An Essex study

David Canning presents an interim report on his research into classroom acoustics in Essex

There has been a lot of interest in the experimental work on acoustics that has been carried out in Essex. It has featured in online discussions, conferences, newspapers and professional magazines in not only the UK but also Europe and the USA.

In recent years, a number of parents of deaf children asked for out-of-county places for their children, poor classroom acoustics being one of the issues raised at special educational needs and disability tribunals. Essex County Council sought to address the issue of classroom acoustics and £150,000 was initially allocated to do this. Following a meeting of education officers and teachers (mainstream and specialist) it was decided to take a considered, evidence-based approach to the classroom refurbishment process. While the building regulations refer to *Building Bulletin 93,* regarding acoustics there is a degree of confusion as to which of the three standards that appear in the publication should be applied in order to create an environment that is appropriate for the inclusion of deaf pupils in mainstream secondary schools.

The research considered the three published standards in classroom acoustic design and sought to explore the impact of these on the occupied classroom:

- *BB93* regular secondary school classroom performance standard (less than 0.8Tmidfrequency)
- *BB93* classrooms specifically for use by deaf pupils (less than 0.4Tmidfrequency)
- BATOD (less than 0.4T 125–4000Hz) (*BB93* Sections 1 and 6)

Studies that have examined the effects of reverberation time in controlled conditions suggest that the lower the reverberation time the better the speech perception. This does not help guide the design of mainstream schools where there has to be a balance between what is achievable and what is desirable. There have been very few peer-reviewed experimental studies using real classrooms that provide helpful guidance. A number of reports, however, have been published in New Zealand which give some direction. In a survey carried out with 122 teachers to identify good and poor classrooms for use in further work the authors found that reverberation times of 0.6 seconds were considered 'poor' by teachers and 0.4 seconds as 'good'. A purely acoustical approach based on the self-masking of typical running speech would suggest a reverberation time of between 0.3 seconds and 0.4 seconds for deaf children.

It was therefore hoped that by conducting a controlled experiment in occupied classrooms ('real' school situations), it would be possible to assess the impact on the teaching and learning environment and consequently guide the design of new and refurbished classrooms in inclusive secondary schools.

Starting point for acoustical design

The acoustic environment is an often overlooked variable in classroom design. The NDCS campaign *Sounds good?* has recently highlighted this issue with examples of schools that have failed to ensure adequate acoustic environments. Acoustic design in school, however, does have legislative weight: 'Each room or other space in a school building shall be designed and constructed in such a way that it has the acoustic conditions and the insulation against disturbance by noise appropriate to its intended use.' Requirement E4 from Part E of Schedule 1 to The Building Regulations 2000 (as amended) (*Building Bulletin 93* p3).

There have been many studies from around the world showing an association between higher noise levels in schools with lower academic performance and increased stress in both teachers and children. It is also well established that reverberation has a detrimental effect on speech recognition and is a predictable cause of high noise levels. *BB93* addresses unoccupied noise levels and reverberation time, as both are features that can be addressed in the design of a new school or school refurbishment. They are design targets and relate to the 'physical acoustics' of a space.

The way that a classroom functions when occupied might be called 'functional acoustics' and cannot be specified in the physical design as it relates to the occupants and the activity taking place. These are matters beyond the direct control of a building contractor. That there is a link between physical and functional acoustics is clear, but the precise nature of that link has yet to be described.

One key measure of the appropriateness of an environment is the signal-to-noise level as experienced by the children. Signal is defined as 'whatever is important' and noise is 'everything else'. In general the greater the signal-to-noise level the greater the chance of being able to hear and listen effectively. There is a clear relationship between signal-to-noise level and speech recognition in children which has been demonstrated repeatedly in the literature since the seminal work of Finitzo-Hieber and Tillman ('Room acoustics effects on monosyllabic word discrimination ability for normal and hearing-impaired children', *Journal of Speech and Hearing Research* 1978, 21(3), p440–58).

There are now many automated ways of assessing the impact of signal-to-noise on hearing in children, and in the Essex study we chose to develop an automated audiovisual speech-in-noise test called the Paediatric AudioVisual Speech in Noise Test (PAVT) in collaboration with Advanced Bionics.

