NDCS uses the term 'deaf' to cover all types of hearing loss, including temporary hearing loss such as glue ear.

Introduction

Purpose

This toolkit provides advice and guidance to schools and local authorities to help them:

- create a better learning environment to improve the attainment of all children and particularly those who are deaf;
- prepare their Accessibility Plans and Disability Equality Schemes as required by the disability and special needs legislation in England, Wales, Scotland and Northern Ireland;
- meet their "anticipatory" duties under the Disability Discrimination Act;
- develop their asset management plan;
- involve pupils in the development of their plans and schemes.

Summary

The toolkit has been written in two main sections:

- The first section is aimed at non specialists in schools. It gives an overview of factors affecting school listening environments and a brief introduction to acoustics. It recommends surveys which are simple to conduct which will help identify problem areas within schools and contains practical suggestions to improve listening environments. (See the noise survey section).
- The second section provides more technical advice and is mainly aimed at specialists such as education audiologists, teachers of deaf children, acoustic consultants or acoustical engineers. Its purpose is to enable specialists to build on the information schools have collected and explore in more detail any major problems and identify possible solutions.

A member of school staff with a very keen interest in acoustics could loan or hire the recommended equipment and use the specialist section of the toolkit to conduct more in depth assessments of the acoustics as set out in the second section. However, they may still need support from an experienced specialist particularly in making recommendations to avoid unnecessary costs.

The toolkit is designed to enable a school to identity problems in the school's listening environment and develop measures which will improve speech intelligibility for all pupils and teachers. This will benefit all children as well as ensuring deaf

children do not face unnecessary barriers to learning and are fully supported and included in the learning environment. There may be many improvements that can be made to a school's listening environment at a modest cost. Other improvements may require specialist assessment and require higher levels of expenditure.

Why good acoustics are important for learning

As adults we know it can be difficult to understand speech in noisy situations e.g. a busy restaurant, construction work outside a window and school classrooms can be very noisy environments. For deaf children poor acoustics in school classrooms can be very challenging and can make it very difficult for them to use hearing aids and cochlear implants optimally. Hearing aids and cochlear implants amplify all noises in the classroom not just the teacher's voice. This can mean that a deaf child misses a lot of words spoken by the teacher and therefore misses the message. Research has demonstrated that there is a link between attainment and good acoustics for both deaf and hearing pupils.

To understand what is being spoken the teacher's voice needs to be louder than the background noise, if the classroom is too noisy most teachers will have difficulty speaking loud enough to enable good understanding. In addition school classrooms can be very reverberant and this makes listening even more difficult. Reverberation occurs when the sound from the source has stopped but echoes from the sound continue in the room. If the surfaces have a low absorbency then the sound may bounce around the room arriving at the child's ear at different times making it difficult to listen to the message. The message becomes smeared by the echoed sounds and can be impossible to understand.

Also as adults, because of our linguistic knowledge, we are able to fill in the gaps where we haven't heard the full message. This is often referred to as 'auditory closure'. As children have a limited linguistic knowledge they do not have the skills of 'auditory closure' and are not able to fill in the gaps. Therefore as children can spend about half the school day listening, good listening conditions are essential for all children to access and be fully included in school life.

Acoustic standards

This toolkit is written to comply with national standards:

- Building Bulletin 93 (BB93) Acoustic Design of Schools issued by the DfES in 2003 has defined good acoustic standards for schools. It sets out mandatory standards for new school builds and new extensions in England and Wales and serves as good practice guidelines for how classrooms should be structured if teachers and students are to work effectively.
- The Scottish Executive document Guidance for local authorities on internal environmental conditions in schools states: 'Every part of the school building shall have the acoustic conditions and insulation against disturbance of noise appropriate to the use for which the part of the building is designed'.

- For Northern Ireland section 4.110f the Department of Education's Building Handbook for Primary Schools, which is currently being reviewed as of September 2007, states that 'Not only movement but sound can intrude upon the working arrangements preferred by the teachers in each teaching space. Ways of absorbing sound should be considered both in the basic design of buildings and in the materials used.'

