Primary school hearing of primary importance

 

by Tanya Taudevin and Amanda Robinson

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Traditional primary school classrooms in Australia are being transformed into new generation, open plan, flexible, speaking and listening spaces. In these technology-rich environments multiple groups of young primary school children collaborate, talk and learn together in the one space. Speech communication centred on didactic teaching has given way to group work, where learning activities emphasise the interaction between children as much as listening to teachers.

Do these new flexible spaces provide equitable access to learning for children with hearing impairment?

This article proposes that, for some primary school children with hearing impairment, these spaces may result in acoustical environments that are, in fact, a barrier to participation and access to learning. The article is co-authored by an acoustical engineer and an architect/ access consultant and highlights the importance of good acoustic design for inclusive teaching and learning, and recommends suitable design performance criteria. The discussion thus considers design issues beyond assistive listening technologies covered by AS1428.5 (2010).

The paper proposes that some flexible learning environments may not meet the intent of the Disability Discrimination Act 1992 (Cth).

The needs of primary school children with minimal / mild conductive hearing loss (MMHL) are the focus of this paper. This population of children may not use hearing aids, as causes such as otitis media with effusion may be difficult to detect by parents and caregivers[1], and thus remain undiagnosed. A study in Australia of primary school children aged 5 –11 years of age found that 10.2% of children had conductive hearing loss in one or both ears, and had significantly lower ability to comprehend speech in noise than normally hearing children[2]. At December 2017, the population of children aged 5 – 9 years in Australia was just over 114,000; thus at a ratio of 10%, this would mean that about 11,400 children with MMHL are currently in primary school classrooms. 'Mild' hearing loss is not a mild problem, as children with minimal/ mild hearing loss are at risk for academic and speech-language difficulties.

Multiple international and national research studies have consistently found that open plan learning spaces for younger primary school aged children do not provide for the speech intelligibility needs of those with hearing

1 Keogh, Tegan, Kei, Joseph, Driscoll, Carlie and Khan, Asaduzzaman (2010). Children with minimal conductive hearing impairment: Speech comprehension in noise. Audiology and Neurotology 15 (1) 27-35.

2 Keogh, Tegan, Kei, Joseph, Driscoll, Carlie and Khan, Asaduzzaman (2010). Children with minimal conductive hearing impairment: Speech comprehension in noise. Audiology and Neurotology 15 (1) 27-35.

impairment. There is a growing need to seriously consider the acoustic design in learning spaces, particularly given the shift back to open spaces in schools. In order for learning to take place, levels of noise and reverberation for students with hearing impairment must be far below the threshold[3] specified by standard guidance to allow listeners of all abilities to be able to listen and communicate in education spaces.

Learning in a flexible environment

With new and emerging education facility design models, speech intelligibility is evolving to become a critical issue for children with MMHL. In school spaces such as Innovative learning environments (ILEs), Flexible learning spaces (FLS), Co-operative Learning Environments, 21st Century learning spaces, and open plan classrooms, multiple groups of children talk and work together in small groups, concurrently, and actively move throughout the space. Over 35% of class time is now spent in group work, and teachers now spend 70% of their time mobile in the learning space. This means that being able to hear the voices of other children is equally important to learning as hearing the voice of the teacher. Children are thus endeavouring to learn in classroom environments that contain multiple sources of competing speech[4] with babble and activity noise being more disruptive to speech perception than external noise such as traffic[5].

If children cannot hear the voice of the teacher and the voices of their classmates, they cannot learn effectively. Younger children with MMHL typically have greater difficulty comprehending speech in noise, and participating in situations with multiple talkers, than children of the same age without hearing impairment. The first years of school are also critical for language development. Generally, younger children require very high intelligibility of speech, because they cannot 'fill in the blanks' from garbled words the way adults can.

The Disability Discrimination Act 1992 (Cth)

The Disability Discrimination Act 1992 (Cth) requires non-discriminatory access to, and use of, 'premises'. The definition of 'premises' in Section 23 of the DDA is quite broad and requires ensuring non-discriminatory access to, and use of, both buildings (as addressed in the Disability (Access to Premises – Buildings) Standards 2010) and non-building elements, such as furniture, fixtures and fittings. Section 22 of the DDA states it is unlawful to discriminate against a student on the ground of the student's disability by denying or limiting a student's access to any benefit provided by the educational authority.