BB93 identifies the following communication activities in classes, each of which can be characterised by the signal-to-noise level:

- listening to the teacher when he/she is facing away from the listener
- listening when the class is engaged in activities
- listening to the teacher while he/she is moving around the classroom
- listening when other children are answering questions
- listening when other adults are talking within the same room
- listening to peers when working in groups
- listening in situations with competing background noise from multimedia equipment.

BB93 goes on to state that 'a teacher should manage teaching in such a way as to ameliorate the challenges faced by a student with hearing difficulties. However, the better the acoustic conditions, the less challenging will be the situations described above.'

The acoustic challenge is to create an environment that allows a signal-to-noise level to prevail that is appropriate for each deaf child in each communication activity. The required signal-to-noise level is likely to be different from one deaf child to the next and the PAVT was used to explore the range required.

Study design

The decision by Essex County Council and the co-operation of one large resourced secondary school created the opportunity to undertake a counter-balanced experiment that changed just one variable – the amount of acoustic absorbency in the room. Four similar classrooms from one faculty area were chosen and refurbished to be visually similar. The materials used to alter the total absorbency within the room were also visually similar although they had very different acoustic properties. At various times over two academic terms, the rooms had the acoustic treatments changed. This occurred at the weekends so that teachers would not notice a visual change in the room. Only the school Learning Environment Leader was aware of the precise room treatment, and everyone else, including staff collecting data, was blind to the precise condition. One of the four rooms acted as a control, with the other three rooms variously being treated to one of the desired acoustic standards.

A number of measures were obtained, including a complete range of acoustic parameters of empty and occupied classrooms. Interviews and questionnaires were also used along with expert listening panels and speech discrimination tests. This has generated a considerable quantity of data that is currently being analysed. Where data requires coding it is being done blind to the condition.

Interim findings

In total 400 children were involved, including 25 hearing-impaired children; nine teachers were also involved directly in the research and more than 120 lessons were studied. Data relating to the physical sound levels in working classrooms has been the first aspect of the study to be analysed and is reported here briefly.

Sound levels and reverberation time

The impact of adding absorbency into a classroom on the working environment is complicated. Adding absorbency can have an impact on the class in unexpected ways. It has been observed to change dramatically both teacher and student behaviours. If this is the case it is likely that this will be observed in the physical acoustic data of occupied classrooms.

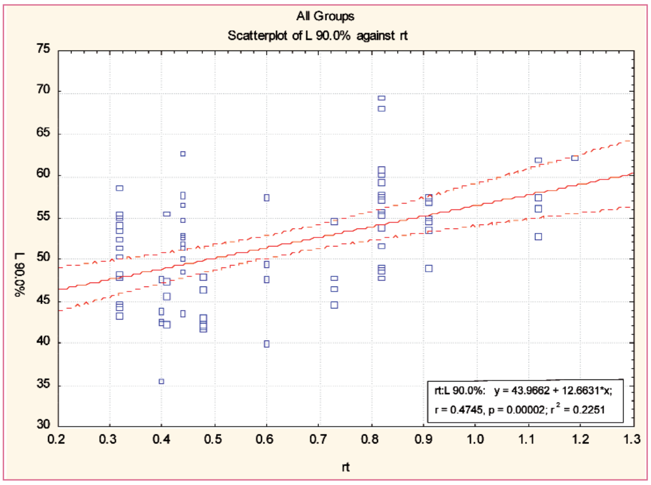

Figure 1: Graph showing the statistical measure L_{A90} (sound level that is exceeded for 90% of the time) against reverberation time. Dashed lines indicate 95% confidence intervals

The statistical measure of sound L_{A90} is often used to represent the background noise level. In Figure 1 the L_{A90} of each of the 120 lessons recorded has been plotted against the reverberation times of the classrooms. It should be noted that there is a distribution of reverberation times because predicting the actual reverberation time of an unoccupied classroom prior to refurbishment was not a certain activity. What can be seen from the data is that there is a very clear relationship between reverberation time and L_{A90}. The longer the reverberation time the greater the level of sound in the room. This is consistent with the findings of David McKenzie during the Herriot Watt study in the late 1990s of 70 primary classrooms which showed reductions following sound treatment in the order of 7–9dBA in occupied working classrooms although only small reductions in unoccupied classrooms.