How to use the toolkit

The toolkit is designed to be a flexible resource. You can follow the content in order in its entirety or you may identify key areas of concern in your school and refer to the relevant section. For example, you may identify that noise is a significant problem in a classroom and undertake the preliminary survey. The sections of the toolkit you choose to follow will also be determined by the equipment available to you.

Section one requires no specialist equipment or knowledge. However, section two requires more in depth knowledge of acoustics and some experience of using the specialist equipment. Undertaking the surveys in section one should help schools identify whether there is a need to seek specialist support to carry out more detailed investigations.

The toolkit includes blank data collection sheets to help gather relevant information. The data collection sheets can be photocopied. Worked examples are also given to show how the data collection sheets can be used.

Links to sources of information about companies that may be able to undertake remedial work or further investigation will be available on the NDCS website: www.ndcs.org.uk.

Equipment required for Section Two

- A long tape measure (speech intelligibility tests)
- A sound level meter (SLM)

You may be able to loan a sound level meter from the local authority's hearing support or sensory impairment service or its property services. They are also available for hire or purchase from a number of different companies such as:

Noise Meters Limited **www.noisemeters.co.uk/hire**
Gracey and Associates **www.gracey.com**
Hire Sound Level Meters **www.inlet.com**

There are four different types of sound level meters

Type 0 This is the most accurate and is intended as a laboratory reference standard. This grade has the tightest tolerance over the widest frequency and amplitude range.

Type 1 This is also for laboratory use and is similar to the old precision grade. It can also be used in the field where the acoustical environment can be closely specified and/or controlled. Local authorities prefer to use type 1 meters as they are perceived to be the minimum acceptable for legal work.

Type 2 This type is suitable for general field applications

Type 3 A noise survey meter to establish whether a noise limit has been violated. The most recent guidance from the Health and Safety Executive specifically states that type 3 meters are not suitable for noise assessments.

Type 1 will be suitable for all testing in the classroom. Types 1 and 2 are the sound level meters most commonly used in the measurement of noise.

Background information about hearing, speech and noise

In considering acoustics it is helpful to have a basic understanding of hearing, speech and noise.

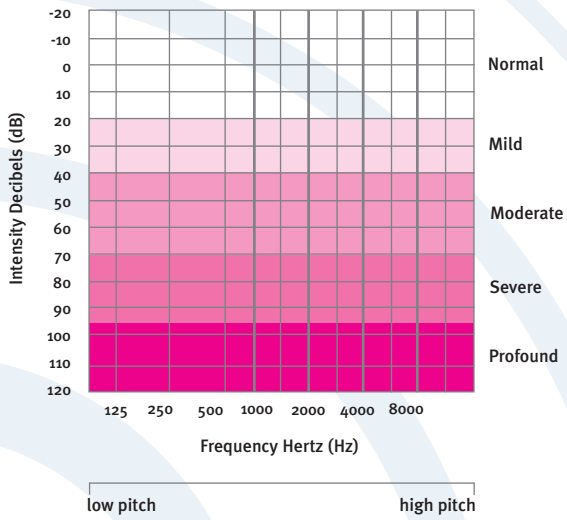
Hearing

Hearing involves the ear, part of the nervous system and part of the brain. All three elements must work together for you to be able to receive sound and be able to convert it into messages for the brain to understand.

Sound is made when objects vibrate and is an invisible vibration. It travels in waves, spreading outwards from the source of the sound. Sounds are different both in loudness (intensity) and pitch (frequency).

Intensity or loudness is measured in decibels (dB). Frequency (pitch) is measured in Hertz (Hz). All sounds are made up of different frequencies. A piano keyboard runs from low pitch on the left to high pitch on the right and an audiogram (see below) is the same.

Hearing is usually measured using behavioural tests. The most common behavioural test is using pure tones. The sounds come through headphones and each time a child hears a sound they respond by moving an object, pressing a button or saying 'yes'.



Audiogram

Hearing test results are recorded on an audiogram. This shows how loud a sound has to be and at what frequency before the child can hear it. Each ear will be tested individually. The frequencies tested are those relating to frequencies produced by our speech.

The above audiogram shows the different levels of hearing losses.

