https://nationaltoday.com/world-autism-awareness-day/

The Impact of Acoustics on Learning Environments for Neurodiverse Students

Michael Lekan-Kehinde | Abimbola Asojo (Ph.D) & B. Sanborn

Content of Presentation

Title Page

Content Page

Research Background

Research Statement

Research Methodology

00 Research Timeline

01 Literature Review

02 Case Study

03 Expert's Interview

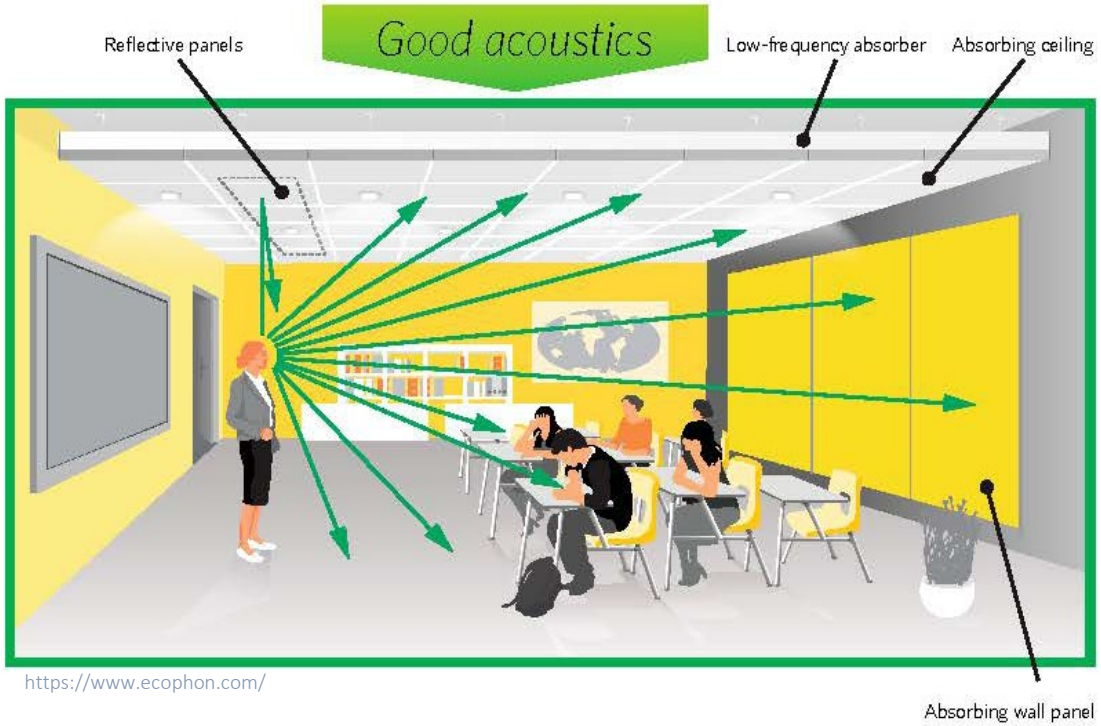
04 Educator | Parent Interview

05 Children Interview

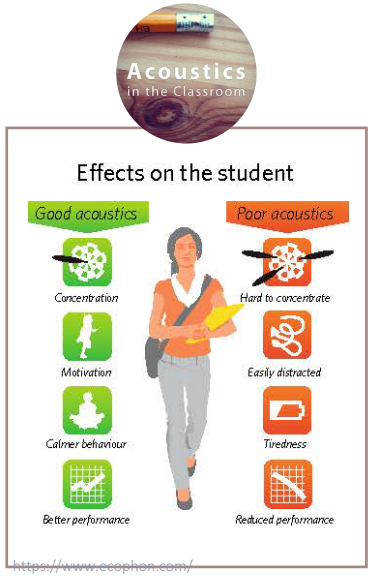
06 Analysis and Recommendation

Next Steps

Research Background



https://www.ecophon.com/



https://www.ecophon.com/

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

Research Statement

www.bangkokpost.com

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

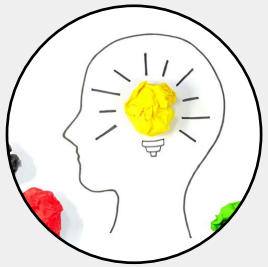
This research looks at guidelines and standard for spaces with good acoustical quality and relates it with the experiences of students with autism spectrum disorder (ASD), their parents, teachers and educators through a mixed methods approach including selected case studies, interviews, and mixed surveys. 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

