The Impact of Acoustics on Learning Environments for Neurodiverse Students

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Next Steps
Good acoustic performance has been identified as one of the critical Indoor Environmental Quality (IEQ) factors for student learning and development. Early childhood is when people develop lifelong skills that will support them throughout their adult lives. Acoustic performance of a space has been identified as a factor that can impact language acquisition, concentration, information retention, and general comfort within the environment. Increasingly, students learn by communication between both teachers and fellow students, making speaking and listening crucial.

There has been several guidelines used to improve the acoustical suitability of the classroom to neurotypical students but little or limited research on the suitability of this guidelines to autistic students.
This research looks at guidelines and standard for spaces with good acoustical quality and relates it with the experiences of students with autism spectrum disorder (ASD), their parents, teachers and educators through a mixed methods approach including selected case studies, interviews, and mixed surveys. The information obtained from these sources will be used to determine if selected materials (with properties relating to sound absorption and reverberation reduction) are equally useful in small, medium sized and large learning spaces. The results would describe the potential impact of acoustics on Neurodiverse students, considering factors that determine the complexity of sound in relation to the auditory processing capabilities of ASD students.

Neurodiversity while initially coined to describe individuals with autism spectrum disorder (ASD) - widely describes anyone with a different brain process. As the understanding from cognitive and neurosciences increases, the number of people identified as neurodiverse is nearly 30% of the population.

Research Questions

1. Is the current acoustical guidelines for designing K-5 learnings spaces suitable for hypersensitive autistic students in learning spaces?

2. What performance thresholds and material recommendation can be used to improve suitability of learning spaces to hypersensitive autistic student?
Research Methodology

Mixed Methods

Establishing Logical Blocks
1. What is the cause of Acoustical Discomfort for Neurodiverse (ASD) Students?

Exploring the Questions
1. What are Design considerations?
2. What is the experience of neurodiverse Students within the building(s)?
3. How can the learning spaces be improved?

Testing the Recommendations
1. Researching material and design improvement for better learning experience for neurodiverse students
2. Final Recommendation
Research Timeline

Literature Review

- Review of Design Consideration for Learning Spaces
- Review of Acoustical Guidelines

Case Study

- The current sound measurement in the space.

Expert Interview

- Interview of Acousticians
- Interview of Audiologist
- Interview with Interior Designer

Analysis and Recommendation

- Analysis and Discussion
- Final Recommendation

Educator’s Interview

- Interview of Parents with children with Autism Spectrum Disorder
- Interview of Teachers/Educators

Timeline:

01: Nov
02: Nov/Febr’22
03: Nov-Mar’22
04: Dec/Mar’22
05: Jan-April’22
Sound radiates in waves in all directions from a point source until it encounters an obstacle like walls or ceiling.

Intensity is a physical measurement of a sound wave that relates to how loud a sound is perceived to be.

This is perceived as pitch, and it is the rate of repetition in vibration of the sound wave. A single frequency is pure tone but most everyday sound like speech, music and noise are complex with a mix of different frequency. Frequency is measured in Hertz (Hz).

Multiple actions can occur simultaneously. High frequency sounds are absorbed and reflection of low frequencies sound. The Absorption Coefficient (α) and Noise Reduction Coefficient (NRC) are used to specify the ability of a material to absorb sound.
Acoustics

How quickly sound decays in a room an depends on the Physical Volume and Surface Materials of a room.

Solutions
1. Decreasing Volume
2. Sound adsorption increased and or Diffusion

Wanted Sound Background Noise/Sound

a. Mechanical Noise
- High ambient noise from mechanical equipment's such as noisy heating, ventilation and air conditioning (HVAC) systems
- Mechanical Noise can also be measured by Noise Criteria , NC 25 to 30
- Typically, Noise Level of a room in dBA is 5 to 7 dB higher than NC
b. Interior Noise i.e., Noise from adjacent rooms, spaces. Even within the class
- C. Exterior Noise – Noise from Site and community

Solutions
1. Better Plaining to reduce noise level
2. Use of different material and design strategies

Noise Reduction, NR ( between two spaces) – Expressed in decibels (dB) – This is the amount of sound produced in one room that passes through into the neighboring room . NR = Noise Level in Source Room – Noise Level in Receiving Room . Measured in dB

Signal to Noise Ratio (S/N) - This is a simple comparison that is useful for estimating how understandable the speech in a room.
S/N = Sound level of Teacher’s voice – The Background Noise level . Measured in dB, This varies across the classroom especially (1) at the back where teacher voice is at the minimum (2) At the noise source where noise level is maximum . The greater the S/N , he greater the Speech Intelligibility and should be greater than 10dB

Speech Intelligibility - This can be measure through an A weighted sound level, Speech Transmission Index, Signal to Noise ratio and Reverberation Time. SI, is also affected by reverberations (undesirable reflection's) due to flutter echo ( between two flat hard surfaces parallel to each other)

Noise Criteria , NC - rating determined by measuring noise level at certain frequencies , plotting the level on the graph and comparing results to established NC curves.

