THE ACOUSTIC DESIGN OF SCHOOLS – RESEARCH AND REGULATION

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Introduction

Poor acoustic design of a school can impede learning by making it difficult for pupils and teachers to hear and understand each other, and by causing high noise levels which affect pupils' concentration. Such problems have been recognised for well over a century, and guidance and recommendations on how to avoid them have been available in the UK for over 80 years. Research carried out during the past 50 years has demonstrated that noise and poor acoustic conditions in schools affect teachers' health and pupils' wellbeing, development and academic achievements. Despite this knowledge, until the new millennium many school buildings still had acoustic conditions that were not suitable for teaching and learning. For this reason, in 2003, the acoustic design of new school buildings in England and Wales became subject to the Building Regulations. The acoustic standards for new school buildings to be met in order to comply with the Building Regulations were contained in Building Bulletin 93: The Acoustic Design of Schools (BB93), published by the Department for Education and Skills. The standards have recently been updated to reflect recent experience of designing and building schools, and the current state of knowledge concerning the effects of poor acoustics on pupils and teachers. In addition to complying with the Building Regulations, meeting the standards in BB93 also provides a means of satisfying the 2012 Schools Premises Regulations (SPR), which apply to school buildings when in use, and the 2013 Independent Schools Standards.

... acoustic conditions that were not suitable ...

What is required to provide a good acoustic environment in a school?

In a school it is essential that pupils are able both to hear and understand their teacher, that is, the acoustic environment must provide good 'speech intelligibility'. It is also important that teachers can speak easily without forcing their voices which can lead to vocal damage.

Speech intelligibility depends upon the level of noise and amount of reverberation, or reflected sound, in a room. If noise levels are too high or a room is too reverberant speech intelligibility is reduced and pupils have difficulty hearing and understanding their teacher and their peers. Noise inside the classroom or transmitted into the classroom from other areas can also interfere with teaching and learning and distract pupils. These potential problems are exacerbated in open plan teaching areas. Furthermore, high noise levels and/or too much reverberation make rooms difficult to speak in, leading to a high risk of voice damage among teachers. In severe cases this may cause extended periods of sick leave or even early retirement.

... control the amount of internal noise ...

The main requirements are therefore low background noise levels and low levels of reverberant sound. To keep noise levels as low as possible it is necessary to control the amount of internal noise from sources such as heating and ventilation systems and equipment within a teaching space. Noise from external sources such as road traffic can be reduced through good sound insulation of the building façade. Internal walls and partitions, floors and ceilings must also provide effective insulation to prevent noise being transmitted from other areas within the school, for example from music rooms to classrooms.

Hard reflective surfaces such as glass increase the quantity of reflected sound in a space, leading to a high level of reverberant sound. The level of reverberation can be controlled by ensuring that there is not an excessive amount of sound reflection within a space. This can be achieved through the installation of sound absorptive

material such as acoustic tiles on the ceiling, absorptive panels on the walls or carpet on the floor.

Evidence for the effects of noise and poor acoustics

An impetus for the original publication of Building Bulletin 93, and its subsequent revision, was the increasing body of evidence concerning the effects on pupils and teachers of noise and poor acoustic conditions[1]. Studies carried out worldwide over the past 50 years have shown that noise from both external sources and inside the classroom can cause annoyance and distraction to pupils and, for younger children, reduced number, letter and word recognition[2].

For the past 15 years a research team from London South Bank University, the Institute of Education and the University of Salford has been investigating the effects of noise and acoustic design in primary and secondary schools in England. This research has been funded primarily by the Engineering and Physical Sciences Research Council, but also, in the early 2000s, by the Department of Health and Defra. This has shown that pupils of all ages and their teachers are annoyed by noise; pupils as young as seven are aware that noise causes difficulties for them in hearing the teacher[3]. It was also found that in primary schools in London both internal classroom noise, or 'babble', and external noise from sources such as road traffic and sirens reduced schools' scores in Standardised Assessment Tests (SATs) at both Key Stage 1 (KS1, year 2, age 7) and Key Stage 2 (KS2, year 6, age 11). These results were maintained when the data were corrected for confounding factors such as social deprivation and English as an additional language[4]. To illustrate these effects, Figure 1 shows the relationship between KS2 Mathematics scores and maximum noise levels of individual external events (LAmax) for one London borough; and Figure 2 shows the effects of internal classroom background noise measured in16 primary schools in London on KS2 English scores. Testing of primary schoolchildren in arithmetic, spelling and reading in controlled classroom noise conditions also demonstrated the adverse effects of noise. A particularly important finding was that children in this age group with additional learning needs were more severely affected by noise than their peers[5]. This can be clearly seen in Figures 3 and 4 which show average scores in reading and spelling tests of children with additional learning needs and their typically developing peers, when the tests were performed in quiet conditions and in classroom babble.

