developing three hierarchical levels of visual communication — macro, meso and micro — differentiated according to the scale and communicative function of the conveyed information (Meadan et al., 2011; Rutherford et al., 2020). A third strategy provides mobile supports for the installation of augmentative visual aids, allowing them to be easily relocated and reconfigured in response to shifts in educational and recreational activities (Meadan et al., 2011; Rutherford et al., 2020; Liang et al., 2024). An additional design strategy involves employing augmented visual systems to foster collaboration and rotation among students, conveying information through clear and immediate visual messages (Meadan et al., 2011; Rutherford et al., 2020; Bateman et al., 2023). Finally, the last strategy focuses on fostering intergenerational collaboration among teachers, therapists and parents through the consistent visualisations of personalised education plan objectives (Rutherford et al., 2020; Petersson-Bloom & Holmqvist, 2022; Bateman et al., 2023). The system of design domains, criteria and corresponding strategies discussed above is visually synthesised in Figure 2, which serves as a reference framework for the proposed multisensory classroom design.

Design domains	Design criteria	Design strategies	Best practices
Regulation of sensory stimuli	**Perceptual environmental neutrality**	• Neutral palette with subdued contrast and moderate reflectance. • A single accent element within the overall colour scheme. • Orderly organisation of materials within designated storage units. • Textures should be uniform and devoid of intricate patterns.	• Opt for palettes in ivory, neutral beige, warm grey, desaturated green, or cyan. • Avoid the overlapping of multiple chromatic accents. • Favor regular, anti-reflective textures with matte or satin finishes and smooth or soft surfaces.
	Responsive lighting	• Use of light intensity variations to delineate the school routine. • Adjustment of light intensity and tone to individual sensory profiles. • Centralised control of artificial lighting under teacher supervision.	• Automatically activated before entry (4000 K). • Intensifies at the start of activities (6500 K). • Dynamically modulated during transitions (3500–6500 K). • Softens to warm tones during breaks and at the end of the day (2700–3000 K).
	Adaptive acoustics	• Undertaking a preliminary acoustic assessment of the classroom. • Defining calibrated, customisable auditory stimulus gradients across functional areas. • Optional and adjustable sound stimulation, modulated by the teacher.	• Adoption of acoustic absorbers and/or diffusers, installable on the ceiling. • Introduction of adjustable background sounds, such as white noise, and the selective use of music and natural sounds. • In decompression areas, acoustic environments should be muted. • Localized and directional sound delivery through the individual use of noise-cancelling headphones.
	Graduated sensory integration	• Providing a sensory toolkit balanced across multiple perceptual channels. • Toolkit materials should be neutral, adaptable and age-appropriate. • Regular maintenance and monitoring of the toolkit's sensory inserts. • Use of materials familiar from the child's home environment.	• Select materials with comfortable, uniform, and easy-to-clean textures. • Favor familiar materials commonly used in domestic settings.
	Controlled sensory isolation	• Compliance with basic ergonomic standards for the decompression corner. • Provision of clearly identifiable and accessible decompression zones. • Position decompression areas laterally to the main space. • Functional differentiation of decompression zones within the classroom environment. • Decompression zones should be modular and cushioned. • Integration of clear visual cues indicating the status of the decompression space.	• Position decompression zones near more stimulating areas. • Provide an accessible and clearly signposted access route. • Design semi-open, partially screened zones, avoiding total isolation. • Ensure single-user access at a time.
Spatial accessibility and usability	**Dynamic spatial adaptability**	• Conceiving the classroom as a modular system. • Use mobile, interchangeable and lightweight furnishings. • Definition of transition zones between the classroom's primary functions. • Creation of spaces supporting teacher co-presence.	• Plan periodic furniture re-layouts to assess and respond to students' sensory feedback.
	Sensory zoning	• Adapt zoning to the structural conditions of the space. • Defining intelligible and predictable micro-spaces. • Design a unidirectional path that gradually guides pupils through varying sensory intensities.	• In large spaces, implement clear functional zoning; in smaller ones, promote spatial fluidity. • Provide six distinct functional zones: entrance, teacher-led instruction area, group learning area, play area, decompression area and storage. • Arrange areas from the calmest to the most stimulating, and back again.
	Environmental functional capacity	• Designing the classroom to accommodate small student groups. • Setting a maximum number of pupils per functional area.	• Visually indicate the maximum number of occupants allowed at the entrance of each area.
	Augmentative visual systems	• Implementation of a structured wayfinding system. • Designing three tiers of visual communication: macro, meso and micro. • Provide mobile supports for installing augmentative visual aids. • Use augmented visual systems to foster collaboration and pupil rotation. • Promote intergenerational collaboration through consistent visualisation of personalised education plan objectives.	• Clarify the sequence of experiences and reduce environmental unpredictability. • The visual communication system must be appropriate to the child's age and developmental stage. • The visual communication system should be easily updatable. • Use of coherent, shared infographics outlining the objectives of the Individualized Education Plan.