There are different levels of deafness and these are most often classified as mild, moderate, severe or profound. Few children are totally deaf: most deaf children can hear some sounds at certain pitches and volume.

A child with:
Mild deafness: 20-40 dB
would hear a baby crying or music from a stereo but may be unable to hear whispered conversation

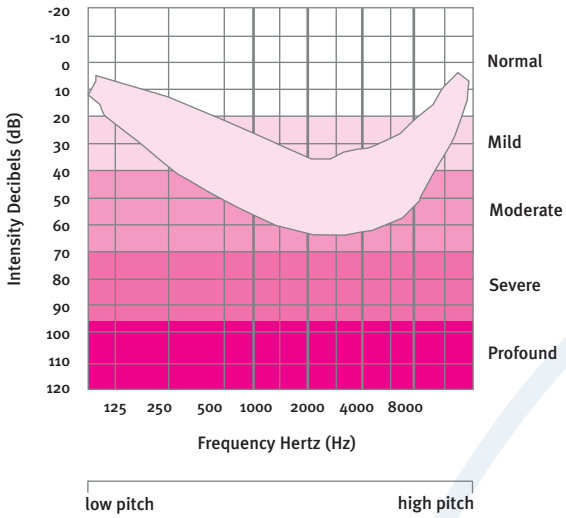
Moderate deafness: 41-70 dB
would hear a dog barking or telephone ringing but may be unable to hear a baby crying

Severe deafness: 71-95 dB
would hear a chainsaw or drums being played but may be unable to hear a piano or a dog barking

Profound deafness: >95 dB
may hear a large lorry or aeroplane, would be unable to hear a telephone ringing

(Source: British Society of Audiology 1988.)

Some children's deafness may fall into two categories e.g. moderate to severe. Deaf children with the same level of deafness may experience sounds differently.



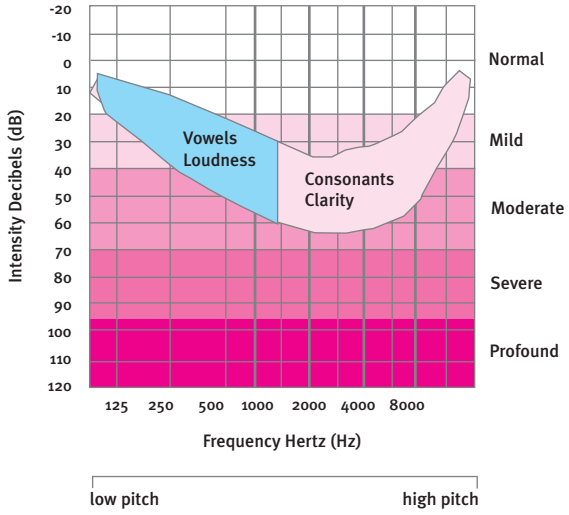
Speech

The pink area on the audiogram opposite is all the speech sounds from normal speech.

Speech comprises of vowels and consonants. The audiogram below shows the main areas in speech where vowels and consonants occur, and these are also the same areas where we perceive loudness and clarity.

Vowels give power and loudness to speech and the consonants give clarity and meaning to speech. Consonants are the weakest sounds and are generally higher in frequency than vowel sounds which are low frequency sounds.

Speech is usually a mix of high and low frequency sounds.



The main issue for schools is that everyday building materials absorb the higher frequency sounds more easily than lower frequency sounds. This means that the consonants, which are required for speech clarity, are more likely to be absorbed than the vowels. Therefore additional special materials may need to be added to a room to absorb more of the lower frequency sounds.

Noise

Noise can come from many sources but in a classroom it mainly comes from the people in the room. This means that it tends to be speech noise.

As stated above, high frequency sounds are more likely to be absorbed and low frequency sounds reflected.

Noise is mainly low frequency in nature and if enough of it is reflected, it will 'mask out' the more important high frequency consonants making it difficult to understand what the teacher is saying.