The Disability (Access to Premises – Buildings) Standards 2010, however, do not address the subject of accessible acoustical environments within a space (room acoustics), just as they do not address the subject of accessible furniture, fixtures and fittings within a space. The acoustical environment is a fundamental characteristic of a room, and therefore part of a 'premises'. The Disability Standards for Education 2005 do not address the subject of acoustical environments either.

The non-referenced standard AS 1428.5 (2010) Design for access and mobility – communication for people who are deaf or hearing impaired, whilst mentioning the acoustical environment in Clause 2.2, only states that an 'appropriate' acoustical environment must be provided for speech intelligibility, without specifying any performance criteria. Instead, AS/NZS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors' is referred to. However, this standard does not include speech intelligibility criteria, and only addresses children with learning difficulties as distinct from children with hearing impairment.

If a school learning space, by virtue of its design, and the way the space is managed, denies or limits access to intelligible speech by

3 Sigfrid D Soli and Jean A Sullivan (1997) Factors affecting children's speech communication in classrooms. Journal of the Acoustical Society of America 101, 3070

4 Lori Leibold, Ryan W. McCreery, and Emily Buss (2017). Classroom acoustics and children's speech perception. Journal of the Acoustical Society of America 141, 3457

5 Nicola Prodia, Chiara Visentin, and Alice Feletti (2013) On the perception of speech in primary school classrooms: Ranking of noise interference and of age influence. Journal of the Acoustical Society of America 133, 255

a child with hearing impairment, upon which language learning is critically dependent, this may be inconsistent with the DDA.

Speech Transmission Index

In contrast to Australian Standards, international design guidelines for schools specify speech intelligibility criteria for children with hearing impairment – using the standard objective measure called the Speech Transmission Index (STI). In Australia, the Guideline for Educational Facilities Acoustics 2018, by the Association of Australasian Acoustical Consultants (AAAC) also nominates STI criteria.

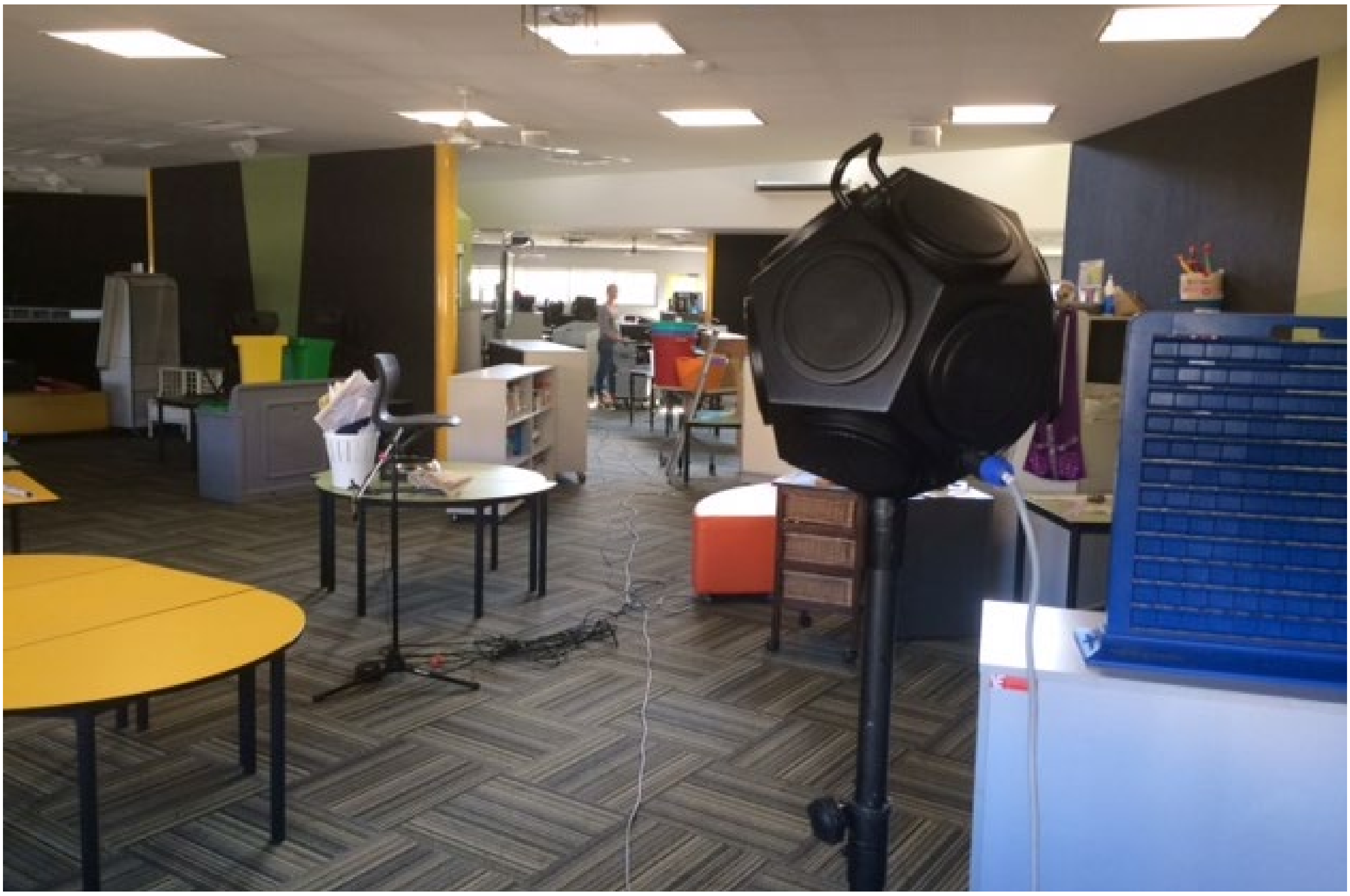
In this context, it is suggested that when designing school learning spaces to achieve the objects of the DDA with respect to the needs of younger children with MMHL, reliance on the Premises Standards, AS1428.5 or AS/NZS2107 may be insufficient.