Figure 2. Summary table of domains, criteria and design strategies

PRELIMINARY VALIDATION OF THE DESIGN FRAMEWORK

A validation questionnaire was developed and administered to assess the coherence, relevance, and perceived effectiveness of the proposed design criteria for a multisensory classroom intended for neurodivergent and neurotypical children aged five to ten, in accordance with the principles of

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Design for All (DfA). The primary aim of this phase was to gather expert-based feedback on the pedagogical and design value of the proposed criteria, as well as to identify potential critical issues and areas for further refinement. The questionnaire was submitted to the same group of professionals involved in the interview phase (n = 5), reflecting an intentionally focused and expert-driven sample. While limited in size, this group represented complementary disciplinary perspectives spanning architecture, education, psychotherapy, behavioral analysis, and autism advocacy. Accordingly, this validation phase should be understood as a preliminary and exploratory step, aimed at testing the internal coherence and conceptual soundness of the proposed framework rather than providing statistically generalizable results. The questionnaire consisted of multiple-choice items rated on a five-point Likert scale (1 = not effective; 5 = very effective), complemented by open-ended questions. This mixed structure enabled both the quantification of consensus levels and the collection of qualitative insights regarding the perceived effectiveness of each design criterion. Participants evaluated the proposed design criteria across the two identified design domains, producing differentiated yet largely convergent outcomes. Within DD1 (regulation of sensory stimuli), results indicated a strong level of agreement among respondents: 80% of experts rated the criteria of perceptual environmental neutrality and responsive lighting as effective, while adaptive acoustics received the highest level of endorsement, with 100% of participants rating it as very effective. The criteria of graduated sensory integration and controlled sensory isolation were also positively assessed, with 60% of respondents rating them as very effective. Evaluations related to DD2 (accessibility and spatial usability) reflected a comparable degree of approval. Dynamic spatial adaptability was rated as very effective by 80% of participants, while sensory zoning received a very effective rating from 60% of respondents. The criterion of environmental functional capacity achieved unanimous agreement, with 100% of experts evaluating it as very effective. More differentiated responses emerged for augmentative visual systems: 40% of participants rated them as very effective and 40% as moderately effective, suggesting an overall positive yet more nuanced perception of this criterion. The distribution of expert evaluations across the design criteria is summarized in Figure 3, which provides a visual synthesis of the results obtained for both the regulation of sensory stimuli and the accessibility and spatial usability domains. Given the exploratory nature of this validation phase and the limited number of participants, future research will necessarily involve the expansion of the evaluation sample to include a broader range of stakeholders, such as additional educators, designers, therapists, and school administrators, to further test, refine, and consolidate the proposed framework.

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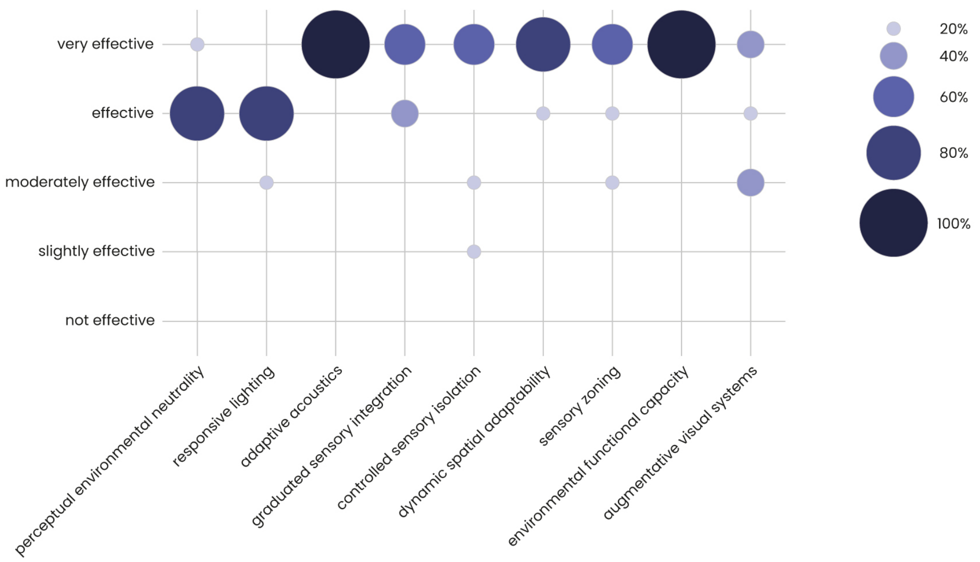

