Classroom Acoustics Research in New Zealand – Past, Present and Future

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ABSTRACT

This paper briefly reviews the notable body of research on primary school classroom acoustics to come out of New Zealand in the last ten years. Major findings are summarised and discussed in context with recent studies abroad and hotly debated topics amongst the international classroom acoustics community. Additionally, future proposed NZ re-search which plans to aid in resolving the formidable 'classroom amplification system' issue.

Introduction and Background

The acoustical design of a classroom is important be-cause it influences the ability for students and teachers to communicate. A classroom with too high a reverberation time (RT) or excessive intrusive background noise is a difficult learning environment because speech intelligibility is reduced, meaning students may not fully understand what their teacher or fellow classmates are saying.

This is particularly relevant in Primary School class-rooms where language and listening skills of the occupants are still developing. Imagine, during language class, trying to learn and adopt new words in a room where you can't hear those words properly.

Primary School classrooms are also dynamic teaching spaces where teachers use a range of teaching styles from one-on-one tuition to group work activities. Didactic teaching (that is, the teacher at the blackboard and all students facing the front) is no longer the norm, and in the main, classroom acoustic design has not changed to accommodate this.

Another issue is that New Zealand favours lightweight timber design with openable windows for natural ventilation. This is wonderful in providing a natural, fresh environment, but it can lead to higher noise levels in the class due to outside noises like traffic, roadworks or other class activities.

In short, a primary school classroom is a very complex but very critical acoustic space, and research conducted over the last 10 years in NZ has suggested that all is not well.

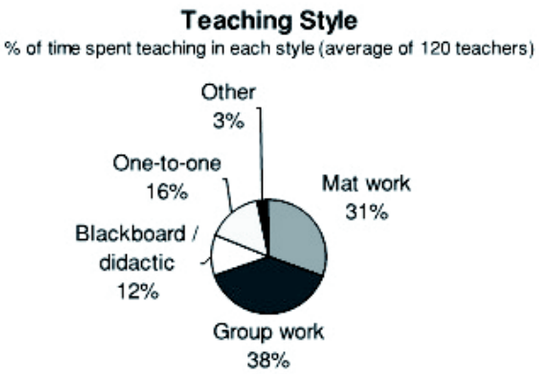

Figure 1. Proportion of teaching style from Wilson, Dodd et al. 2002

New Zealand Research

The following research studies conducted in New Zealand have begun do deconstruct the issue through questionnaires, building surveys and controlled psycho-acoustical experiments on the acoustic needs of children.

NZ Classroom acoustics Research Group – Oticon Study (Wilson, Dodd et al)

In 1999 the NZ Classroom Research Group (NZCRG) - a group of professionals from the fields of audiology, acoustics, education, building science and special needs education, was formed in Auckland.

For several years they undertook the largest research survey of NZ Primary School Acoustics resulting in their acclaimed publication in 2002 "Classroom Acoustics – A New Zealand Perspective"[1]. The research was funded by the Oticon Foundation,

Their work involved acoustic measurements and building inspections of classrooms in seven primary schools in Auckland and a questionnaire survey of 122 teachers about their classroom. Selected classrooms were then upgraded acoustically by installing high quality acoustic ceiling tiles (donated by building industry suppliers) and measurements were repeated to assess the effect of this upgrade.

A brief summary of their findings is included below (copies of their full publications can be obtained from www.oticon.org.nz.):

- Our classrooms are too noisy: 71% of teachers reported classroom noise as a problem. Aver-age noise levels range from 50 to 70 decibels (equivalent in noise level to a busy restaurant)
- Acoustic ceilings make a positive difference: Classrooms with absorptive ceilings were rated more highly by teachers, and the up-graded rooms were rated significantly better after the upgrades
- As shown in Figure 1 below, group work activities are the most common teaching-style (38%). Traditional didactic teaching accounts for only

12% of all activities.

Optimum reverberation time (RT) for children is 0.4 seconds. This is less than the previous internationally accepted standard of 0.6 seconds.