Evidence based design guidance is available from the United Kingdom, as well as Australia, based on peer reviewed research, that recommends performance criteria to meet the speech intelligibility needs of students with hearing impairment. Key criteria are presented below.

Room acoustical design parameters for speech

For rooms to function as listening and communication environments, there are three main factors to consider: reverberation, ambient noise in the space, and the signal-to-noise ratio. These are described in layperson terms below.

Reverberation: Reverberation time is defined as the length of time required for sound to decay 60 decibels from its initial level, and is normally measured in seconds. AS/NZS 2107 suggests reverberation times for open plan learning spaces, depending on the volume (m3) of the space. Reverberation is directly linked to volume, so the larger the room, the higher the reverberation time. Rooms with many hard surfaces will have longer reverberation times than those with acoustically absorptive finishes.



Signal to noise ratio: The concept of signal to noise ratio is effectively how loud the source of noise is above the background sound in the space. The larger the difference, the clearer the signal. Guidance from the British Association of Teachers of the Deaf and the America Speech Language Hearing Association suggests that the signal to noise ratio should be at least 15dB, and preferably 20dB in the lower frequency range (125Hz-750Hz).

The direct sound from a voice will dissipate with distance, so the closer the distance between the speaker and listener, the higher the signal to noise ratio. The directivity of the speech is also an important factor – a speaker who is facing away from the receivers (i.e. head is turned away from the listeners) may reduce the signal by a significant amount.

Speech Transmission Index: The intelligibility of speech in a room is a complex function of the location of the speaker, the location of the listener, ambient noise levels, the acoustic characteristics of the space and the loudness and quality of the speech itself. STI is an objective measure which accounts for all of the above factors.

STI is a value between 0 and 1, and the higher the value the better the speech intelligibility. The STI is a useful measure for open plan style learning spaces in particular. This is because whilst reverberation time is a primary acoustic descriptor for a learning space, many other factors also need to be considered.