Figure 3. Validation results for all design criteria

A FIRST APPLICATION OF DESIGN CRITERIA AND STRATEGIES: HUDDLE, A PILOT DESIGN PROJECT

This section outlines the initial application of the proposed design criteria through Huddle, a pilot project developed within a standard classroom compliant with Italian educational regulations. Defined by appropriate dimensional and lighting parameters, the space provides a technical framework for testing the integration and replicability of multisensory and inclusive design strategies within a real school context. The design of Huddle is grounded in the principle of perceptual environmental neutrality, aimed at minimizing sensory load and enhancing visual comfort. The project adopts a palette of neutral tones combined with a single system of desaturated accents, used as orientation tools to signal different levels of sensory stimulation and spatial functions, thereby avoiding perceptual fragmentation. From a material perspective, the furniture system primarily employs poplar plywood, selected for its structural properties and its contribution to a visually balanced atmosphere. The uniformity of textures and the organization of materials within dedicated storage areas collectively help reduce visual noise within the classroom. The project incorporates responsive lighting as a tool to support sensory regulation and accommodate the different phases of the school day. Four lighting configurations are defined: neutral lighting at entry to facilitate transition; brighter and cooler illumination during learning activities to support attention; dynamic modulation during transitional phases; warmer and dimmed lighting during breaks and at the end of the day to promote relaxation. Alongside lighting, the project implements an adaptive acoustic strategy aimed at reducing ambient noise and enhancing auditory comfort. Ceiling-mounted sound-absorbing elements and acoustic diffusers are provided to control reverberation, while localized sound delivery in the decompression area is enabled through the use of noise-cancelling headphones. In this space, adjustable sounds may be introduced, or a muted acoustic environment may be maintained as needed. The management of both lighting and sound is centralized and entrusted to the teacher, allowing for control and personalization of the sensory experience. The project introduces the criterion of graduated sensory integration through an analog sensory wall accessible to all students and located within the free-play area. The device provides controlled stimulation of tactile, visual, auditory and proprioceptive

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channels through manipulable modules, low-intensity sound-producing volumes and a tactile pathway organized by texture type and perceptual intensity. The use of common, readily available materials supports the generalization of sensory experiences between school and domestic contexts, while modularity and interaction predictability foster sensory regulation and tactile discrimination without inducing overstimulation. Furthermore, Huddle adopts the criterion of controlled sensory isolation to support moments of self-regulation through a decompression area, which is strategically located near more stimulating zones. Positioned laterally within the classroom, the space offers two alternative configurations: a partially screened option and a semi-open one, balancing perceptual protection and the possibility of teacher monitoring. Conceived as a modular and padded element, the decompression areas integrate seamlessly into the furniture system and adapt to the classroom's various spatial configurations. The project applies the criterion of dynamic spatial adaptability, conceiving the classroom as a modular system in which fixed furniture is designed according to principles of modularity, while mobile components are lightweight and interchangeable. This configuration enables periodic reconfigurations of the layout in response to activities and students' sensory responses. Given the limited floor area of the classroom, spatial continuity is prioritized, while still providing a designated area for teacher co-presence integrated within the frontal teaching zone. In addition, the project applies the criterion of sensory zoning, adapting it to the classroom's structural conditions and favoring a fluid and legible configuration. Functions are organized into six distinct zones, arranged along a progression from lower to higher levels of stimulation and back again: entrance, frontal instruction, group learning, free play, decompression and storage (reserved for teachers). Each area is made immediately recognizable through the use of color as a sensory and functional code indicating levels of stimulation and activity types, while the storage space is deliberately left unmarked to prevent it from being perceived as accessible to students. Huddle addresses the environmental functional capacity, dimensioning the classroom for 25 students while allowing for controlled use by a maximum of 10 students at any given time, in order to ensure well-being and limit sensory stimulation. For each functional zone, a maximum number of users is defined, preventing overcrowding and ensuring a clear correspondence between space and function, thereby supporting differentiated modes of use and the diverse learning and self-regulation needs of students. Finally, the project integrates augmentative visual systems through a structured wayfinding framework designed to clarify the sequence of experiences and reduce environmental unpredictability. Visual communication is organized across three hierarchical levels: macro, to identify classroom zones; meso, to support transitions between areas; and micro, to make rules and daily activities visible. This system complements the physical configuration of the space, supporting predictability and the construction of shared routines, particularly for neurodivergent children. Figure 4 illustrates the floor plan of the Huddle pilot project, highlighting the arrangement of fixed and movable furniture and the organization of the different stimulation zones within the classroom.

