Reverberation Times for school st

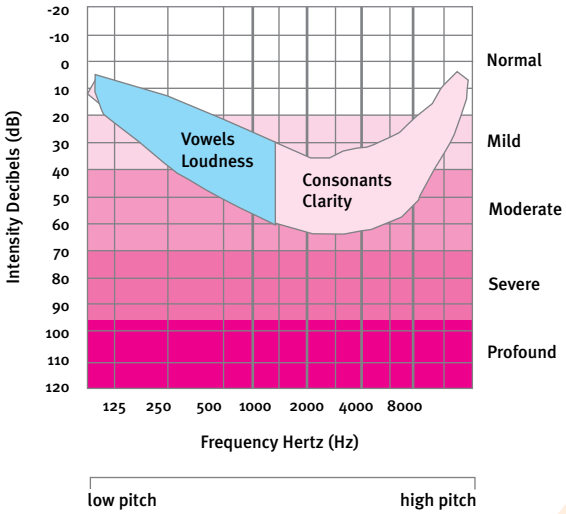
Reverberation occurs when the sound from the source has stopped but reflections from the sound continue in the room. BB93 defines reverberation time (RT) as the time taken for the reverberant sound energy to decay to one millionth of its original intensity (corresponding to a 60 dB reduction in the sound level)

Both Boothroyd and Crandell warn that RT varies with frequency.

Crandell and Smaldino go further and say, "Generally, because most materials do not absorb low frequencies well, room reverberation is shorter at higher frequencies and longer in low frequency regions." From Classroom Acoustics for Children by Crandell and Smaldino.

We commonly think of frequency as the pitch of a sound and it is measured in hertz (Hz). The sounds of speech cover a range of frequencies.

Look at the speech spectrum below, low frequency sounds in speech are mainly vowels which gives speech its loudness and power and the consonants which give speech meaning and clarity are high frequency sounds.



Reverberating speech noise will be low frequency sounds which are mainly vowel based. As vowels are the most powerful phonemes in speech, there is a tendency for them to 'mask' the high frequency sounds. This masking effect makes it difficult to hear the consonants, the information carrying sounds needed for good speech intelligibility.

It is important to reduce low frequency reverberation as much as possible for good speech intelligibility.

The way to reduce the reverberation time is to either decrease the volume of the room or increase the amount of absorption in the room. As it is usually difficult to make a room smaller then the most sensible way is to put more absorption in the room.

However, not all reverberation is bad. Boothroyd makes distinctions between early and late reverberations.

He defines early components of reverberation as, "those reflections that arrive soon enough to be integrated with the direct sound, and with each other, so as to enhance

perception (less than 1/20th of a second) and these early components of reverberation increase the level of speech at a distance".

The late components of reverberation he describes as ones that, "arrive too late to be integrated with the direct signal or the early components (more than 1/10th of a second). If their level is still high enough, they interfere with the current sound by both physical and perceptual masking."

His visual analogy of these statements is:

Late reverberation

The two sentences are greatly out of phase and make it difficult to read.

Early reverberation

In this case the sentences are only slightly out of phase and now it is possible to read the sentence. In fact in this situation the words look bolder and in the case of sound would be slightly amplified.

A room with no reverberation is a very uncomfortable room to listen in, so we need to have some reverberant sound but for good speech intelligibility two things need to happen –

1. The room needs to have a short reverberation time.

2. As much low frequency sound needs to be absorbed as possible.

Combined effects of noise and reverberation

There have been many studies that show the effect of poor acoustics and noise on speech intelligibility in a classroom, mainly from the United States. The Finitzo-Heiber paper produced in 1978 looked at the combined effect of reverberation and background noise levels on both hearing and hearing-impaired children. The table below shows the results.

	RT = 0.0 seconds		RT = 0.4 seconds		RT = 1.2 seconds	
Signal/ Noise Ratio	Normal Hearing	Hearing Impaired	Normal Hearing	Hearing Impaired	Normal Hearing	Hearing Impaired
Quiet	94.5%	83.0%	92.5%	74.0%	76.5%	45.0%
+12 dB	89.2%	70.0%	82.8%	60.2%	68.8%	41.2%
+6 dB	79.7%	59.5%	71.3%	47.7%	54.2%	27.0%
0 dB	60.2%	39.0%	47.7%	27.8%	29.7%	11.2%

The scores are the percentage of words correctly identified in various conditions.

Yacullo and Hawkins (1987) presented 32 hearing 8-9 year olds with words in rooms with reverberation times of 0 seconds and 0.8 seconds plus signal to noise ratios of +2 and +6 dB. They discovered that the reverberation decreased the mean speech discrimination by 41.1% whilst the scores decreased by 27.4% as the signal to noise ratio dropped.

There are various recommendations to improve the reverberation time in classrooms e.g. using acoustic tiles on the ceiling, adding a suspended acoustic tile ceiling, sound absorbing wall panels. However, each classroom needs to be assessed by a specialist to ensure the solution is appropriate and cost effective.

To calculate accurate RTs and make appropriate recommendations for reducing reverberation times in individual classrooms you will need to employ an education audiologist, teacher of deaf children (your local authority may already employ these), acoustic consultant or acoustical engineer. They can use the sections 'calculating reverberation times' and 'using the spreadsheet and data collection sheets' included in this toolkit.

However, a member of school staff with a keen interest in this area could loan or hire the recommended equipment and use the toolkit to calculate reverberation times using the sections 'calculating reverberation times' and 'using the spreadsheet and data collection sheets' included in this toolkit. They may still need support from an experienced specialist to make appropriate recommendations, especially where higher costs may be involved.