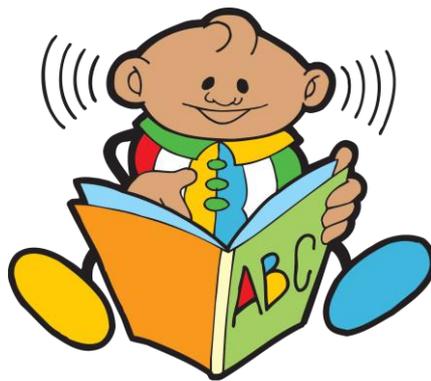


Classroom Acoustics

Teacher Information



Why are classroom acoustics important?

The accurate transmission of acoustical information in a classroom is imperative for optimal academic achievement. A student's ability to hear and understand what is being said in the classroom by the teacher is vital for learning. Unfortunately, this ability can be significantly reduced by poor classroom acoustics. We know that when classroom acoustics are poor then it can affect a child's:

- Listening comprehension, higher order cognitive functions and speech intelligibility¹
- language development²
- Development of English as a second language³

As younger children have a less mature auditory system and a less-well developed knowledge of language, they require a better quality acoustical environment than adults to understand speech – they perform more poorly in noisy situations than adults.⁴ Therefore, an adult's impression of how 'good' a classroom sounds is not an accurate measure of how acceptable it is for children. Children also exhibit a great deal of listening effort when attending to the spoken message.⁵

Good classroom acoustics are vital for children in any stage of language development, students where their home language is different from the language of learning, and students with hearing loss.⁶ This is particularly relevant in Australian classrooms with a high number of Aboriginal and Torres Strait Islander children who are from diverse linguistic and cultural backgrounds and who have a high prevalence of hearing loss due to otitis media. It is estimated that between 30-80% of Aboriginal and Torres Strait Islander school children experience significant conductive hearing loss caused by otitis media.⁷

In addition, poor classroom acoustics require teachers to speak at vocal levels, which cause stress and fatigue. Teachers often complain of tired voices, vocal strain and health concerns because of the need to speak at such high vocal levels.⁸

What are we measuring?

Children who have hearing loss experience the greatest challenges in acoustically inappropriate classrooms; quiet rooms allow them to use hearing aids and cochlear implants far more effectively. But research shows that all children will benefit from classrooms with low background noise and short reverberation times. Even children with hearing in normal ranges can miss as much as one-third of the words in a teacher's message when they are listening in noise.

¹ Jamieson D, Kranjc G, Yu K, Hodget W. Speech intelligibility of young school-aged children in the presence of real-life classroom noise. *J Am Acad Audiol* 2004;15:508-17.

² Crandell CC, Smaldino J. (2000). Room acoustics for listeners with normal hearing and hearing impairment. In: Valente M, Hosford-Dunn H, Roeser R, editors. *Audiology Treatment*. New York: Thieme.

³ Williams, J. & Capizzi-Snipper, G. (1990). *Literacy and bilingualism*. New York: Longman.

⁴ Massie R, Dillon H. The impact of sound-field amplification in mainstream cross-cultural classrooms: Part 2 Teacher and child opinions. *Aust J Educ*. 2006;50(1):78–95.

⁵ Bess, F. H., & Hornsby, B. Y. (2014). Commentary: Listening can be exhausting—Fatigue in children and adults with hearing loss. *Ear & Hearing*, 35, 592–599.

⁶ Crandell CC, Smaldino J. (2000). Room acoustics for listeners with normal hearing and hearing impairment. In: Valente M, Hosford-Dunn H, Roeser R, editors. *Audiology Treatment*. New York: Thieme.

⁷ Couzos, S. and Murray, R. (1999). *Aboriginal primary health care: an evidence-based approach*. Oxford University Press.

⁸ Durup N., Shield B. M., Dance S., Sullivan R., Gomez-Augustina L. How classroom acoustics affect the vocal load of teachers. *Energy procedia*. 2015;78:6.

Classroom Acoustics

How do we measure sound?

We measure sound with a device known as a **Sound-level Meter (SLM)**. A SLM measures the intensity of noise, music, and other environmental sounds. A typical SLM consists of a microphone for picking up the sound and converting it into an electrical signal, followed by electronic circuitry for operating on this signal so that the desired characteristics can be measured. The SLM is calibrated to read the sound level in decibels.

What parameters are we measuring?