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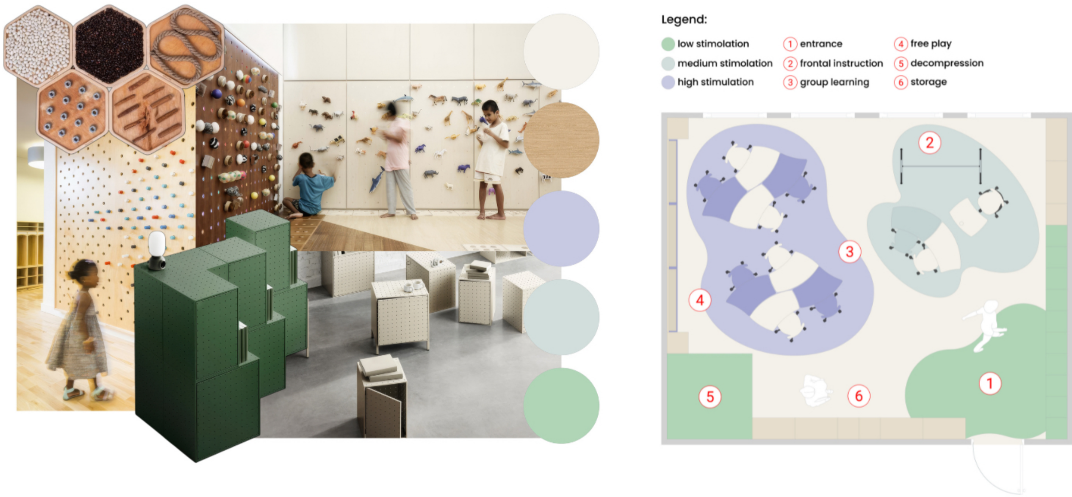

Figure 4. Huddle, a pilot design project for an inclusive learning space

DISCUSSION AND CONCLUSIONS

The article advances the ongoing international discourse on autism-friendly design, building on established frameworks such as the ASPECTSS™ Design Index (Mostafa, 2014) and its updated Second Iteration (Mostafa et al., 2024). It aligns with key assumptions of the ASPECTSS™ model, highlighting how spatial design influences well-being, behaviour, and sensory regulation in individuals with ASD, while incorporating several criteria from both versions of the model. A key distinction, however, lies in the methodology: the proposed framework introduces an explicit hierarchy of domains, criteria, and strategies, providing a systematic, operational tool to translate theoretical principles into best design practices for inclusive learning environments for children with ASD and their neurotypical peers. Moreover, while the ASPECTSS™ model is designed specifically for ASD-oriented environments, this research adopts a broader and inclusive perspective grounded in Design for All (DfA) and Universal Design for Learning (UDL) approach. This enables the design of spaces that can be used by both neurodivergent and neurotypical students within the same educational context. Nevertheless, it is important to note several limitations of the study. The first one concerns the size and composition of the expert sample involved in the validation questionnaire. Although the participants represented three complementary disciplinary fields, the overall number remained limited and thus not fully representative of the broader scientific and professional community engaged in inclusive design. A further methodological limitation lies in the absence of direct empirical evidence derived from the application and monitoring of the criteria within real school settings. Validation to date has relied primarily on expert judgment, with field testing still in progress. The ongoing development of a multisensory classroom based on the proposed framework will enable direct observation of children's behaviours and sensory responses in a fully designed environment. Future research should focus on implementing the proposed design criteria in real school