- FM hearing systems are essential for hearing impaired students: This means a microphone worn by teacher, with the signal transmitted directly to students' hearing aids. (Note system this is different from a teacher voice amplification system, which will be discussed be-low.)
- The day-long classroom levels in upgraded rooms dropped more than acoustic theory alone predicts. This suggests there was a change in children's behaviour. We suspect this is due to the Lombard Effect, which was later researched in greater detail (Whitlock, 20032 Whitlock & Dodd, 20083, as discussed below)

The NZCRG was also instrumental in pushing for the NZ standard on acoustic criteria AS/NZS 2107:20004 to include 0.4 seconds RT for primary school class-rooms.

Integration Time and Lombard Effect studies on children (Whitlock, Dodd and Francis)

One of the points underlined by the NZCRG study above was that children have specific intelligibility needs in a classroom situation.

For this reason, additional research followed on directly from the NZCRG study which directly tested the differences in speech intelligibility needs of children compared with adults.

In particular, the research looked at two psychoacoustical phenomena:

- The Integration Time of Speech, which reflects ones ability to decode speech which has been compromised by echoes and reverberation, and
- The Lombard Effect, which is one's susceptibility to increasing their vocal output in the presence of background noise

This second point is especially relevant in classroom group work activities, where noise breeds noise as group members compete to be heard over other groups. This social manifestation of the Lombard Effect is called the 'Cafe Effect' because the effect is often seen in cafes too.

Experiments on both children and adults showed that there is indeed a measurable difference between their ability to understand speech in reverberant conditions, and the effect of background noise on their speech level.

"...acute exposure to noise affected performance on academic tasks, with language-based tasks being particularly affected by background babble..."

Work was also begun developing a prediction model to determine the activity noise level in a classroom, based on the number of occupants, and the room's acoustic properties.

The full breadth of this research is included in Whitlock, 2003[2] and Francis, 2005[5], and is summarised in Whitlock & Dodd, 20083

These findings add weight to the NZCRG recommendation that reducing reverberation time and limiting background noise are essential in a learning environment for children.

International Research And Discussion Forums

The NZ studies above complement the international surge by researchers and professionals in the last ten years who have made significant advances in the field.

This paper focuses in particular on recent large-scale classroom surveys in The United Kingdom and Germany, and the powerful influence of the Coalition for Classroom Acoustics in the United States, and their online discussion forum.

Largest ever noise study on British Class-rooms (Shield & Dockrell)

This major study [6] was a government funded joint collaboration between South Bank University, London University's Institute of Education and several government departments.

The two-year project looked at the effects of noise on the attainment and cognitive development of primary school children in three London boroughs. Over 2000 children aged 7 and 10 were surveyed to establish how disruptive classroom noise was.

The researchers carried out internal and external noise surveys of schools, undertook experimental testing of children in different noise conditions. The teachers were also questioned on their perceptions of noise. Key findings include the following:

- Most external noise came from road traffic, although air traffic noise was also common
- Children were aware of external noise and annoyed by specific sounds
- Classroom noise levels were often dominated by the noise made by the children themselves
- Acute exposure to noise affected performance on academic tasks, with language-based tasks being particularly affected by background babble
- Children with special educational needs were especially vulnerable to the effects of back-ground noise.

These findings strongly echo the NZCRG study high-lighting on a large scale the classroom acoustics issue.

Large German study supports RT reduction (Oberdörster & Tiesler)

This study [7] was another significant work involving in-situ noise measurements of 175 lessons at two primary schools with different pedagogical approaches. The researchers focused on the effect of reducing reverberation time, and teaching method on classroom noise.

Key findings include the following:

- The primary source of noise in a classroom is from the students themselves
- The activity noise was higher in the classrooms with higher RT (i.e. prior to treatment)
- Noise from group work activities reduced significantly more than didactic teaching with reduced RT (as shown in Figure 2 be-low).
- The measurements showed a linear reduction of the L95 sound pressure level by around 1.6 to 2 dB per 0.1 sec reduced reverberation time
- Supports 0.4 seconds as ideal RT

This is another well received and well published study, whose findings strongly support the NZCRG research.