Research Questions

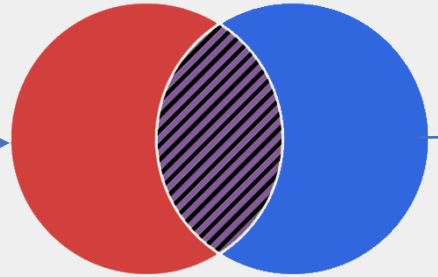
1. Is the current acoustical guidelines for designing K-5 learnings spaces suitable for hypersensitive autistic students in learning spaces ?
2. What performance thresholds and material recommendation can be used to improve suitability of learning spaces to hypersensitive autistic student?

Research Methodology

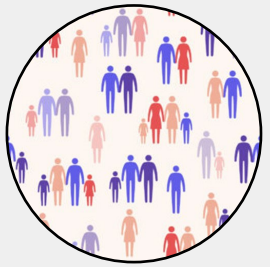
Mixed Methods



Logical Research / Argumentation



Case Studies and Combined Strategies



Simulation and Modeling

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

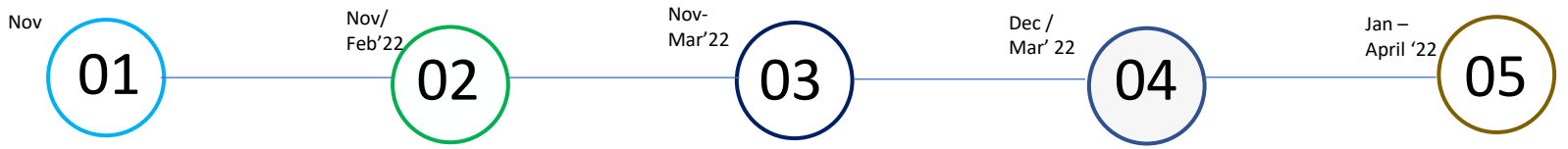
- Review of Design Consideration for Learning Spaces
- Review of Acoustical Guidelines

Case Study

- The current sound measurement in the space.

Analysis and Recommendation

- Analysis and Discussion
- Final Recommendation



Expert Interview

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

Educator's Interview

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

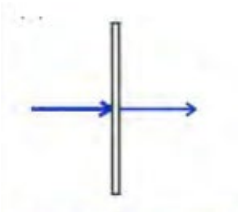
01 Literature Review

Sound

Sound radiates in waves in all directions from a point source until it encounters an obstacle like walls or ceiling.

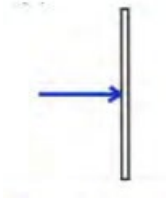
Transmission

Sound passes through the surface into space beyond - Windows



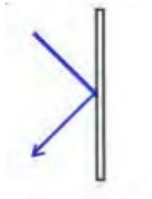
Adsorption

Sound is absorbed by the surfaces it strikes



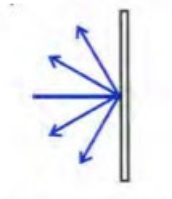
Reflection

Sound strikes a surface and changes direction – Walls and ceilings



Diffusion

Sound strikes the surface and is scattered in many directions



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 o absorb sound*

Characteristics

Two Characteristics of these sound waves with interest to architectural or interior acoustics

Intensity

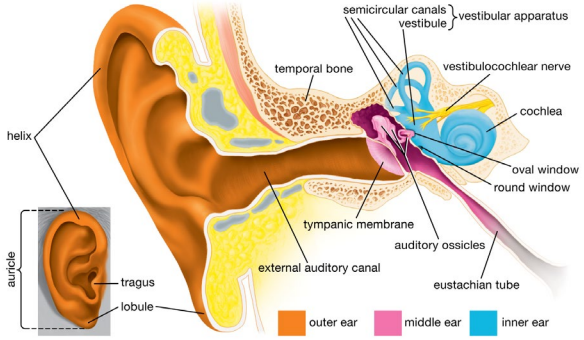
Intensity is a physical measurement of a sound wave that relates to how loud a sound is perceived to be.

