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Original Article

Physical and sensory characteristics in classrooms: implications for the inclusion of autistic students

Características físicas y sensoriales de las aulas: implicancias para la inclusión de estudiantes autistas

Ambiente físico e sensorial em salas de aula: implicações para a inclusão de estudantes autistas

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Abstract

Introduction: The literature indicates that the physical and sensory characteristics of the classroom (size, lighting, visual and auditory information) can create barriers to educational inclusion, affecting the participation of autistic students in school activities and their well-being. **Objective:** To analyze the physical and sensory characteristics of classrooms in the first cycle of primary education in Chilean public schools and their potential implications for autistic students. **Method:** Quantitative study with a cross-sectional descriptive design. Forty-four classrooms from ten Chilean public schools were analyzed. Data were collected through structured observations, photographic records, and measurements of size (m^2), illuminance (lx), and background noise (dB). Analysis was conducted using descriptive and inferential statistics, as well as multiple correspondence analysis. **Results:** The most common physical and sensory characteristics of classrooms were fluorescent lighting (86.4%), white light (98%), absence of rubber protectors on furniture legs (75%), a high level of visual information on the front wall (67.4%), and partition wall construction (59%). The classrooms frequently presented physical and sensory features previously reported as potential barriers for autistic students, particularly affecting those with sensory processing differences. **Conclusion:** It is recommended that the educational community and school administrators adequately manage classroom conditions, considering that these may affect the educational inclusion of autistic students, and that appropriate management can lead to improvements for all students.

Keywords: Autism Spectrum Disorder, Autism, Sensory Processing Disorder, Educational Inclusion, Learning Environment, Classroom.

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Resumen

Introducción: La literatura ha reportado que el ambiente físico y sensorial del aula (tamaño, iluminación, información visual y auditiva) puede configurar barreras para la inclusión educativa, afectando la participación de estudiantes autistas en actividades escolares y su bienestar en la escuela. **Objetivo:** Analizar las características físicas y sensoriales de aulas de primer ciclo básico de escuelas públicas chilenas y sus posibles implicancias para los estudiantes autistas. **Método:** Estudio cuantitativo con diseño descriptivo transversal. Se analizaron 44 aulas de diez escuelas públicas chilenas. Los datos fueron recolectados mediante observaciones estructuradas, registros fotográficos y mediciones de tamaño (m^2), luminosidad (lx) y ruido de fondo (dB). El análisis se realizó con estadística descriptiva, inferencial y correspondencia múltiple. **Resultados:** Las características físicas y sensoriales más comunes de las aulas fueron iluminación fluorescente (86,4%), blanca (98%), ausencia de gomas protectoras en las patas del mobiliario (75%), alto grado de información visual en la pared frontal (67,4%) y construcción de tabiquería (59%). Las salas de clases observadas presentan con frecuencia aspectos físicos y sensoriales reportados previamente como posibles barreras para estudiantes autistas y que pueden afectar especialmente a quienes presentan problemas de procesamiento sensorial. **Conclusión:** Se anima a la comunidad educativa y a los sostenedores a gestionar adecuadamente las condiciones de las salas de clases, considerando que estas pueden afectar la inclusión educativa de los estudiantes autistas y que su adecuada gestión puede resultar en mejoras para el estudiantado en general.

Palabras clave: Trastorno del Espectro Autista, Autismo, Procesamiento Sensorial, Inclusión Escolar, Ambiente de Aprendizaje, Aula.

Resumo

Introdução: A literatura tem relatado que o ambiente físico e sensorial da sala de aula (tamanho, iluminação, informação visual e auditiva) pode configurar barreiras para a inclusão educacional, afetando a participação de estudantes autistas em atividades escolares e seu bem-estar na escola. **Objetivo:** Analisar as características físicas e sensoriais de salas de aula do primeiro ciclo do ensino fundamental em escolas públicas chilenas e suas possíveis implicações para estudantes autistas. **Método:** Estudo quantitativo com delineamento descritivo transversal. Foram analisadas 44 salas de aula de 10 escolas públicas chilenas. Os dados foram coletados por meio de observações estruturadas, registros fotográficos e medições de tamanho (m^2), luminosidade (lx) e ruído de fundo (dB). A análise foi realizada com estatística descritiva, inferencial e correspondência múltipla. **Resultados:** As características físicas e sensoriais mais comuns das salas de aula foram iluminação fluorescente (86,4%), branca (98%), ausência de protetores de borracha nos pés do mobiliário (75%), alto grau de informação visual na parede frontal (67,4%) e construção em divisórias (59%). As salas de aula observadas frequentemente apresentaram aspectos físicos e sensoriais previamente relatados como possíveis barreiras para estudantes autistas, que podem afetar especialmente aqueles com dificuldades de processamento sensorial. **Conclusão:** Recomenda-se à comunidade educacional e aos mantenedores que gerenciem adequadamente as condições das salas de aula, considerando que estas podem afetar a inclusão educacional de estudantes autistas e que sua adequada gestão pode resultar em melhorias para todo o corpo discente.