Lively debates on the US-based Classroom Acoustics email forum (Lubman, Rollow, Stewart & Campanella primary contributors)

The classroom acoustics movement in the US began in 1998 with the formation of the "Coalition for Classroom Acoustics", a group of individuals (including acousticians, audiologists, educators and parents) and organisational advocates whose work directly resulted in the development of the ANSI S12.60 standard.9

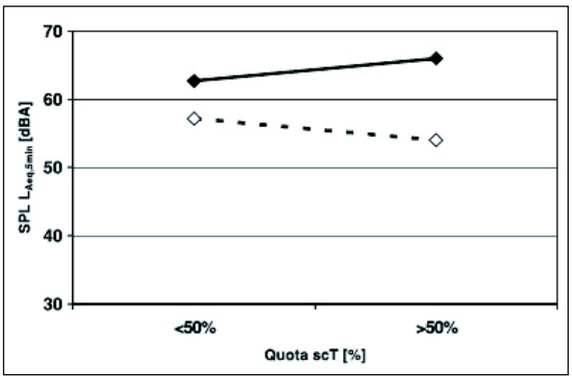

Figure 2. Classroom noise for two teaching methods, with reduced RT (reprinted from Oberdörster & Tiesler, 2006[8])

Members of the group are still active and hold regular conversation (and often, vigorous debate) via the classroom acoustics discussion forum on Yahoo! Groups[10]. The group currently has 343 subscribers.

Recent topics of note include:

- Review of the ANSI S12.60 standard criterion for RT of 0.6 seconds. Should this be reduced to 0.5 or 0.4 seconds in light of the studies above?
- Discussions on how to meet the ANSI standard unoccupied background noise criterion of 35 dBA with HVAC systems
- A detailed account of the German Oberdörster & Tiesler study
- Costs and cost-benefits associated with designing classrooms with good acoustics
- Continued debate on the benefit (or otherwise) of teacher voice amplification systems (TVAS).

This last topic regarding TVAS (also known as sound-field amplification systems, or sound distribution systems) is a significant one, which has generated much lively debate.

Teacher Voice Amplification Systems, And The Next Step For NZ Research

A developing trend for achieving better audibility of the teacher in classrooms is the installation of TVAS, where the teacher wears a wireless microphone and his or her voice is amplified and delivered to the class via an array of loudspeakers fixed to the walls in each corner of the room.

These systems are currently considered to be "must-haves" for primary schools, and consequently there is some considerable pressure on school boards and management to adopt them. Additionally, the fact that hearing impaired children are mainstreamed in NZ schools means that teachers often already utilise FM systems (see NZCRG findings above). These systems (whilst wholly different from TVAS) also incorporate a teacher-worn microphone, so this may naturally lead to predisposition towards TVAS.

Research has shown that TVAS provide benefits in students' learning outcomes and reduce teacher voice strain, however many parties worldwide feel that these systems fail to address the central issue of poor room acoustics and only aids the teacher-student speech stream,

neglecting both the student-teacher stream and the crucial student-student stream during group work. It is this dichotomy which is fuelling the US debate.

There are fears that if students experience these systems from a young age, their development of essential listening skills (such as localization & discrimination) may be hindered, as the amplification system removes the need for really 'attending' to the speaker.

Acousticians tend to take the view that the natural acoustics of the room should be improved as much as possible so that the environment lends itself to good speech communication without the need for aids. US research has indicated that the costs of a TVAS system and acoustic improvement of a classroom are comparable.

The NZCRG has recently reformed and expanded to include experts in TVAS systems to undertake an investigation into appropriate uses of amplification systems in classrooms.

We propose to compare and contrast the benefits of TVAS and acoustical design in classrooms to establish a structured approach for their implementation.

Summary

The issue of classroom acoustics is a worldwide concern, with many groups and individuals taking a proactive approach.

There have been significant developments in the last 10 years with respect to understanding and refining room requirements, and New Zealand research has been at the forefront.

Regular discussion takes place via the classroom acoustics Yahoo! Group, and any interested parties are encouraged to join this group and contribute.

The hot issue of teacher voice amplification systems is enjoying much debate at present. Further work proposed by New Zealand researchers looks to assess this in a balanced way, with a view to developing guide-lines for their implementation to complement the natural classroom acoustics.

Acknowledgements

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