Frequency - A young normal person can detect a wide range of frequencies about 20 – 20,000 Hz and to deal with the spectrum . There are commonly divided into standard octave bands – 63, 125,250, 500, 1000, 2000, 4000 and 4000 and 8000 Hz
Literature Review

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Solutions

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<table>
<thead>
<tr>
<th>Learning Spaces</th>
<th>Background Noise Level / Occupied sound Level (dB)</th>
<th>Maximum Permitted Reverberation with midband frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of Less than or equal to 283m³ (10,000ft³) - (Small Space)</td>
<td>35/55</td>
<td>0.6s</td>
</tr>
<tr>
<td>Volume of greater than to 283m³ (10,000ft³) but less than or equal to 566m³ (20,000ft³) - (Medium Space)</td>
<td>35/55</td>
<td>0.7s</td>
</tr>
<tr>
<td>Volume of greater than 566m³ (20,000ft³) and Auxiliary Learning Spaces - (Large Space)</td>
<td>40/60</td>
<td>No requirement</td>
</tr>
</tbody>
</table>
**Literature Review**

**Autism**

**Hypo Sensitivity**
This is an under reactive (abnormal) response to incoming sensory information from the surrounding environment which could be caused by the inability to process information from several senses at once.

**Hyper Sensitivity**
This is a hyper reactive (abnormal) response to incoming sensory information from the surrounding environment which could be caused by the inability to process information from several senses at once.

**Three Functional Levels of Autism**

**Level 1**
- **Requiring Support**
  This is the mildest and most functioning form of autism.
  1. Difficulty initiating social interactions
  2. Organization and Planning Problems can hamper independence
  3. May have difficulty moving from one activity to the another or try new things

**Level 2**
- **Requiring Substantial Support**
  This people have more obvious challenges with verbal and social communication than those diagnosed with level.
  1. Social Interaction limited to narrow special interests
  2. Frequent restricted repetitive behaviors

**Level 3**
- **Requiring very Substantial Support**
  This is the most severe form of autism. Have many of the same behaviors of Level 1 & 2 but to an extreme degree.
  1. Severe deficits in verbal and non-verbal social communication skills
  2. Great distress/difficulty changing actions or focus

[View the image](https://carmelblogs.ee.com/blog/what-is-autism-spectrum-disorder/)
Literature Review

**Autism**

### Hypo Sensitivity
This is an under reactive (abnormal) response to incoming sensory information from the surrounding environment which could be caused by the inability to process information from several senses at once.

### Hyper Sensitivity
This is a hyper reactive (abnormal) response to incoming sensory information from the surrounding environment which could be caused by the inability to process information from several senses at once.

### Level 1
- Difficulty initiating social interactions
- Organization and Planning Problems can hamper independence
- May have difficulty moving from one activity to the another or try new things

**Requiring Support**
This is the mildest and most functioning form of autism
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### Level 2
- Social Interaction limited to narrow special interests
- Frequent restricted repetitive behaviors

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### Three Functional Levels of Autism
- **Level 1**
  - Requiring Support
    - Difficulty initiating social interactions
    - Organization and Planning Problems can hamper independence
    - May have difficulty moving from one activity to the another or try new things

- **Level 2**
  - Requiring Substantial Support
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- **Level 3**
  - Requiring very Substantial Support
    - Severe deficits in verbal and non-verbal social communication skills
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### Sensory Processing
- Auditory (Sound)
- Tactile (Touch)
- Visual (Sight)
- Vestibular (Motion)
- Smell/Taste (Olfactory)
- Proprioception (sense of body’s location)
Hansen defines learning spaces in the learning environment as the combination of the physical environment [the classrooms]; the learning activities which take place in this environment during school hours, and the behavior of the students which affects or might affect these activities.

### Physical Learning Space

- **Small Space**
  - Volume of less than or equal to 283m$^3$ (10,000ft$^3$) - (Small Space)

- **Medium Space**
  - Volume of greater than 283m$^3$ (10,000ft$^3$) but less than or equal to 566m$^3$ (20,000ft$^3$)

- **Large Space**
  - Volume of greater than 566m$^3$ (20,000ft$^3$) and Auxiliary Learning Spaces

### Behavior | Experience during Learning

<table>
<thead>
<tr>
<th>Phycological Consequences</th>
<th>Physiological Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energized</td>
<td>Productive</td>
</tr>
</tbody>
</table>
Expert Interview

**Acousticians**
Interview two (2) – three (3) accusations to better understand the acoustical design consideration and challenges in learning spaces. Relate my literature finding and methodology. Clarify considerations for improving learning spaces (especially for neurodiverse students).

**Auditory Processing Expert | Audiologist**
Interview two (2) audiologist with a focus on Autism Spectrum Disorder. Clarify the acoustical challenges of ASD students – At the ear or processing. Clarify the impact and understand how to improve auditory response for ASD students.

**Designers**
Interview Interior Designer working with ASD. Clarify considerations for improving learning spaces acoustically (especially for neurodiverse students). Discuss Research methodology and Expectation. Practice Challenges in improving spaces for Neurodiverse students.

Advice | Help: Audiologist working with ASD.