Palavras-chave: Transtorno do Espectro Autista, Processamento Sensorial, Inclusão Educacional, Ambiente de Aprendizagem, Sala de Aula.

Introduction

This research is framed within the Chilean educational context, specifically in public schools managed by the Local Public Education Services (SLEP). These decentralized state agencies, created by Law No. 21,040, are responsible for administering and coordinating public educational establishments within a given territory, with the aim of strengthening the quality, equity, and inclusion of the national education system (Chile, 2017).

In Chile, the approach to educational inclusion has been promoted through various regulations aimed at ensuring access, participation, and learning for all students. Among these, Exempt Decree No. 83 of 2015 stands out, as it promotes the implementation of Universal Design for Learning (UDL) as a key tool to support relevant and high-quality education adapted to classroom diversity. Universal Design for Learning (UDL) represents a shift in perspective by moving the focus away from individual deficits toward learning contexts, proposing adjustments and supports that foster the development and progress of all students throughout their educational trajectories (López Díaz et al., 2024; Chile, 2015b).

Within this broader shift toward inclusive public education, the enrollment of autistic students in mainstream schools has increased considerably, with a reported rise of 1064% between 2015 and 2023 (Chile, 2023a). Although this increase may reflect progress in recognizing the right to education, it does not necessarily ensure other key dimensions of inclusion, such as active participation, emotional well-being, and academic progress.

At the same time, a political and community movement has emerged in the country, led by autistic individuals and advocacy groups, bringing greater visibility to demands related to the full realization of rights in areas such as education, health, and employment. As a result of these developments, Law No. 21,545 and Circular No. 586 (Chile, 2023b) have been enacted, reinforcing the State's commitment to creating conditions that support access, participation, retention, and progress for autistic students within the school system.

In this context, the present study seeks to provide empirical evidence on the physical and sensory dimensions of learning environments in Chilean schools. More specifically, it aims to contribute to understanding how classroom characteristics, in interaction with psychosocial factors, may function as facilitators and/or barriers to inclusive education for this group of students.

Barriers and facilitators of the physical and sensory learning environment

The physical learning environment refers to the different educational spaces where pedagogical interactions occur and includes attributes such as available space, ventilation, lighting, furniture arrangement, access, and circulation routes, among others. It is recognized as a key element in the complex and highly contextualized nature of learning (Baars et al., 2021).

The physical dimension of school environments is considered an element that, through its attributes, can promote student participation and perceptions of well-being and comfort within the educational community (Barrett et al., 2015; Byers et al., 2018; Suraini & Aziz, 2023). Considering students' preferences and perspectives regarding spatial organization and furniture arrangement, introducing variations and personalization in school workspaces, and responding to diverse physical and sensory needs support the development of more inclusive school environments (Angulo de la Fuente, 2024).

The sensory learning environment is particularly relevant for autistic students, as they often experience differences in sensory processing (Marco et al., 2011; Salah et al., 2024; Silva et al., 2025). The DSM-5 describes these as "hyper- or hypo-reactivity to sensory input or unusual interest in sensory aspects of the environment" (American Psychiatric Association, 2013, p. 50). According to Tomchek & Dunn (2007), approximately 90% of autistic individuals exhibit hypo-reactivity or sensory-seeking behaviors. Leekam et al. (2007) similarly report that these sensory differences are common across autistic individuals, regardless of age or IQ. Grandin (1997) highlights the wide variability in sensory perception: while certain stimuli may be appealing to some individuals, others may experience them as intolerable.

For autistic students, specific sensory characteristics of environments can have distinct effects, influencing attention during tasks, emotional regulation, and overall comfort, with implications for effective participation in school activities (Butera et al., 2020; Rajotte et al., 2024; Whiting et al., 2021) as well as for learning processes (Vives-Vilarroig et al., 2022). Difficulties in filtering sensory information can make school environments overwhelming, contributing to internalizing and externalizing difficulties (Chen et al., 2024), anxiety, fear, or even physical discomfort (Goodall, 2019; Tokarskaya & Bystrova, 2023), and may also affect social interactions and relationships, potentially leading to social isolation (Brake, 2024).Table 1 presents a synthesis of the main classroom factors identified in the literature, along with their educational implications and recommendations to support the participation and learning of autistic students.

Table 1. Literature Review: Classroom Factors, Implications, and Recommendations for Autistic Students.