1. Background Noise (BGN). Background noise refers to any undesired auditory stimuli that interfere with what a child wants, or needs, to hear and understand⁹. Background noise can originate either from outside the classroom (eg: lawn-mowing, traffic or children playing loudly in the playground) or inside the classroom (eg: air-conditioning, fans or children talking). According to the Australian and New Zealand Standard¹⁰, a classroom should have a satisfactory unoccupied noise level of 35dBA and a maximum of 45dBA. Within this level the BGN is controlled and will have a minimal impact on the acoustics of the classroom environment.

2. Reverberation Time (RT). Reverberation is a measure of how much sound 'bounces' around in a space. RT is measured by how long it takes a sound to decrease by 60dB after the generation of the sound has stopped. An example of an environment with high levels of reverberation is a squash court while in contrast a sound-treated space, with low levels of reverberation is a movie cinema. According to the Australian and New Zealand Standard¹¹, a primary classroom should have a reverberation time no greater than 0.4s and no greater than 0.5s for secondary school classrooms.

3. Signal-to-Noise Ratio (SNR). In most learning environments, the most important consideration for accurate speech perception is the relationship between the intensity of the signal (the teacher's voice) and the intensity of the background noise at the child's ear. This is referred to as the signal-to-noise ratio (SNR). The SNR at a student's ear should exceed a minimum of +15dB greater than BGN.¹² This will allow clarity of sound or speech and allow optimum chance of perception and understanding. These measurements will be made both and during class with the teacher.

A decibel (dB) is a logarithmic unit used to measure the sound intensity). Threshold of hearing is about zero dB for the average young listener, and threshold of pain (extremely loud sounds) is around 120dB.

Interesting fact: On 27 August 1883, the Earth made the loudest noise in recorded history – the eruption on the island of Krakatoa (Indonesia). The sound could be heard by people across 50 different geological locations around the world. The force of the blast was 10,000 times that of a hydrogen bomb, and the sound was registered at around 172dB over 160 kilometres away.

Interesting fact: The world record for RT was recorded in 2015 when acoustic scientists measured the reverberation time of a gunshot that was fired into an oil storage tank in Inchindown, Scotland. It lasted an amazing 112 seconds!

Tip: An effective way for teachers to increase the SNR is to use your Sound-field Amplification system. However, in a reverberant classroom, this may make listening more difficult.

⁹ Crandell, C., & Smaldino, J. (1995). An update on classroom acoustics for children with hearing impairment. *Volta Review*, 1, 4-12.

¹⁰ Australian New Zealand Standard. "AS/NZS 2107:2000, Acoustics-Recommended design sound levels and reverberation times for building interiors." Standards New Zealand, December 2000.

¹¹ Australian New Zealand Standard. "AS/NZS 2107:2000, Acoustics-Recommended design sound levels and reverberation times for building interiors." Standards New Zealand, December 2000.

¹² Wilson, Oriole, et al. *Classroom Acoustics: A New Zealand Perspective*. Wellington: The Oticon Foundation in New Zealand, 2002.

Other Measures and Tools

A **Classroom Acoustic Audit** asks teachers “*how acoustically friendly is your classroom?*” This process enables teachers to identify both the positive aspects as well as potential areas for improvement in their classrooms.

A **Teacher Interview and questionnaire** can build on the acoustic audit by delving into the specific causes (or otherwise) of background noise and reverberation, and how the teacher has set up their classroom. The process can also look at issues surrounding the teacher’s use of their sound-field amplification system. A teacher interview and questionnaire can also assist with capacity building by assisting the Deadly Ears team to understand the strengths and challenges of your classroom environment and allowing us to work together to decide acoustic adjustments that could improve listening for children in your classroom.

Pre and Post Modification Classroom Photographs can effectively demonstrate the integration of the acoustic modifications into the existing teaching environment. It can also allow Deadly Ears staff to consult with teachers about possible modifications whilst not in community.

Classroom Maps identify potential places where acoustic modifications would have the most benefit, and to also record where the modifications were placed. This assisted the team to identify and confirm the location and measurements of the different acoustic modifications.

A Classroom Acoustic Audit is easy and takes only a few minutes to complete.

Tip: It is good idea to record the interview (with the teacher’s permission) so that it can be transcribed later. This makes the qualitative analysis easier to undertake.

Tip: These can be done with your smartphone. The more photos, the better!

Tip: This can assist the Deadly Ears worker to understand the different landmarks of your room.