Similar results have been found in the research in secondary schools. Noise of classroom babble reduced the performance of students aged from 11 to 15 in reading, numeracy and memory tasks. A questionnaire survey of over 2500 students found that those with additional learning needs (including hearing impairment, speaking English as an additional language and receiving learning support) were significantly more aware of, and affected by, the

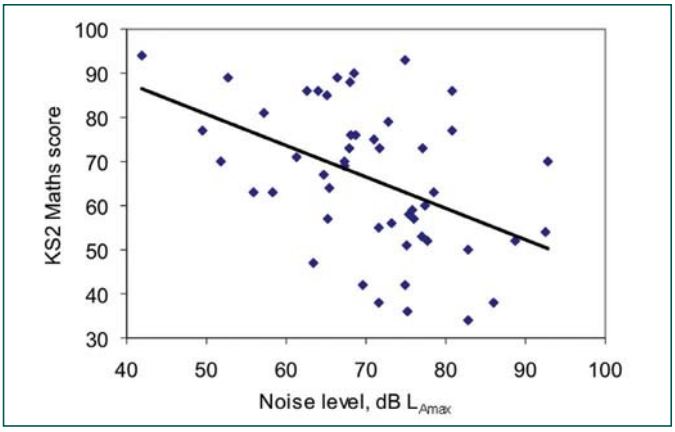

Figure 1. Scatter diagram illustrating relationship between Key Stage 2 Mathematics scores and maximum noise levels of individual events

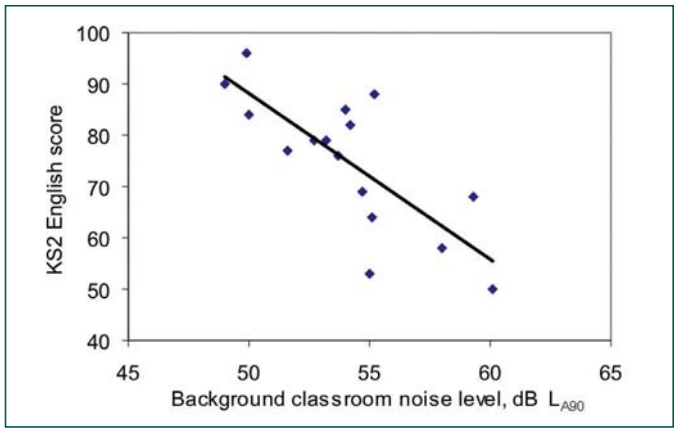

Figure 2. Scatter diagram illustrating relationship between Key Stage 2 English scores and occupied classroom background noise level.

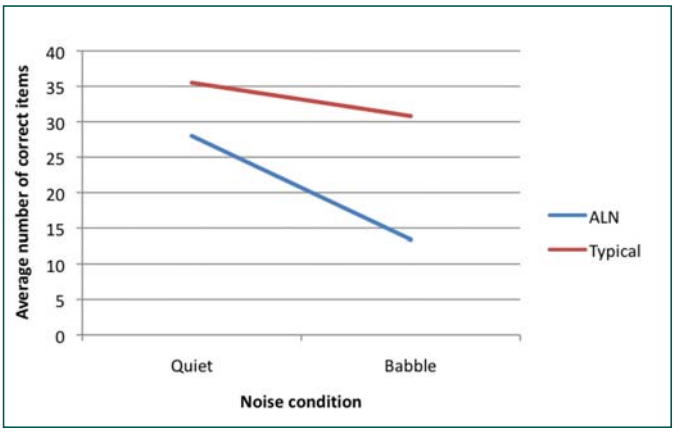

Figure 3. Effects of classroom babble on reading for pupils with additional learning needs (ALN) and typically developing pupils.