Inclusive design recommendations

The performance criteria below list recommendations for open-style learning spaces in primary schools for children with hearing impairment by professional organisations:

Speech Transmission Index (within groups - open plan style learning spaces)	0.70 >0.60	Association of Australasian Acoustical Consultants V 2.0 2018 UK Guideline Acoustics of Schools: a design guide (Nov 2015)
Reverberation time T_{60} Unoccupied	0.4s 0.4s	Association of Australasian Acoustical Consultants V 2 2018 UK Guideline Acoustics of Schools: a design guide (Nov 2015)
Ambient noise levels Unoccupied internal	≤30dBA <35dBA <35dBA	Association of Australasian Acoustical Consultants V 2 2018 UK Guideline Acoustics of Schools: a design guide (Nov 2015) WELLS rating tool for Comfort Noise Criteria in Schools[1]
[1]Not specifically targeted to hearing impaired, but to be adopted for all users		

Discussion

It can be seen that there is good correlation between criteria recommended both nationally and internationally for acoustic spaces to support students with hearing impairment.

However, if the levels within AS/NZS 2107 for mainstream spaces are adopted, it is likely that, for children with hearing impairment:

- Ambient noise levels will be too high (potentially up to 45dBA)
- Reverberation times will be higher than desired (up to 0.6/0.7s for large spaces)

And as a result, speech intelligibility may be compromised.

There is a trend to use the technology termed ‘soundfield amplification’ (SFA) to ensure that the signal level of speech is delivered to all parts of the classroom at an appropriate level. This technology has benefits for situations where the voice of the teacher needs to reach all children in the space, not only students who use hearing aids or cochlear implants. However, in open plan classrooms where multiple smaller groups of children are working and talking concurrently in the one space, SFA does not address the need for children within smaller groups to hear the voices of other children with whom they are collaborating and learning. Additional sound from amplification elsewhere in the learning space, may result in higher general background noise levels, with children increasingly raising their voices to be heard by others within their own smaller groups.

It is important to note that **whole class technology is not a substitute for remedying poor classroom acoustics**, and poor room acoustics can in fact limit the effectiveness of such systems. A study of SFA installed in classrooms in Brisbane, concluded that the potential benefits of SFA devices are only likely to be realised in classrooms with better basic acoustics[6]. Good acoustic design to optimise speech intelligibility can make a significant difference to the listening environment. For example, when existing classrooms are treated with well-designed absorption and scattering acoustic treatments, speech reception thresholds have been found to improve by up to 6.8 dB after acoustic intervention[7].

Design approaches to achieve the recommended performance outcomes

Whilst designing learning spaces to meet specified STI criteria requires an acoustic consultant, the following references provide useful background information:

- *Acoustics of Schools – a design guide November 2015*. Institute of Acoustics and Association of Noise Consultants. Available at: https://www.ioa.org.uk/publications/schools-acoustics-guide
- *Classroom Acoustics for Architects* – A companion booklet for ANSI/ASA S12.60 Parts 1 and 2. Acoustical Society of America Available at: https://acousticalsociety.org/standards/
- *Guideline for Educational Facilities* Association of Australasian Acoustical Consultants: http://www.aaac.org.au/resources/Documents/Public/Educational%20Facilities%20Acoustics%20V2.0.pdf

6 Wilson, Wayne J., Marinac, Julie, Pitty, Kathryn and Burrows, Carolyn (2011). The use of soundfield amplification devices in different types of classrooms. Language, Speech and Hearing Services in Schools 42 (4) 395-407.

7 Giuseppina E. Puglisi, Filippo Bolognesi, Louena Shtrepi, Anna Warzybok (2017) Optimal classroom acoustic design with sound absorption and diffusion for the enhancement of speech intelligibility. Journal of the Acoustical Society of America 141, 3456

It is recommended that access consultants providing advice on evolving and innovative design models for primary school open plan, collaborative and flexible learning spaces consider the Disability Discrimination Act 1992 (Cth), and younger children with hearing impairment. How will the spaces in the proposed design actually be used for collaboration, interaction and group work by children and by teachers? Will the acoustical conditions, that arise as a consequence of design decisions and choices, limit or deny access to intelligible speech by younger children with hearing impairment? Are there 'universal design' options for the architectural and acoustic design that better enable inclusive and equitable participation and learning?

For further information about this topic feel welcome to contact the authors at Alpen Access Architects and Marshall Day Acoustics.