Frequency

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 I measured in Hertz(Hz)

Frequency

Sensitivity of human ear



© Encyclopædia Britannica, Inc.

https://www.britannica.com/science/ear

Disturbance with High and Medium frequency noises especially pure tones

01 Literature Review

Acoustics

Logical block – First Principle – Classroom Needs

Sound Level

Measured in decibels (dB)

Reverberation Time

Measured in Second(s)

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 Nose – Noise from Site and community

Solutions

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

Terminologies

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

Frequency

Sound Transmission Coefficient

Vibration

Sound Pitch

01 Literature Review

Acoustics

Logical block – First Principle – Classroom Needs

Sound Level

Measured in decibels (dB)

Reverberation Time

Measured in Second(s)

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 Nose – Noise from Site and community

Solutions

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

ANSI
American National Standards Institute

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

01 Literature Review

Autism

Logical block – First Principle – Autism Categories (Sensory Processing)

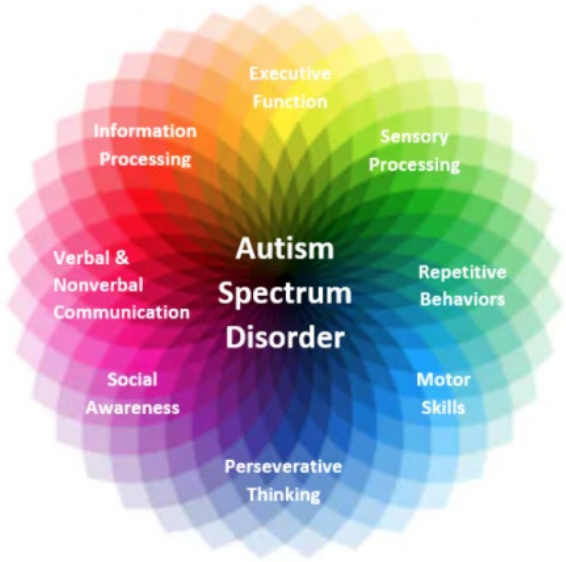
Hyper Sensitivity

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

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

- Auditory (Sound)
- Tactile (Touch)
- Visual (Sight)
- Vestibular (Motion)
- Smell/Taste (Olfactory)
- Proprioception (sense of body's location)



carmenbpingree.com/blog/what-is-autism-spectrum-disorder/

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

01 Literature Review

Autism

Logical block – First Principle – Autism Categories (Sensory Processing)

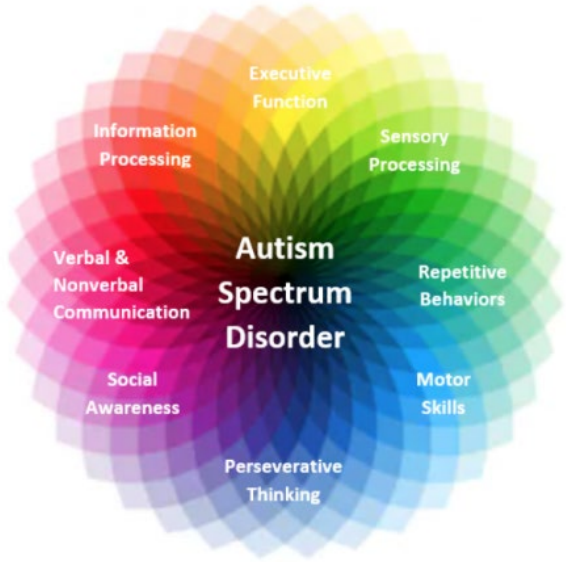
Hyper Sensitivity

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

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

- Auditory (Sound)
- Tactile (Touch)
- Visual (Sight)
- Vestibular (Motion)
- Smell/Taste (Olfactory)
- Proprioception (sense of body's location)