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environments and testing the model's replicability across educational levels and cultural contexts. This would provide empirical insights into its impact on children's engagement, learning, and sensory regulation, while guiding broader application in inclusive education. Ultimately, this study has contributed to the development of an integrated framework of design criteria for the conception of inclusive multisensory classrooms capable of accommodating both neurodivergent and neurotypical children within a shared educational environment. Despite the study's limitations, the results provide a valuable starting point for discussion. Further contributions are encouraged to refine and enhance the framework, ultimately supporting its development as a practical guide for the design of inclusive school environments. This work offers an original contribution to both the theoretical and practical discourse on inclusive design, advancing a multisensory paradigm that translates the complexity of neurodiversity into concrete and replicable design criteria.

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REFERENCES

- Al Qutub, R., Luo, Z., Vasilikou, C., Tavassoli, T., Essah, E., & Marcham, H. (2024). *Impacts of school environment quality on autistic pupil's behaviours – A systematic review. Building and Environment, 265,* 111981. https://doi.org/10.1016/j.buildenv.2024.111981
- Almaz, A. (2022). *The impact of sensory perception on interior architecture standards for visually impaired and blind students in educational facilities. 12*(3), 263–273. https://doi.org/10.21608/idj.2022.234845
- American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR™* (Fifth edition, text revision). American Psychiatric Association Publishing.
- Baars, S., Schellings, G. L. M., Joore, J. P., & Van Wesemael, P. J. V. (2023). *Physical learning environments' supportiveness to innovative pedagogies: Students' and teachers' experiences. Learning Environments Research, 26*(2), 617–659. https://doi.org/10.1007/s10984-022-09433-x
- Banire, B., Al Thani, D., Qaraqe, M., Mansoor, B., & Makki, M. (2021). *Impact of mainstream classroom setting on attention of children with autism spectrum disorder: An eye-tracking study. Universal Access in the Information Society, 20*(4), 785–795. https://doi.org/10.1007/s10209-020-00749-0
- Bateman, K. J., Wilson, S. E., Gauvreau, A., Matthews, K., Gucwa, M., Therrien, W., Nevill, R., & Mazurek, M. (2023). *Visual supports to increase conversation engagement for preschoolers with autism spectrum disorder during mealtimes: An initial investigation. Journal of Early Intervention, 45*(2), 163–184. https://doi.org/10.1177/10538151221111762
- Bluteau, J., Aubenas, S., & Dufour, F. (2022). *Influence of flexible classroom seating on the wellbeing and mental health of upper elementary school students: A gender analysis. Frontiers in Psychology, 13,* 821227. https://doi.org/10.3389/fpsyg.2022.821227
- Brandes-Aitken, A., Powers, R., Wren, J., Chu, R., Shapiro, K. A., Steele, M., Mukherjee, P., & Marco, E. J. (2024). *Sensory processing subtypes relate to distinct emotional and behavioral phenotypes in a mixed neurodevelopmental cohort. Scientific Reports, 14*(1), 29326. https://doi.org/10.1038/s41598-024-78573-2
- Butera, C., Ring, P., Sideris, J., Jayashankar, A., Kilroy, E., Harrison, L., Cermak, S., & Aziz-Zadeh, L. (2020). *Impact of sensory processing on school performance outcomes in high functioning individuals with autism spectrum disorder. Mind, Brain, and Education, 14*(3), 243–254. https://doi.org/10.1111/mbe.12242
- Chaxiong, P., Dimian, A. F., & Wolff, J. J. (2022). *Restricted and repetitive behavior in children with autism during the first three years of life: A systematic review. Frontiers in Psychology, 13,* 986876. https://doi.org/10.3389/fpsyg.2022.986876
- Clément, M.-A., Lee, K., Park, M., Sinn, A., & Miyake, N. (2022). *The need for sensory-friendly "zones": Learning from youth on the autism spectrum, their families, and autistic*