Classroom Visual Environment	
Implications	**Recommendations**
Lighting has been identified as a critical factor for autistic individuals. Autobiographical accounts report sensitivity to fluorescent lighting, linking it to sensory overload and visual discomfort, which may lead to headaches, fatigue, or other forms of discomfort in students with sensory hypersensitivity (Fenton & Penney, 1985; Grandin, 1997).	Wizaka et al. (2021) recommend optimizing natural light in classrooms by considering window orientation and size, in order to create more comfortable environments for students who are sensitive to artificial lighting. They also suggest reducing light intensity, ensuring softer and less glaring conditions (Fitri et al., 2025; Kinnealey et al., 2012), and installing blackout curtains (Williams et al., 2024).
Studies such as those by Ashburner et al. (2013) and Saggers et al. (2016) highlight that visual overstimulation caused by direct sunlight, bright lighting, and excessive classroom decoration can be problematic. Zazzi & Faragher (2018) found that visual clutter and certain wall colors were associated with negative emotional responses among autistic students in Australia. Conversely, reducing visual overstimulation has been shown to improve students' attention and concentration (Gaines & Curry, 2011; Martin & Wilkins, 2022).	Martin & Wilkins (2022) recommend reducing unnecessary stimuli, organizing the amount and placement of visual information—particularly along classroom side walls—using neutral colors, and providing areas with a lower density of visual input.

Table 1. Continued...

Available size and surface area	
Implications	**Recommendations**
Difficulties in tactile processing also affect the school experience of autistic students, often manifesting as discomfort with physical proximity, unexpected contact, and certain clothing textures (Saggers et al., 2016). Fusaro et al. (2023) note that proxemics—the perception of interpersonal space—may differ in autistic individuals, who may require greater distance to feel comfortable.	Qualitative research indicates that mothers of autistic children perceive large class sizes in the Chilean school context as a barrier, noting that smaller groups would allow for more individualized support (Martínez et al., 2023; Villegas Otárola et al., 2014).
In this context, classroom size and the number of students per classroom are important factors to consider. Chilean regulations specify that the space available per student must be at least 1.1 m^2, whereas the minimum standard recommended by the OECD is 2 m^2 (Centro de Políticas Educativas y Prácticas en Educación, 2016).	Environmental modifications—such as arranging desks and chairs to reduce crowding and ensure personal space—may contribute to lower levels of anxiety and improved concentration among autistic students (Fitri et al., 2025).
Classroom Auditory Environment	
Implications	**Recommendations**
Noise in school classrooms has been identified as a significant barrier to the inclusion of autistic students (Angulo de la Fuente et al., 2025; González de Rivera Romero et al., 2022), given that some may be particularly sensitive to loud sounds (Khalfa et al., 2004). Excessive noise can disrupt attention and behavior, which is especially relevant for autistic individuals (Howe & Stagg, 2016). Kanakri et al. (2016, 2017) found a positive correlation between noise levels above 70 dB and disruptive behaviors in second- and third-grade autistic students.	Measures such as sound-absorbing walls, carpets, and acoustic cladding to reduce noise levels, as well as the provision of quiet areas, have been suggested (Fitri et al., 2025). Attention to architectural design is also recommended (Dargue et al., 2022), particularly in relation to glazing and windows, as these may increase reverberation (Shield et al., 2015).
Guo et al. (2024) identified multiple sources of classroom noise, including poor sound insulation and the proximity of classrooms to noisy areas such as playgrounds or recreational spaces. The WHO recommends a maximum noise level of 35 dB in indoor school environments and 55 dB in play areas (Berglund et al., 2002), although international studies report higher levels. In England, for example, levels between 45 dB and 80 dB were recorded across 274 classrooms, while in India, levels ranged from 62.1 dB to 65.6 dB in 18 classrooms (Sundaravadhanan et al., 2017).	

Based on the background presented above, the following research question is posed: What are the physical and sensory characteristics of classrooms in the first cycle of Chilean primary education that may constitute barriers and/or facilitators to the inclusive education of autistic students? The general objective is to analyze the physical and sensory characteristics of classrooms in the first cycle of primary education in schools within a Chilean public education service (SLEP), relating them to potential barriers and/or facilitators for the inclusive education of autistic students.

In this context, the present study contributes to the national and international literature in three main ways. First, it provides empirical evidence based on direct observations and objective in situ measurements of the physical and sensory characteristics of school classrooms, an approach that remains relatively underexplored in Latin America. Second, it examines these characteristics from a framework of barriers and facilitators for the inclusive education of autistic students, integrating physical and sensory dimensions of the school environment. Finally, using multiple correspondence analysis, the study identifies classroom environmental profiles that make it possible to understand patterns of stimulation and spatial density, providing an empirical basis to inform pedagogical practices, school management, and public policy decisions in inclusive education contexts.

Methodology

This study adopts a quantitative approach with a cross-sectional descriptive design. The target population consists of public schools administered by a Local Public Education Service (SLEP), totaling 55 establishments. The sample selection was carried out in collaboration with the SLEP's technical-pedagogical support team, applying criteria that excluded special education schools (n=4), schools in correctional facilities (n=1), high schools that do not offer basic education (n=6), and schools located on islands (n=1). As a result, a pool of 43 potentially participating schools was defined.