Classroom Acoustics

What simple advice can you give teachers to improve the acoustics in their classrooms?

There are a number of practical ways teachers can improve the acoustics in their classrooms without spending too much money. Individually they may not seem like much, however when combined they can make a significant difference to how well children hear in your classroom.

Reducing Background Noise (BGN)

1. Internal Noise

Air-conditioners and heaters

- Turn down or off during teaching times
- Replace with cheaper and quieter split-system units
- Ensure systems are regularly maintained and serviced

Computers/iPads/Electronic equipment

- Ensure any unnecessary equipment is turned off (eg: projectors, fish tanks)
- Headphones ensure sound is confined to those children using that particular device
- Splitters enable more than one child to listen at any one time to a particular device

Children's behaviour

- Curtains make the room darker/calmer which can help children to calm down, especially after a break. Curtains also decrease the temptation for distraction from students passing on verandahs
- Behaviour-based classroom sound-level meters can challenge children to keep the noise levels down, especially when combined with a reward system.

Furniture

- Chair and table stoppers/siders reduce noise on hard surfaces like lino. You can even put tennis balls on the feet of chairs and desks
- Chair bags (rather than noisy tidy-trays)

2. External Noise

Maintenance

- Arranging lawn-mowing/whipper-snipping outside of teaching times.

Student-generated noise

- Rubber matting can be placed on the verandahs to reduce noise
- Outdoor student activities may be able to be moved away from classrooms

You can reduce background noise at either:

- a) the source
- b) the transmission route, or
- c) the destination.

Tip: A teacher in a remote Aboriginal community reported that children calmed down quicker after a break when the curtains were drawn, the children were lying on carpet squares and listening to quiet music for 5 minutes.

Tip: You can fit old tennis balls on the feet of tables yourself to reduce noise¹³

Remember, there will always be noise that you cannot control (eg: traffic, aircraft...).

Reducing Reverberation (Echo)

Adding soft furnishings to your classroom where possible, for example:

- Carpet squares and matting
- Cushions (in a reading corner)
- Felt/pin/cork boards
- Egg cartons and netting
- Curtains on windows
- Hanging flags, hessian, material

Increasing the Signal-to-Noise Ratio (SNR)

The two components to increase the SNR is for teachers to:

- increase the level of their voice. The most effective and sustainable way to do this is for teachers to always use their sound-field amplification system (SAS);
- decrease the BGN (see above)

The most effective way to reduce reverberation (echo) is to add sound absorbing elements to the surfaces of the space.

It is important to ensure there is a SAS user and trouble-shooting guide in every classroom near the SAS.

The use of communication behaviours to maximise hearing opportunities

- Make sure the students can see your face when you are speaking or reading
- Ensure that there is good light on your face, your mouth is not covered by your hands or a book when reading to the class.
- Speak clearly
- Aboriginal and Torres Strait Islander Education Officers are skilled at subtly watching children who find listening hard and prompting them to pay attention, or re-instructing those who need it.
- When giving direct instruction or instructions to complete a task, formally notify the class to listen. Look for attentive behaviours (ie. looking at teacher, not talking) in at-risk students. Prompt them (call their name) or ask your Aboriginal and Torres Strait Islander Education Officers to monitor them. Try to maintain a position in the classroom where all children can see you. Walking around while instructing can make it difficult for hearing impaired children.
- Make clear distinctions between listening time and other times. Children should be encouraged to “*sit still*” at listening time
- Routine is essential, particularly for children in the early primary years.
- Make sure the hearing impaired student is attending, not just listening when you begin new work, when you ask a question, or when you give out a job. Alternative indications of auditory attention could be:
 - sitting up straight, hands in lap;
 - no talking to others.
- Check to ensure that students have understood instructions and encourage them to let you know if they have not understood what has been said
- Make other students aware of conductive hearing loss and encourage positive acceptance of students who may have difficulty in hearing

Middle Ear Disease and Aboriginal and Torres Strait Islander Children

Aboriginal and Torres Strait Islander children have a significantly different experience of middle ear disease than most non-Indigenous children, which is characterised by:

- **earlier onset:** babies and infants acquire the disease at a younger age;
- **higher frequency:** the disease occurs often and repeatedly;
- **greater severity:** more children experience one of the severest forms of the disease; and
- **persistence:** the disease lasts for longer periods of time.