mentors using a participatory approach. Frontiers in Psychology, 13,* 883331. https://doi.org/10.3389/fpsyg.2022.883331
- Danesh, A. A., Howery, S., Aazh, H., Kaf, W., & Eshraghi, A. A. (2021). *Hyperacusis in autism spectrum disorders. Audiology Research, 11*(4), 547–556. https://doi.org/10.3390/audiolres11040049
- Fan, Y., Chong, D. K., & Li, Y. (2024). *Beyond play: A comparative study of multi-sensory and traditional toys in child education. Frontiers in Education, 9,* 1182660. https://doi.org/10.3389/feduc.2024.1182660
- Finnigan, K. A. (2024). *Sensory responsive environments: A qualitative study on perceived relationships between outdoor built environments and sensory sensitivities. Land, 13*(5), 636. https://doi.org/10.3390/land13050636
- Gao, B., Fu, Y., Gao, J., & Gao, W. (2025). *Effects of colour temperature in classroom lighting on primary school students' cognitive outcomes: A multidimensional approach for architectural and environmental design. Buildings, 15*(16), 2964. https://doi.org/10.3390/buildings15162964
- Gardner, L., Gilchrest, C., & Campbell, J. M. (2024). *Intellectual, adaptive, and behavioral functioning associated with designated levels of support in a sample of autistic children referred for tertiary assessment. Journal of Autism and Developmental Disorders, 54*(11), 4145–4151. https://doi.org/10.1007/s10803-023-06141-0
- Gentil-Gutiérrez, A., Cuesta-Gómez, J. L., Rodríguez-Fernández, P., & González-Bernal, J. J. (2021). *Implication of the sensory environment in children with autism spectrum disorder: Perspectives from school. International Journal of Environmental Research and Public Health*, *18*(14), 7670. https://doi.org/10.3390/ijerph18147670
- Godwin, K. E., Seltman, H., Scupelli, P., & Fisher, A. V. (2020). *Attentional competition in genuine classrooms: Analysis of the classroom visual environment*. *Creative Commons Attribution 4.0 International License.* https://cognitivesciencesociety.org/cogsci20/papers/0524/0524.pdf
- Habbak, A. L. Z., & Khodeir, L. (2023). *Multi-sensory interactive interior design for enhancing skills in children with autism. Ain Shams Engineering Journal*, *14*(8), 102039. https://doi.org/10.1016/j.asej.2022.102039
- Helvacıog˘lu, E., & Olguntürk, N. (2011). *Colour contribution to children's wayfinding in school environments. Optics & Laser Technology*, *43*(2), 410–419. https://doi.org/10.1016/j.optlastec.2009.06.012
- Hill, C., Keville, S., & Ludlow, A. K. (2023). *Inclusivity for children with autism spectrum disorders: Parents' reflections of the school learning environment versus home learning during COVID-19. International Journal of Developmental Disabilities*, *69*(4), 546–554. https://doi.org/10.1080/20473869.2021.1975253
- Hutson, P., & Hutson, J. (2024). *Expanding sensory kit utilization across age and contexts: Bridging gaps for inclusive accessibility*. https://digitalcommons.lindenwood.edu/faculty-research-papers/699
- Hyman, S. L., Levy, S. E., Myers, S. M., COUNCIL ON CHILDREN WITH DISABILITIES, SECTION ON DEVELOPMENTAL AND BEHAVIORAL PEDIATRICS, Kuo, D. Z., Apkon, S., Davidson, L. F., Ellerbeck, K. A., Foster, J. E. A., Noritz, G. H., Leppert, M. O., Saunders, B. S., Stille, C., Yin, L., Weitzman, C. C., Childers, D. O., Levine, J. M., Peralta-Carcelen, A. M., Poon, J. K., … Bridgemohan, C. (2020). *Identification, evaluation, and management of children with autism spectrum disorder. Pediatrics*, *145*(1), e20193447. https://doi.org/10.1542/peds.2019-3447
- Jiang, A., Fang, W., Liu, J., Foing, B., Yao, X., Westland, S., & Hemingray, C. (2023). *The effect of colour environments on visual tracking and visual strain during short-term simulation of three gravity states. Applied Ergonomics*, *110*, 103994. https://doi.org/10.1016/j.apergo.2023.103994
- Jones, E. K., Hanley, M., & Riby, D. M. (2020). *Distraction, distress and diversity: Exploring the impact of sensory processing differences on learning and school life for pupils with autism spectrum disorders. Research in Autism Spectrum Disorders*, *72*, 101515. https://doi.org/10.1016/j.rasd.2020.101515
- Larose, D., Massie, C.-L., St-Aubin, A., Boulay-Pelletier, V., Boulanger, E., Lavoie, M. D., Yessis, J., Tremblay, A., & Drapeau, V. (2024). *Effects of flexible learning spaces, active breaks, and active lessons on sedentary behaviors, physical activity, learning, and musculoskeletal health in school-aged children: A scoping review. Journal of Activity, Sedentary and Sleep Behaviors*, *3*(1), 30. https://doi.org/10.1186/s44167-024-00068-2
- Lech, J. C., Halma, M. T. J., Obajuluwa, A. O., Baker, M., & Hamblin, M. R. (2023). *Fiat lux: Light and pedagogy for the 21st century. Annals of Neurosciences*, *30*(2), 133–142. https://doi.org/10.1177/09727531221136646
- Li, W., Ma, S., Liu, Y., Lin, H., Lv, H., Shi, W., & Ao, J. (2024). *Environmental therapy: Interface design strategies for color graphics to assist navigational tasks in patients with visuospatial disorders through an analytic hierarchy process based on CIE color perception. Frontiers in Psychology*, *15*, 1348023. https://doi.org/10.3389/fpsyg.2024.1348023