Based on this, 30% of the schools with the highest enrollment of autistic students, according to the administrator's records, were selected, resulting in a total of 12 schools. Subsequently, one school declined to participate and another did not respond to the initial contact, ultimately forming a sample of 10 schools. Observations were conducted in 44 classrooms across grades 1 through 4 in these schools.

Procedure: Fieldwork began with an initial visit to each selected school, during which a meeting was held with the administrative team to present the project in detail. After obtaining institutional consent, the study was shared with the school community, including teachers and classroom assistants in the first cycle of primary education. Observations were conducted by the principal investigator (occupational therapist) and a research assistant (architect), using a digital form for the systematic recording of information and the storage of classroom photographs. Visits took place in 2024, during recess or lunch periods, always within the regular school schedule. Each observation lasted approximately 25 minutes. Background noise measurements were taken with the classroom occupied, during Language, Mathematics, or Science classes, lasting between 60 and 80 minutes.

***Instrument*:** To develop the structured classroom observation instrument, a systematic literature review was conducted using academic databases such as Web of Science, Scopus, ERIC, and EBSCO. Keywords such as *physical learning environment*, *sensory learning environment*, *inclusive education*, and *autism spectrum disorder* were used, combined through Boolean operators (AND/OR). This review enabled the identification of physical and sensory environmental aspects that, according to international evidence, are relevant for the inclusive education of autistic students (see Table 2).

Table 2. Conceptual Definitions of the Aspects Observed in the Classroom.

Variables	Conceptual definition	Operational definition	Observation methodology
Classroom infrastructure	Set of physical spaces, facilities, and equipment that make up an educational establishment, designed to ensure conditions of safety, habitability, accessibility, and inclusion (Dirección de Presupuestos, 2021).	Wall materials: concrete, wood, or partition walls. Floor covering: ceramic, vinyl, or wood. Window size (m^2). Presence or absence of protective rubber feet on classroom chairs and tables.	Direct classroom observation and photographic documentation
Size and area per student.	Available area per student in a classroom or educational space (Chile, 2015a).	Measurement of the total classroom area (length × width). Number of students per classroom and calculation of the available m^2 per student.	Measurement using a digital rangefinder. Enrollment data obtained from SIGE (General Student Information System).
Lightning	Lighting conditions required for learning activities, considering the type, use, and adjustability of natural and artificial light sources (Barrett et al., 2015).	Type of electric lighting: LED or fluorescent. – Illumination intensity (lux, lx).	Photographic documentation and observation of the light sources present. Measurement of light intensity at four points in the classroom (center, center-right, center-left, and under the light source) using the Luxometer v1.1.5 application (Smart Tools), installed on an Android tablet.
Background noise	Any sound perceived as annoying, unpleasant, or untimely by the individual (Chile, 2011).	Background noise level during a class, expressed in decibels (dB).	Measurements were taken during Language, Mathematics, or Science classes using the Sonometer v1.7.21 application (Smart Tools) on an Android tablet. Minimum, maximum, and average values were recorded over 60–80 minutes from the teacher's desk.
Visual Information	Degree to which the classroom provides appropriate and organized visual diversity, avoiding stimulus saturation (Barrett et al., 2015).	Level of visual information on the front wall: high, medium, or low. Color range of the front wall paint.	Evaluation by three raters (interrater). Panoramic photograph taken from the back wall of the classroom.

Although lighting and background noise were measured using digital applications installed on tablets, this approach is appropriate for descriptive studies in real school settings, where access to specialized equipment may be limited. The use of these tools allowed for continuous estimation of environmental conditions during routine school activities, providing ecologically valid information about the everyday conditions of the observed classrooms.

- ***Data Analysis:*** Descriptive and inferential statistics were used for data analysis, including t-tests and ANOVA. A panel of three raters, consisting of the principal investigator and two occupational therapy academics with experience in inclusive education, analyzed the photographs. The JAMOVI software (The Jamovi Project, 2023) and multiple correspondence analysis in R (R Core Team, 2023) were used for the statistical analysis of the variables studied. Multiple correspondence analysis (MCA) is an extension of correspondence analysis (CA) that allows for the analysis of patterns of relationships among several categorical variables. It can also be understood as a generalization of principal component analysis when the variables are categorical rather than numerical (Abdi & Valentin, 2007).

Regarding ethical considerations, the research project was approved by the Bioethics Committee of the sponsoring university (code *BIOEPUCV-H 802-2024*). The administrative team of each school signed the consent form after receiving a detailed explanation of the study. The researcher is committed to anonymizing school-level data and ensuring the confidentiality and secure handling of all information.

Results

A total of 44 classrooms were analyzed, distributed as follows: 1st grade (n=12), 2nd grade (n=12), 3rd grade (n=10), and 4th grade (n=10). The average number of students per classroom was $\bar{x} = 19$ (SD = 6.73), with a minimum of 5 and a maximum of 35, indicating substantial variability in class size.