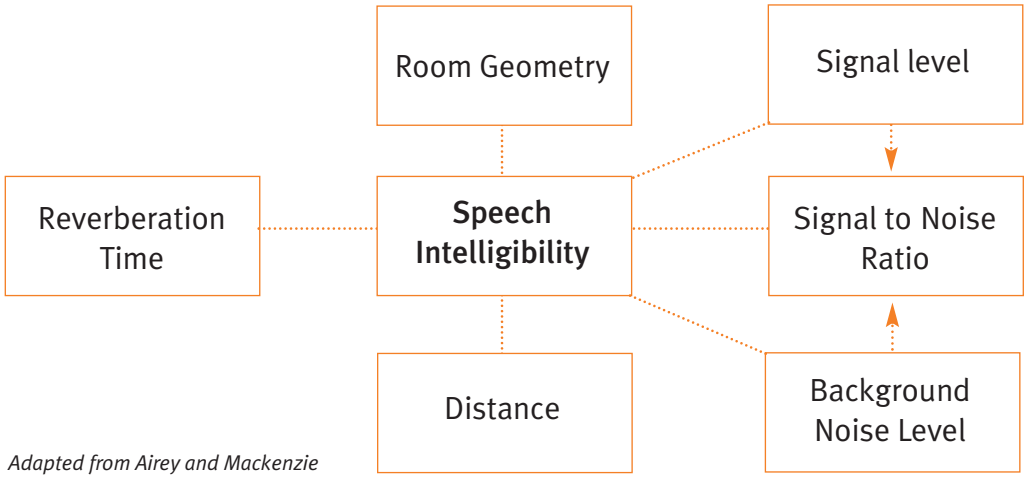
In summary we need to hear the consonants in speech if we are to understand what is being said, keep noise as low as possible and prevent as much low frequency reflection as possible.

The importance of good acoustic design in schools

The most serious acoustic problems are due to excessive noise transfer between rooms and/or excessive reverberation in rooms. Both these factors reduce speech intelligibility in a classroom.

The table below shows the factors which affect speech intelligibility in a room. For speech to be intelligible in a room the reverberation time (RT) needs to be low. Reverberation time is the time taken for the reverberant sound energy to decay to one millionth of its original intensity (corresponding to a 60db reduction in the sound level).

The factors which can affect speech intelligibility are shown below



Adapted from Airey and Mackenzie

Table 1.5 in BB93 (Appendix B) shows the RTs for all the types of rooms in a school. Where understanding of speech is essential, ie the classrooms, the RT is 0.8s but in music rooms where listening to music is important, the RT is <1.0s. Classrooms specifically designed for use with deaf pupils must have a RT of <0.4s.

It could be argued, with a view to effective inclusion, that all classrooms should be designed for deaf students and they should all have an RT of <0.4s, although BB93 does not require this.

The other significant issue is noise in the room. It is important that the only noise in a classroom stems from factors which are under the control of the teacher. BB93 has levels of 'indoor ambient noise' which are measured when the room is empty.

Table 1.1 in BB93 (Noise Survey section - interior noise in the classroom school empty) shows performance standards for indoor ambient noise levels for all the types of rooms in a school. BB93 regulations for indoor ambient noise levels should include the sum of noise from all sources from outside the school, along with any internal noise from heating and ventilation systems. The windows, if used for natural ventilation, should be open. Primary and secondary classrooms should have an ambient noise level of 35dB LAeq,30mins and classrooms specifically designed for use with deaf pupils should be 30dB LA eq,30mins.

To control the level of noise entering the room from other classes, corridors etc., BB93 has regulations on sound insulation and impact noise. Calculations need to be made as to the level of sound insulation needed for the building to comply with the regulations.

The first part of the toolkit 'Noise Survey' is concerned with identifying problem noise areas in the classrooms and around the school. This enables you to determine where the major problems lie and where to focus your attentions to improve the situation. The next part 'Reverberation Times' looks at how to measure reverberation times in the classroom and explains the benefits of low reverberation times on listening conditions and speech intelligibility for the pupils. 'Speech Intelligibility' demonstrates how you can measure speech intelligibility and how improvements you make to the acoustics of the classroom impact on this. The final part explains about other assistive listening devices that can be used in the classroom to help improve the listening conditions for the pupils.