carmenbpingree.com/blog/what-is-autism-spectrum-disorder/

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

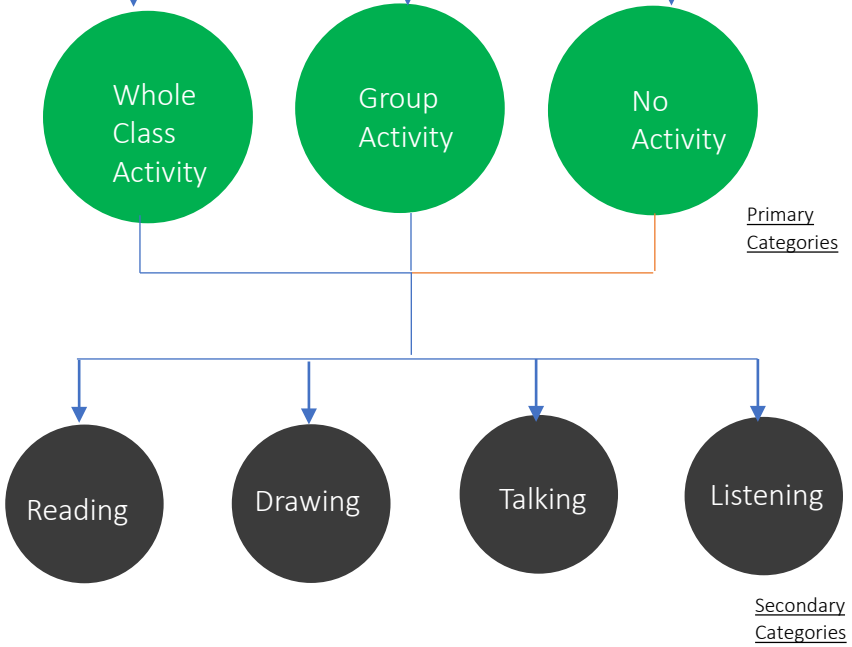
This is the most severe form of autism . Have many of the same behaviors of Level 1 & 2 but to an extreme degree.

1. Severe deficits in verbal and non-verbal social communication skills
2. Great distress/ difficulty changing actions or focus

01 Literature Review

Learning Space

Logical block – First Principle – Children Learning Activity



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 to 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