The most common characteristics observed were: white lighting (97.7%), fluorescent lighting (89.7%), installed curtains (91.1%), absence of protective rubber feet on furniture (75%), a high level of visual information on the front wall (65.6%), partitioned structures (59%), lights on at the time of observation (59%), exposure to afternoon sunlight (55.5%), and vinyl flooring (54.5%).

Results of structured classroom observation

- ***Materials:*** The materials used for walls and flooring were observed. Three types of wall materials were identified: partition walls (59.1%), concrete (38.6%), and wood (2.3%). Classroom flooring consisted of vinyl (54.5%), ceramic tile (31.8%), and wood (13.6%).
- ***Size and Area per Student:*** The length and width of the classrooms were measured to calculate total area in square meters. The area per student was then calculated based on the number of students per classroom, obtained from SIGE (General Student Information System – MINEDUC Chile). The average total classroom area was $\bar{x} = 45.2$ m^2, ranging from 20.50 m^2 to 67.50 m^2. The average available area per student was 2.80 m^2, with a minimum of 1.21 m^2 and a maximum of 9.76 m^2 per student. The null hypothesis (H_0) for classroom size was defined as follows: the area per student differs significantly across grades in the first cycle of primary education. Levene's test for homogeneity of variances yielded a p-value of 0.356, indicating similar variances across grades. Subsequently, a one-way ANOVA (Fisher's test) was conducted, yielding a p-value of 0.295. Although first grade showed a higher area per student (3.40 m^2) compared to other grades, this difference was not statistically significant (F = 1.28).

For the analysis of classroom density or occupancy levels, classrooms were classified based on cut-off points for area per student into three equal groups. Each classroom was assigned to one of the following categories: low occupancy (≥ 2.9 m^2 per student), medium occupancy (between 2.0 and 2.9 m^2 per student), and high occupancy (≤ 2.0 m^2 per student). According to this classification, 27.3% of classrooms had high occupancy, 34.1% had low occupancy, and 38.6% had medium occupancy.

- ***Visual Information:*** Classrooms were primarily painted in three colors: yellow (30.2%), white (23.3%), and blue (14.0%). An additional 11.6% combined white with another color. An interrater procedure was used to analyze the level of visual stimulation generated by the classroom front wall. Photographs of the front wall (n = 44), where the whiteboard is located, were analyzed and divided into four quadrants. Each rater reviewed the photographs and assigned a visual information category based on three levels (low, medium, high), following the criteria described below:
- Low visual information: Only 1 of the 4 quadrants in the photograph displays visual information such as notices, school schedules, alphabets, classroom rules or instructions, decorations, etc. Neutral colors in the gray, white, and beige range predominate.
- Medium visual information: 2 of the 4 quadrants display visual information such as notices, school schedules, alphabets, classroom rules or instructions, decorations, etc. There is a combination of neutral tones and more stimulating colors such as yellow, orange, and red.
- High visual information: All 4 quadrants display visual information such as notices, school schedules, alphabets, classroom rules or instructions, decorations, etc., using a wide range of colors, often with decorations or elements suspended from the ceiling.

The Fleiss' kappa (Fleiss, 1971) interrater reliability coefficient was 0.56, with 65% agreement among the three raters, indicating moderate agreement according to the interpretation scale proposed by Landis & Koch (1977). Based on this classification, 67.4% of the classrooms had high levels of visual information, 20.9% had medium levels, and only 11.6% were classified as having low visual information (see Figure 1).

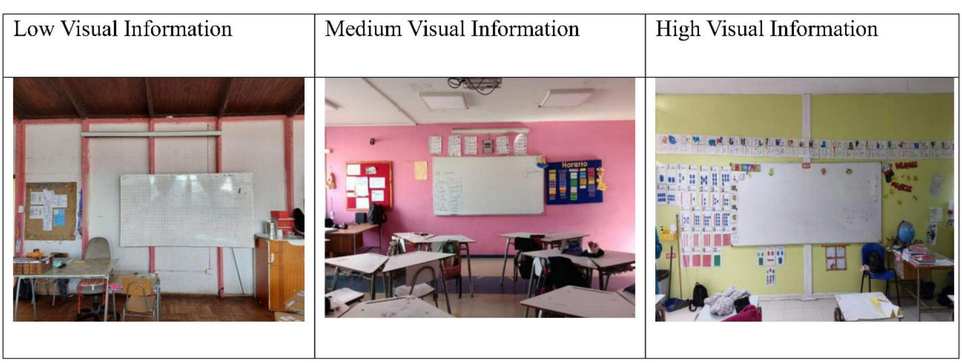

Figure 1. Levels of Visual Information on the Classroom Front Wall.

- ***Electric Lighting:*** The type and color of lighting were observed, as well as whether the lights were on or off at the time of observation. Most classrooms had fluorescent lighting (89.4%), while only 13.6% had LED lighting. A total of 97.7% of classrooms (n = 43) had white or cool white lighting. Only one classroom (2.3%) had a combination of one white and one warm light bulb. Most classrooms (59.1%) had the lights on at the start of the observation.