Perhaps a measure that might be more meaningful to teachers is the proportion of time that classes exceed 65dBA. This is a level that many would find comfortable and sustainable in a working classroom. Figure 2 shows the proportion of the class time exceeding 65dBA for all classes observed plotted against reverberation time. It can be seen that there is a relationship between reverberation time and proportion of time that classrooms exceed 65dBA.

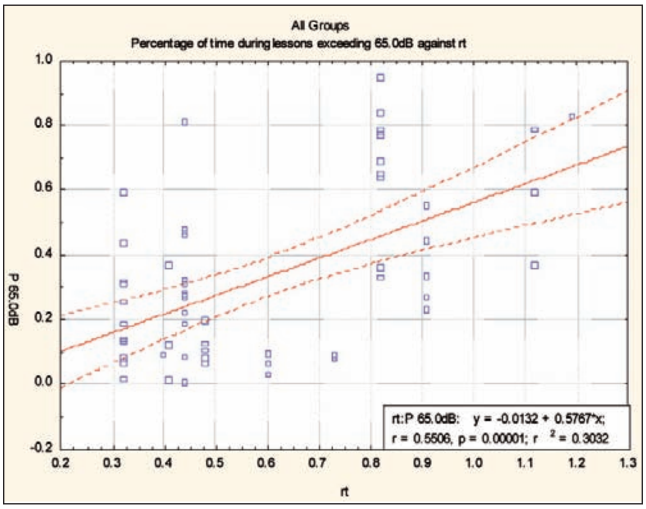

Figure 2: Graph showing the proportion of time during which classes exceeded 65dBA plotted against reverberation time. Dashed lines indicate 95% confidence intervals

Clearly both figures require detailed exploration and interpretation as the nine teachers who took part in the study had different teaching styles (although the curriculum area was the same). However, the message appears clear – the more absorbency in a room the more likely it is to be acceptably quiet. Because no other variables were manipulated in the study, the changes must be a consequence of altering the amount of absorbency in the rooms.

Discussion

This short report on interim findings from the Essex study has given a tantalising glimpse at the effect of taking control of the physical environment. One of the more important findings is that sound treatment can be added to very 'typical' classrooms. It is not complicated and not particularly expensive and we found that modifying rooms to have a short reverberation time was much easier than accurately achieving relatively long reverberation times recommended in *BB93*. Essex County Council calculated the costs to be small in

One of the classrooms before the study

The same classroom after refurbishment – the rooms remained visually similar for all acoustic conditions

relation to the benefits. More importantly, there is support for avoiding the minimum standard (0.8 seconds reverberation time) and aiming for the 0.4 seconds as a target for all work regardless of any expected inclusion of deaf children. This would be consistent with some international approaches and the current drive in the USA to introduce 'international building standards' of below 0.5 seconds for all classrooms.

We will have to wait until the full report is available later this year to discover whether the classrooms have been able to create opportunities for appropriate signal-to-noise levels in all communication activities; however, a recent *See Hear* programme interviewed children from the school. They reported that the sound-treated rooms were now 'fair' and made them feel 'equal' and able to participate on equal terms in a classroom.

If you would like further information about the study, have a look at the acoustics bulletin maintained by Ecophon (http://acousticbulletin.com) and search for Essex. Some information about the classrooms is also available online (http://tinyurl.com/UCLAPDCA).

David Canning is Study Leader and Director of Hear2Learn, an independent educational audiology consultancy.

Further reading

Building Bulletin 93: Acoustic Design of Schools, David Canning et al, DCSF, 2003, TSO

Classroom Acoustics, A New Zealand Perspective, Oriole Wilson et al, Oticon Foundation in New Zealand, 2002

Classroom Acoustics – Milestone 6 Report – An investigation of the classroom acoustics needs of primary school children, James Whitlock and George Dodd, University of Auckland, 2002