Phycological Consequences

Physiological Consequences

Energized | Productive | Frustrated | Fatigue | Annoyed | Stress| Tired

02 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

03 Case Study

Minnesota

Florida

Louisiana

Nebraska

Nevada

Washington DC

Sources

- Ackley, A., Donn, M., & Thomas, G. (2017). The Influence of Indoor Environmental Quality in Schools A Systematic Literature Review. *The Next 50 Years, (51st International Conference of the Architectural Science Association (ANZAScA))*, *December*.
- ADHD Aware. (n.d.). *Neurodiversity and other conditions - ADHD Aware*. Retrieved October 11, 2021, from https://adhdaware.org.uk/what-is-adhd/neurodiversity-and-other-conditions/
- Benton, L., Vasalou, A., Khaled, R., Johnson, H., & Gooch, D. (2014). Diversity for Design : A Framework for Involving Neurodiverse Children in the Technology Design Process. *CHI '14: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 3747–3756.
- Cheryan, S., Ziegler, S. A., Plaut, V. C., & Meltzoff, A. N. (2014). Designing Classrooms to Maximize Student Achievement: *Https://Doi-Org.Ezp2.Lib.Umn.Edu/10.1177/2372732214548677*, *1*(1), 4–12. https://doi.org/10.1177/2372732214548677
- Choi, S., Guerin, D., Kim, H.-Y., Brigham, J. K., & Bauer, T. (2014). Indoor Environmental Quality of Classrooms and Student Outcomes: A Path Analysis Approach. *Journal of Learning Spaces*, *2*(2).
- Classroom Acoustics Working Group. (2000). Improving Acoustics in American Schools: Working Draft of Standard "Acoustics in School Classrooms and Other Learning Spaces." *Language, Speech, and Hearing Services in Schools*, *31*(4), 391–393. https://doi.org/10.1044/0161-1461.3104.391
- Cooper, R. (n.d.). *NEURODIVERSITY AND DYSLEXIA; CHALLENGING THE SOCIAL CONSTRUCTION OF SPECIFIC LEARNING DIFFICULTIES*.
- ECLKC. (2021). *Learning Environments | ECLKC*. https://eclkc.ohs.acf.hhs.gov/learning-environments
- Emily, W. (n.d.). *Design for Neurodiverse Learners*. Retrieved October 11, 2021, from https://www.td.org/magazines/td-magazine/design-for-neurodiverse-learners
- Fodstad, J. C., Kerswill, S. A., Kirsch, A. C., Lagges, A., & Schmidt, J. (2021). Assessment and Treatment of Noise Hypersensitivity in a Teenager with Autism Spectrum Disorder: A Case Study. *Journal of Autism and Developmental Disorders*, *51*(6), 1811–1822. https://doi.org/10.1007/S10803-020-04650-W/FIGURES/4
- Gheller, F., Lovo, E., Arsie, A., & Bovo, R. (2020). Classroom acoustics: Listening problems in children. *Building Acoustics*, *27*(1), 47–59. https://doi.org/10.1177/1351010X19886035
- Hansen, E. K., Nielsen, S. M. L., Georgieva, D., & Schledermann, K. M. (2018). The impact of dynamic lighting in classrooms. A review on methods. *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*, *229*, 479–489. https://doi.org/10.1007/978-3-319-76908-0_46
- Kanakri, S. M., Shepley, M., Tassinary, L. G., Varni, J. W., & Fawaz, H. M. (2016). An Observational Study of Classroom Acoustical Design and Repetitive Behaviors in Children With Autism: *Https://Doi-Org.Ezp2.Lib.Umn.Edu/10.1177/0013916516669389*, *49*(8), 847–873. https://doi.org/10.1177/0013916516669389
- Klatte, M., Hellbrück, J., Seidel, J., & Leistner, P. (2010). Effects of Classroom Acoustics on Performance and Well-Being in Elementary School Children: A Field Study. *Environment and Behavior*, *42*(5). https://doi.org/10.1177/0013916509336813
- Leggett, S., Dodd, G., & Donn, M. (2015). *The Acoustic Performance of Modern Learning Environments Vs . Single Cell classrooms*. *December*. https://doi.org/10.3850/978-981-09-7961-4
- Luscombe, J. L. i. (2016). *Acoustics Affect Productivity and Well Being*. https://information.insulationinstitute.org/blog/noise-affects-productivity-and-well-being
- Mark, I. (2020). *Acoustics and Learning | How do they improve learning? | Resonics*. https://resonics.co.uk/how-acoustics-improve-learning/
- Mott, M. S., Robinson, D. H., Williams-Black, T. H., & McClelland, S. S. (2014). The supporting effects of high luminous conditions on grade 3 oral reading fluency scores. *SpringerPlus*, *3*(1). https://doi.org/10.1186/2193-1801-3-53
- National Centre for Educational Statistics. (2008). *Average number of hours in the school day and average number of days in the school year for public schools, by state: 2007–08*. Schools and Staffing Survey (SASS). https://nces.ed.gov/surveys/sass/tables/sass0708_035_s1s.asp
- National Research Council. (2007). Green schools: Attributes for health and learning. In *Green Schools: Attributes for Health and Learning*. The National Academies Press. https://doi.org/10.17226/11756
- Open & Inclusive Special Interest Group. (2020). *Guidance: Designing Learning for Autistic and Neurodiverse Students*. http://www.open.ac.uk/blogs/opentel/guidance-designing-learning-for-autistic-and-neurodiverse-students/
- Scannell, L., Hodgson, M., García, J., & Villarreal, M. (2015). *The Role of Acoustics in the Perceived Suitability of , and Well-Being in , Informal Learning Spaces*. *January*. https://doi.org/10.1177/0013916514567127
- Valtonen, T., Leppänen, U., Hyypiä, M., Kokko, A., Manninen, J., Vartiainen, H., Sointu, E., & Hirsto, L. (2020). Learning environments preferred by university students: a shift toward informal and flexible learning environments. *Learning Environments Research 2020 24:3*, *24*(3), 371–388. https://doi.org/10.1007/S10984-020-09339-6