The average light intensity under the observed conditions was 558 lux . The median = 398 lux; SD = 477 lux). For the analysis of light intensity, classrooms were classified based on cut-off points into three equal groups. Each classroom was assigned to one of the following categories: high (≥ 456 lux), medium (271–455 lux), or low (≤ 271 lux). According to this classification, 40% of classrooms had medium lighting levels, 35% had high levels, and 25% had low levels.

- ***Windows and Sunlight:*** Sunlight exposure and the presence of curtains were recorded. Most classrooms received sunlight in the afternoon (54.5%), 29.5% in the morning, and 15.9% did not receive direct sunlight at any time of day. A total of 90.9% of classrooms had curtains installed. The average size of exterior windows was 12.5 m^2 (median = 10.9 m^2; SD = 6.55 m^2), indicating considerable variability in window size across classrooms.

For the analysis of window size, classrooms were classified using cut-off points for three equal groups. Each classroom was assigned a window size classification: large (≥ 13.1 m^2), medium (between 10.4 and 13.0 m^2), or small (≤ 10.3 m^2). According to this classification, 34.1% of classrooms had large windows, 31.7% had medium windows, and 34% had small windows.

- ***Auditory Environment:*** Due to fieldwork limitations, background noise measurements were obtained in only seven classrooms, during Language, Mathematics, and Science classes. The mean was 71.9 dB and the median was 73.0 dB, with a standard deviation of 1.99 dB, indicating low variability in background noise levels. The average minimum noise level was 46 dB, and the maximum was 89 dB.

Additionally, the presence of protective or non-slip rubber feet on the legs of classroom furniture was analyzed. A total of 75% of the classrooms did not have them, which may be a relevant factor given the high-intensity noise produced by friction between aluminum legs (the material of the furniture) and the floor, particularly on ceramic tile surfaces (31.8% in this sample) (see Figure 2).

Figure 2. Ceramic Tile Flooring and Classroom Furniture Without Protective Rubber Feet.

Figure 3 visually summarizes the physical and sensory characteristics of the classrooms analyzed in this study.

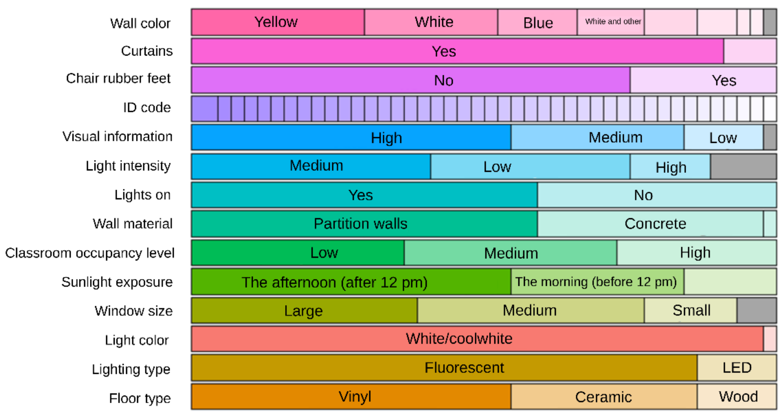

Figure 3. Summary of the Physical and Sensory Characteristics of the Classrooms.

Multiple Correspondence Analysis (MCA)

Through multiple correspondence analysis (MCA), the categorical variables related to the physical and sensory characteristics of the classrooms were grouped. Figure 4 illustrates these classroom characteristics organized into dimensions. Dimension 1 has an eigenvalue of 3.37 and explains 24.1% of the total variance; dimension 2 has an eigenvalue of 1.61 and contributes 11.5%; and dimension 3 has an eigenvalue of 1.21 and contributes 8.5% of the variance, reaching a cumulative total of 44%. Figure 4 shows the grouping of the categorical variables, identifying three dimensions, which are presented below.

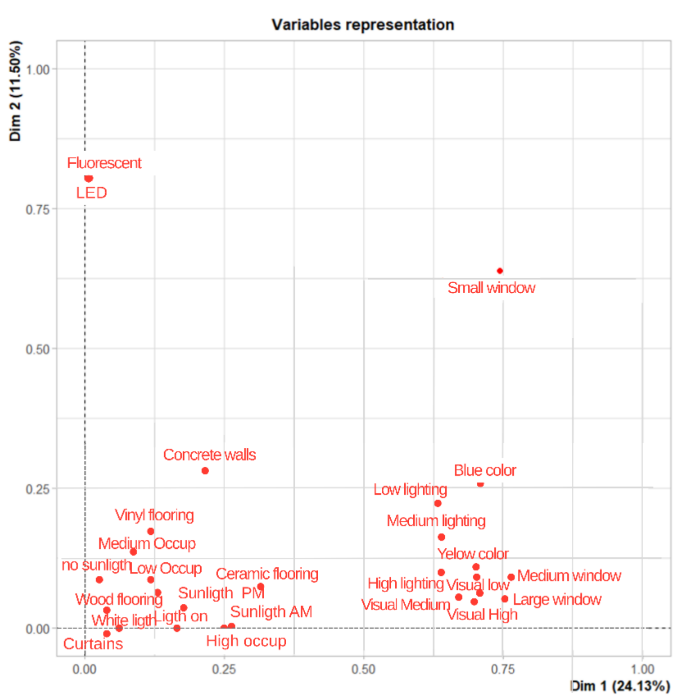

Figure 4. Dimensional Grouping of the Physical and Sensory Environment.