- Liang, Z., Lee, D., Zuo, J., & Liang, S. (2024). *The use of visual schedules to increase academic-related on-task behaviors of individuals with autism: A literature review. International Journal of Developmental Disabilities*, 1–14. https://doi.org/10.1080/20473869.2024.2402124
- Llorens-Gámez, M., Higuera-Trujillo, J. L., Omarrementeria, C. S., & Llinares, C. (2022). *The impact of the design of learning spaces on attention and memory from a neuroarchitectural approach: A systematic review. Frontiers of Architectural Research*, *11*(3), 542–560. https://doi.org/10.1016/j.foar.2021.12.002
- Mallory, C., & Keehn, B. (2021). *Implications of sensory processing and attentional differences associated with autism in academic settings: An integrative review. Frontiers in Psychiatry*, *12*, 695825. https://doi.org/10.3389/fpsyt.2021.695825
- Marwati, A., Dewi, O. C., Wiguna, T., & Aisyah, A. (2023). *Visual-sensory-based quiet room: A study of visual comfort, lighting, and safe space in reducing maladaptive behaviour and emotion for autistic users. Journal of Accessibility and Design for All*, *13*(1), 69–93. https://doi.org/10.17411/jacces.v13i1.318
- Meadan, H., Ostrosky, M. M., Triplett, B., Michna, A., & Fettig, A. (2011). *Using visual supports with young children with autism spectrum disorder. TEACHING Exceptional Children*, *43*(6), 28–35. https://doi.org/10.1177/004005991104300603
- Mealings, K. (2023). *The effect of classroom acoustic treatment on listening, learning, and well-being: A scoping review. Acoustics Australia*, *51*(2), 279–291. https://doi.org/10.1007/s40857-023-00291-y
- Mills, C., Nash, S., Agho, K. E., Hinitt, J., & Coxon, K. (2025). *Children's sensory processing in the classroom: A cross-sectional study using teacher rating. Psychology in the Schools*, *62*(10), 4080–4091. https://doi.org/10.1002/pits.23598
- Morris, J. E., & Imms, W. (2025). *Flexible furniture to support inclusive education: Developing learner agency and engagement in primary school. Learning Environments Research*, *28*(2), 223–248. https://doi.org/10.1007/s10984-024-09522-z
- Mostafa, M. (2014). *Architecture for autism: Autism ASPECTSS™ in school design. International Journal of Architectural Research: ArchNet-IJAR, 8*(1), 143. https://doi.org/10.26687/archnet-ijar.v8i1.314
- Mostafa, M., Sotelo, M., Honsberger, T., Honsberger, C., Brooker Lozott, E., & Shanok, N. (2024). *The impact of ASPECTSS-based design intervention in autism school design: A case study. Archnet-IJAR: International Journal of Architectural Research, 18*(2), 318–339. https://doi.org/10.1108/ARCH-11-2022-0258
- Mott, M. S., Robinson, D. H., Walden, A., Burnette, J., & Rutherford, A. S. (2012). *Illuminating the effects of dynamic lighting on student learning. Sage Open*, *2*(2), 2158244012445585. https://doi.org/10.1177/2158244012445585
- Nair, A. S., Priya, R. S., Rajagopal, P., Pradeepa, C., Senthil, R., Dhanalakshmi, S., Lai, K. W., Wu, X., & Zuo, X. (2022). *A case study on the effect of light and colors in the built environment on autistic children's behavior. Frontiers in Psychiatry*, *13*, 1042641. https://doi.org/10.3389/fpsyt.2022.1042641
- Petersson-Bloom, L., & Holmqvist, M. (2022). *Strategies in supporting inclusive education for autistic students—A systematic review of qualitative research results. Autism & Developmental Language Impairments*, *7*, 23969415221123429. https://doi.org/10.1177/23969415221123429
- Pfeiffer, B. A., Koenig, K., Kinnealey, M., Sheppard, M., & Henderson, L. (2011). *Effectiveness of sensory integration interventions in children with autism spectrum disorders: A pilot study. The American Journal of Occupational Therapy*, *65*(1), 76–85. https://doi.org/10.5014/ajot.2011.09205
- Posar, A., & Visconti, P. (2018). *Sensory abnormalities in children with autism spectrum disorder. Jornal de Pediatria*, *94*(4), 342–350. https://doi.org/10.1016/j.jped.2017.08.008
- Quiles-Rodríguez, J., Palau, R., & Mateo-Sanz, J. M. (2025). *How artificial intelligence-assisted colour lighting can improve learning: Evidence from recent classrooms studies. Applied Sciences*, *15*(7), 3657. https://doi.org/10.3390/app15073657
- Rezaul Karim, A. K. M., Prativa, S., & Likova, L. T. (2022). *Perception and appreciation of tactile objects: The role of visual experience and texture parameters. Journal of Perceptual Imaging, 5*(0), 000405-1-000405–000420. https://doi.org/10.2352/J.Percept.Imaging.2022.5.000405
- Rutherford, M., Baxter, J., Grayson, Z., Johnston, L., & O'Hare, A. (2020). *Visual supports at home and in the community for individuals with autism spectrum disorders: A scoping review. Autism*, *24*(2), 447–469. https://doi.org/10.1177/1362361319871756
- Salah, A., Amr, M., El-Sayed, M., ElWasify, M., Eltoukhy, K., Salama, S., & Tobar, S. (2024). *Sensory processing patterns among children with autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD) using short sensory profile and evoked potentials: A case–control study. Middle East Current Psychiatry*, *31*(1), 52. https://doi.org/10.1186/s43045-024-00441-6
- Schledermann, K., Pihlajaniemi, H., Sen, S., & Hansen, E. K. (2019). *Dynamic lighting in classrooms: A new interactive tool for teaching.* In A. L. Brooks, E. Brooks, & C. Sylla (A