Chronically diseased ears and hearing loss can lead to long-term developmental and learning problems for children, creating significant challenges in the educational and home environments. As children enter and progress through early childhood education and into schooling, the disease has ramifications for school readiness, communication skills, learning abilities and educational outcomes. And in the home environment, it can affect family relationships, social skills and contribute to perceptions of behavioural problems.

Children with a conductive hearing loss may hear you talking, however to them your speech will sound soft and unclear, even face-to-face. They may experience some difficulty when:

- there is any background noise
- the room echoes or is reverberant
- listening to the teacher at a distance
- listening to the teacher without visual cues (eg: when the teacher is writing on board)

These children will often *'fall out'* of conversations in groups quickly due to difficulty in turn-taking, accessing speech-reading and due to the effort used in this listening situation. They may feel embarrassed about having to ask for repeats. They may become very tired by the end of the school day. They often respond very well to gesture and demonstration.

The impacts of middle ear disease and associated hearing loss have far-reaching social and economic consequences because it influences the trajectory of children's lives towards adolescence and adulthood, including future employment outcomes. In this way it is both an 'acute' and 'chronic' disease — the effects are life long as children are unable to make the most of available opportunities because they are unable to hear.

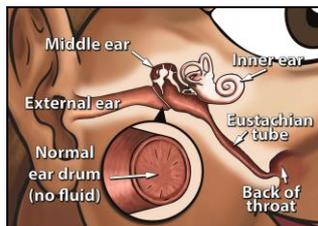
Research: A prevalence study conducted in a remote Queensland Aboriginal community in 2012 found that 43% of school-aged children had a conductive hearing loss due to middle ear disease.

Ear and Hearing Health

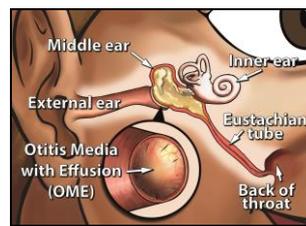
Middle Ear Disease (Otitis Media)

Otitis Media is a childhood health condition that most children acquire at some stage during early childhood. It is caused by a bacterial or viral infection behind the eardrum that gets there through the tube that runs between the back of the throat and middle ear (Eustachian tube). Fluid builds up in the middle ear space and this may affect the hearing level of the child. In most cases, the condition resolves itself quickly with limited or no medical intervention.

Middle ear disease (Otitis Media) becomes a serious health problem when children experience it frequently and persistently, and it is accompanied by mild to severe hearing loss.



Anatomy of a healthy middle ear



A middle ear with otitis media with effusion.

Different types of middle ear disease

Acute Otitis Media (aOM) is the presence of fluid behind the eardrum plus at least one of the following: bulging and/or red eardrum, fever, ear pain or irritability.

Otitis Media with Effusion (OME) is the presence of fluid behind the eardrum often without any acute symptoms. It is commonly referred to as *'glue ear'* and can be episodic or persistent.

Chronic Suppurative Otitis Media (CSOM) is persistent ear discharge through a perforation (hole) in the eardrum. Definition of CSOM varies in the duration of persistent ear discharge (from 2 weeks to 12 weeks).

Dry Perforation is the presence of a perforation (hole) in the eardrum without any signs of discharge or fluid behind the eardrum.

Children who develop CSOM are more likely to continue to have ear and hearing problems as adults

Contact Information

Deadly Ears

Deadly Ears is Queensland Health's State-wide Aboriginal and Torres Strait Islander Ear Health Program for children. We work to coordinate the effort to manage and reduce the high rates of ear disease in Aboriginal and Torres Strait Islander communities.

Name: XXXX
Position: XXXX
Phone: 07 XXXX XXXXX
e-mail: XXX@health.qld.gov.au
www: http://www.health.qld.gov.au/deadly_ears/default.asp

Australian Hearing

Australian Hearing is an Australian Government agency dedicated to helping people manage their hearing impairment so they have a better quality of life. We provide a full range of hearing services for children and young people up to the age of 26 and eligible adults.

Name: XXXX
Position: Audiologist
Phone: 07 XXXX XXXX
e-mail: XXXX@hearing.com.au
www: www.hearing.com.au

Advisory Teacher (AT)

ATs play a key role in the delivery of quality education to students with disability whose education support needs have been verified through the Education Adjustment Program (EAP) or identified as requiring significant education adjustments, in areas such as hearing impairment.

Name: XXXX
Position: Advisory Teacher
Phone: 07 XXXX XXXX
e-mail: XXXX
www: XXXX