Dimension 1 – Physical classroom environment

The analysis of squared cosines and contributions indicates that the variables contributing most to dimension 1 are classroom density or occupancy, sunlight exposure (AM/PM), flooring type, wall materials, and the presence of protective rubber feet on furniture. This dimension primarily reflects the physical characteristics of the classroom, including materials and infrastructure.

In addition, dimension 1 groups a profile of classrooms that may be associated with a higher likelihood of noise. These include classrooms with high occupancy (i.e., less than 2.0 m^2 per student; 0.26), ceramic tile flooring (0.17), partition walls (0.20), and exposure to morning sunlight (0.24).

Dimension 2 – Sensory environment / Low-stimulation classrooms

The analysis of contributions indicates that the variables most strongly associated with dimension 2 are lighting type (LED/fluorescent), window size, wall color, and light intensity. The variables in this dimension define a profile of low-stimulation classrooms, characterized by no sunlight exposure (0.12), small windows ($\leq$ 10.3 m^2; 0.59), concrete walls (0.30), blue wall paint (0.23), medium light intensity (271–455 lux; 0.14), and LED lighting (0.08).

Dimension 3 – Sensory environment / High-stimulation classrooms

Dimension 3 includes variables related to visual stimulation, lighting, and color. The variables in this dimension form a profile of highly stimulating classrooms, characterized by yellow-painted walls (0.04), medium and large windows ($\geq$ 13.1 m^2; 0.04), high levels of visual information (0.08), and high light intensity (i.e., an average above 456 lux; 0.06).

Discussion

This study provides empirical evidence on the physical and sensory characteristics of classrooms in Chilean public elementary schools (first cycle of primary education), as well as their potential implications for the inclusion of autistic students. The results show that classrooms frequently present environmental conditions identified in the literature as potential barriers for this group, particularly in visual, auditory, and spatial domains (Goodall, 2019; Martin & Wilkins, 2022; Saggers et al., 2016).

Among the most relevant findings are the high prevalence of white fluorescent lighting, the absence of protective rubber feet on furniture, and the high level of visual information on front walls, along with noise levels that exceed recommended international standards (Berglund et al., 2002; Kanakri et al., 2016, 2017). These conditions may constitute barriers for autistic students, in line with previous studies linking overstimulating environments to greater difficulties in school participation (González de Rivera Romero et al., 2022; Kinnealey et al., 2012).

- **1. *Classroom Infrastructure:*** The results showed that most classrooms were constructed with partition walls (59%) and concrete (38.6%), with limited use of wood (2.3%). Although the infrastructure meets basic safety and habitability criteria, the predominance of partition walls may affect students with heightened auditory sensitivity. The literature suggests that selecting materials with sound-absorbing properties can facilitate the inclusion of autistic students (Guo et al., 2024; Shield et al., 2015). Adjustments such as acoustic panels or noise-insulating coverings could improve student attention and well-being.
- **2. *Size and Spatiality:*** The average space per student was 2.8 m^2, exceeding the minimum standard (1.1 m^2 per student), although with considerable variability (1.21–9.76 m^2). A total of 27.3% of classrooms showed high density (< 2 m^2 per student), which may affect comfort, proxemics, and the provision of appropriate accommodations for autistic students (Villegas Otárola et al., 2014; Fusaro et al., 2023). Reducing student density may improve sensory experience and participation, providing more suitable learning environments.
- **3. *Visual Environment:*** It was observed that most classrooms (67.4%) presented visually overloaded front walls. The predominance of high levels of visual information aligns with reports of discomfort and distraction in overstimulating environments. Excessive decoration and suspended elements may contribute to distraction or anxiety in autistic students (Martin & Wilkins, 2022; Zazzi & Faragher, 2018), indicating the need for more balanced and regulated visual design. It is recommended that visual information be distributed across side walls, that neutral colors be used, and that areas with low visual information be maintained, which may support attention and participation in school activities.
- **Lighting:** Although the presence of curtains in most classrooms may support the regulation of natural light, significant variability in brightness levels and a tendency toward unnecessary use of artificial lighting were observed. This may negatively affect students with sensory hypersensitivity, consistent with accounts from autistic individuals (Grandin, 1997; Wizaka et al., 2021). These findings highlight the need to consider lighting not only as a functional requirement but also as a key sensory component of the learning environment. The predominance of white fluorescent lighting, combined with medium and high intensity levels, may contribute to overstimulation for students with visual hypersensitivity. The absence of adjustable lighting systems limits the possibility of adapting the environment to the specific needs of each classroom, in line with the principles of Universal Design for Learning.
- **4. Indoor Noise and Furniture**: Although acoustic measurements were taken in a limited number of classrooms, the high average of 72 dB recorded is more than double the level recommended by the WHO (35 dB) and has been associated with the emergence of challenging behaviors (Kanakri et al., 2016, 2017), reinforcing the need for acoustic management strategies in schools. Furthermore, the widespread absence of sound-absorbing rubber pads on furniture represents a low-cost, modifiable factor whose correction could significantly contribute to reducing classroom noise. Excessive noise may generate stress, anxiety, and difficulties in concentration among autistic students. It is recommended that sound-absorbing rubber pads, mats, or panels be incorporated, and that noise levels be monitored, as these measures may help reduce auditory overload and support participation and learning.