Frausin, M., Iurilli, G. M., (2025). Towards inclusive multisensory learning spaces: a criteria-driven design framework . *Rivista Italiana Di Ergonomia*. 31. 23-37. DOI: 10.6093/RIE/12745

c. Di), *Interactivity, Game Creation, Design, Learning, and Innovation* (Vol. 265, pp. 374–384). Springer International Publishing. https://doi.org/10.1007/978-3-030-06134-0_41

- Tola, G., Talu, V., Congiu, T., Bain, P., & Lindert, J. (2021). *Built environment design and people with autism spectrum disorder (asd): A scoping review. International Journal of Environmental Research and Public Health*, *18*(6), 3203. https://doi.org/10.3390/ijerph18063203
- Unwin, K. L., Powell, G., & Jones, C. R. (2022). *The use of multi-sensory environments with autistic children: Exploring the effect of having control of sensory changes. Autism*, *26*(6), 1379–1394. https://doi.org/10.1177/13623613211050176
- Williams, Z. J., He, J. L., Cascio, C. J., & Woynaroski, T. G. (2021). *A review of decreased sound tolerance in autism: Definitions, phenomenology, and potential mechanisms. Neuroscience & Biobehavioral Reviews*, *121*, 1–17. https://doi.org/10.1016/j.neubiorev.2020.11.030
- Zazzi, H., & Faragher, R. (2018). *'Visual clutter' in the classroom: Voices of students with autism spectrum disorder. International Journal of Developmental Disabilities*, *64*(3), 212–224. https://doi.org/10.1080/20473869.2018.1468619

SHORT BIO

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