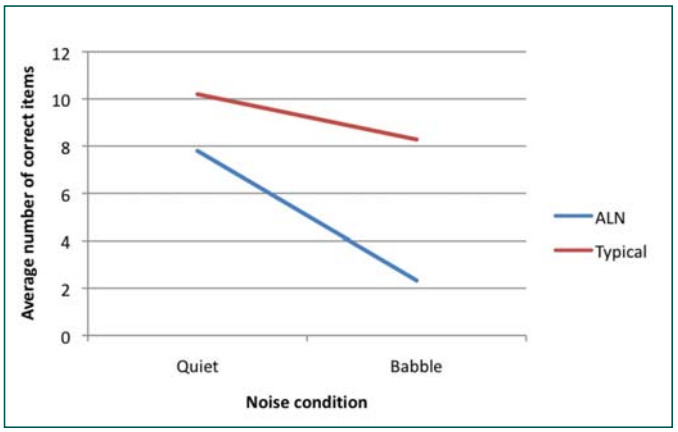

Figure 4. Effects of classroom babble on spelling for pupils with additional learning needs (ALN) and typically developing pupils

negative aspects of their school's acoustic environment than were other pupils[6].

An additional finding in both primary and secondary schools was that the pupils' speed of processing information was significantly less in noise than in quiet classroom conditions.

Open plan classrooms

Open plan classrooms originally became popular in the 1970s but fell out of favour owing to problems of noise and visual distraction. However, in the late 1990s, partly due to changing architectural and educational fashions, many new schools incorporated large open plan areas, many of which are generally unsuitable for traditional teaching and often disliked by pupils and teachers. Additional research at London South Bank University and the Institute of Education investigated the acoustics of open plan classrooms. The research led to the development of designs which could reduce the impact of noise and optimise conditions for teaching and learning in such spaces[7]. These strategies have been incorporated into the revised regulations and guidance on school acoustics.

... annoyance and distraction to pupils ...

Revision of the performance standards and guidance

In order for a school to comply with Building Regulations in respect of its acoustic design, the acoustic performance standards set out in BB93 must be met. The purpose of BB93 is to ensure that school buildings provide acoustic conditions that enable effective teaching and learning, taking account of the current state of knowledge of construction techniques, building materials and research. Throughout the drafting of the 2003 edition of BB93 and its subsequent revision the Department for Education has been advised by a panel of specialists in classroom acoustics. The panel has included academics, acoustic consultants, educationalists and audiologists, drawn mainly from the Institute of Acoustics and the Association of Noise Consultants.

BB93 gives individual minimum requirements aimed at providing appropriate levels of noise and reverberation in many different types of area within a school such as classrooms, science laboratories, music rooms and sports halls. Standards are given for ambient noise levels (the level when a space is unoccupied), reverberation times (a measure of the amount of reverberation in a room), and sound insulation between spaces. The 2003 edition of BB93 applied only to new school buildings. However, the scope of the recent (December 2014) revision has been extended so that it now contains standards for both new and refurbished buildings.

... effective in improving the acoustic quality ...

Another change relates to the provision of suitable acoustic conditions for teaching pupils with hearing impairments and other special needs in mainstream schools. In 2003 more stringent conditions were specified for rooms used specifically by hearing impaired pupils. In the 2014 version the group of pupils to whom the more stringent standards apply has been widened to include pupils with other communication difficulties such as auditory processing disorders, attention deficit hyperactivity disorders (ADHD), autism, visual impairments and general speech and language difficulties.

... additional learning needs were more severely affected ...

The standards for these pupils are more rigorous than previously, reflecting increasing knowledge about their requirements.

Detailed guidance on how to design school buildings to meet the standards is to be published by the Institute of Acoustics and Association of Noise Consultants in the summer of 2015.

Have the regulations and standards been effective?

The recent project on the acoustics of secondary schools provided an opportunity to examine the effectiveness of the standards introduced in 2003.

... Standards are given for ambient noise levels ...

Following the introduction of regulation, the number of school buildings with acoustic conditions meeting the performance standards doubled[8]. This demonstrated that the regulations have been effective in improving the acoustic quality of school buildings and that the majority of new school buildings now have appropriate acoustic conditions. With the standards now applying also to refurbishment, it is to be hoped that eventually all schools will provide a satisfactory acoustic environment for both pupils and teachers. The increasing body of evidence on the effects of poor acoustics and the apparent effectiveness of the introduction of the standards in 2003 also highlight the importance of maintaining regulations on the acoustic design of schools.

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