Finally, multiple correspondence analysis enabled the identification of classroom profiles by integrating the variables under study, offering insight into how certain combinations of physical and sensory characteristics coexist in school spaces. These profiles suggest the presence of classrooms with higher levels of sensory stimulation and others with potentially more favorable conditions for sensory regulation, reinforcing the importance of considering the environment as a complex system that interacts with students' needs.

These results invite reflection on the complex relationship between environmental characteristics and the diversity of physical and sensory needs that students may present. In this regard, Chilean regulatory frameworks, such as Decree 83, provide guidance for understanding the environment as a pedagogical resource; however, specific standards regulating the sensory aspects of classrooms remain limited (Biblioteca del Congreso Nacional de Chile, 2022; Chile, 2015a, 2015b, 2009). The application of a Universal Design for Learning approach should also incorporate the possibility of creating flexible environments that respond to the specific composition of each group of students (Baars et al., 2021; Gentil-Gutiérrez et al., 2021).

The development of educational communities emerges as a central element in advancing toward more inclusive classrooms. Strategies such as participatory noise monitoring, the intentional use of natural and artificial lighting, the selection of neutral colors, and the reduction of unnecessary visual stimuli can be implemented with the active participation of students and teachers, strengthening both a sense of belonging and shared responsibility in the design of school environments (McAllister & Sloan, 2016; Gentil-Gutiérrez et al., 2021).

Finally, it is important to acknowledge the limitations of the study: the sample, restricted to public schools, and the limited number of acoustic measurements constrain the generalizability of the findings. Future research should incorporate private and subsidized schools, as well as extend the analysis to other educational levels and regions of the country. Despite these limitations, this study provides an initial description and analysis of the physical and sensory environment of classrooms in the first cycle of education from an inclusive perspective. The findings establish a baseline for future research aimed at further examining the relationship between environmental characteristics, levels of inclusion, and students' experiences, thereby contributing to the development of more robust and transferable recommendations to inform inclusive public policies and school practices.

Conclusions

The results of this study show that the classrooms observed in Chilean public schools share physical and sensory characteristics that, in many cases, may constitute significant barriers to the inclusion of autistic students. The prevalence of fluorescent lighting, the absence of noise-reducing elements on furniture, high noise levels, and visual overload are aspects that require active management by educational communities. At the same time, the availability of physical space exceeding the minimum regulatory requirement was identified as a facilitating factor that may support student well-being and participation.

In a context where national literature has not yet sufficiently examined the relationship between classroom characteristics and educational inclusion, this study contributes to addressing an existing gap. The findings provide empirical evidence that can inform the design of pedagogical and school management strategies aimed at improving learning environments.

Among the practical recommendations are the replacement of fluorescent lighting with dimmable LED systems, the installation of protective rubber covers on furniture, the reduction of unnecessary visual stimuli, and the use of sound-absorbing materials in classrooms. These relatively low-cost and feasible measures not only benefit autistic students but also contribute to more comfortable, equitable, and healthy environments for the broader school community.

In sum, this study reinforces the need to consider the classroom as both a resource and a space for inclusive practice, which, when appropriately managed, can become a key facilitator of the retention, participation, and well-being of autistic students. In doing so, it contributes to the full realization of their rights and to the strengthening of inclusive educational pathways within the Chilean school system.

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Author's Contributions

Verónica Angulo de la Fuente was responsible for the conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, writing – original draft. Verónica López was responsible for the conceptualization, funding acquisition, investigation, methodology, formal analysis, supervision, writing – review & editing. Carolina Urbina was responsible for the conceptualization, funding acquisition, formal analysis, investigation, methodology, supervision, writing – review & editing. Javiera Salazar Rivera was responsible for the validation, visualization, writing – review & editing. Ximena Aranda Aguirre was responsible for the validation, visualization, writing – review & editing. All authors approved the final version of the text.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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