USUALLY A CHANCE TO TEACH IN A BRAND NEW CLASSROOM IS WELCOMED BY TEACHERS. But complaints from primary school teachers about the high level of noise they encountered in a style of new relocatable classrooms prompted a comprehensive study into classroom acoustics in New Zealand primary schools.

With funding from The Oticon Foundation in New Zealand, and sponsorship from three building industry suppliers: Holden Architectural (Ecophon), Alotech NZ Ltd and Fletcher Wood Panels, a research project started in 1999.

The researchers wanted to answer the questions: what makes a good classroom for listening, hearing and teaching in; and, can Kiwi kids hear their teachers? In particular, they wanted to know what children with mild, temporary, permanent or severe hearing loss experience in our classrooms.

To answer this question they needed to understand how our classrooms are constructed, what teachers think of them, how different styles of teaching might influence classroom noise, and what were the noise levels. 120 teachers in seven Auckland primary schools took part in the study.

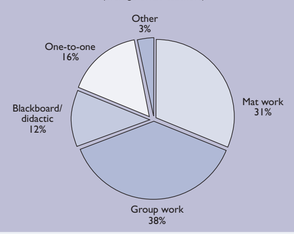
The researchers identified rooms for detailed study that were rated as 'good' or 'poor' for acoustics and then treated the `poor' classrooms to try and improve the listening environment. A 'poor' or 'very poor' classroom was one where the majority of teachers listed "too much echo", and "noise level produced by students too high", or cited noise from outside the room as a problem.

Finally, they published *Classroom Acoustics: A New Zealand Perspective* and shared the results with the Ministry of Education.

FIGURE 1:

Teaching style

% of time spent teaching in each style (average of 120 teachers)



FINDINGS

• Our classrooms are too noisy

The study confirmed the dramatic change in teaching style that has occurred in recent years. The traditional lecture-style that today's adults experienced as children has been largely replaced with 38 percent of time being spent in group work and 31 percent in mat work.

Today's teaching style is a dynamic one with over 70 percent of teachers reporting 'walking around' as their usual position in the classroom. This has changed the way that information from the teacher is delivered to and received by the child.

Noise from within the classroom is a problem for 71 percent of the teachers surveyed.

Because of our reliance on opening windows for ventilation, noise from outside contributes to high classroom noise. Figure 2 shows that noise from lawn mowing and sports fields and other classrooms is the most significant.

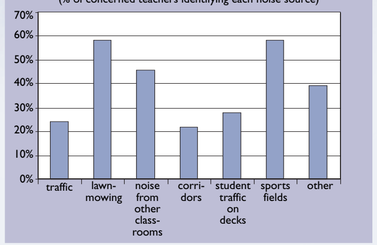
Vocal strain, recognised as a serious occupational hazard for teachers, occurs when teachers need to speak for long periods of time at an elevated voice level. More than a third of the teachers in this study say they need to speak at a level that strains their voices. Around half of the teachers say that they need to raise their voices during group work.

The listening environment was assessed on a variety of scales including signal-to-noise ratio, clarity, and reverberation[1] . Some of our 'good classrooms' meet recommended reverberation guidelines of 0.4 seconds, and our 'poor' ones mostly do not.

FIGURE 2:

Sources of intrusive external noise

(% of concerned teachers identifying each noise source)



Classroom before treatment

Classroom fitted with one style of acoustic ceiling tiles

Special 'day-long' recording of actual sound from classrooms confirmed that average noise levels range between 50–70 decibels. Other researchers have measured the average level for a teacher's voice being 71 dBA at one metre dropping to 63 dBA at 4 metres—meaning children are often trying to listen well below the recommended signal-to-noise ratio.[2]

[1] Reverberation time is a measure of how long sound persists in a room after the source has stopped. Ideally sound should disappear quickly in classrooms – they should have short reverberation times. Classrooms with longer reverberation times may sound echoey and there will be more problems with reverberation blurring speech sounds together and increased noise blocking out the reception of speech.

[2] Signal-to-noise ratio – This is a measure of the level of the signal which the listener wishes/needs to hear compared with the level of the noise they do not want/need to hear – the background noise. E.g. if speech was 65 dB and noise was 55 dB the signal-to-noise ratio would be +10 dB. For young children and the hearing-impaired this should be at least +15 dB. In classrooms signal-to-noise ratio is constantly varying with the various activities.

• Acoustic ceilings make a positive difference

A survey was made of the construction of the classrooms and this was compared to the teacher ratings of the classrooms to try to find out which building features were associated with a good acoustic rating.

The results showed clearly that the presence of absorptive/ acoustic ceiling treatment was most important, not if the building was relocatable or not.

Table 1 presents the range of building types in the survey, and the teachers' subjective ratings of the classroom listening environment for each classroom type.

Classrooms that were identified as having good acoustics were generally permanent older style classrooms with masonry floors and soft-board acoustic ceiling tiles (Type 3), permanent classrooms with timber floors and soft-board acoustic ceiling tiles (Type 5), or relocatable classrooms with a suspended soft-board acoustic tile ceiling (Type 2).

Classrooms identified as having poor acoustics were generally relocatable type classrooms with acoustically hard pitched ceilings (Type 1), or permanent classrooms of a similar design (Type 6). Permanent classrooms with hard ceilings and concrete floors were mainly regarded as only acceptable (Type 4).

• Good listening conditions are vital

Because children's brains are not fully developed for listening until they are in their teenage years, primary age children find it harder to correctly hear the teacher's voice in difficult listening situations. They miss key words, phrases and concepts in poor listening conditions so they don't really understand what words have been spoken.

They need very good signal-to-noise ratios. This means the teacher's voice needs to be loud and clear above the background noise. Groups that are particularly affected by background noise are children with temporary hearing loss from ear infections (otitis media), those with speech impediments, learning disabilities, behavioural or attention-deficit disorders, with permanent hearing impairment, very young children, and those for whom English is a second language— in all around 15–20 percent of all children. Overseas research has shown this group are highly likely to suffer educational failure or behaviour problems related to the poor listening environment.

• Speech tests revealed FM systems are essential for hearing impaired children

Speech testing was carried out in the 12 study rooms to try and see how well children heard in background noise in classrooms. Children with good reading ages, normal hearing, and no disabilities or special language needs were tested by asking the child to repeat each sentence played through a loudspeaker to the researcher seated next to them. A small number of hearing-impaired children were also tested.

The researchers wanted to see if there was a significant difference in the speech test results between the rooms which were noted as good or poor on the survey questionnaire— there were not. They concluded that the speech tests may not have been sensitive enough to pick up the difference in intelligibility in the rooms or that the acoustical differences reported by the teachers could not be measured by speech testing.

The most dramatic finding was that of the group of hearing-impaired children, those who had the worst hearing losses scored the best! The most likely reason for this finding is that they were wearing personal FM systems (radio aids). The other children with mild to moderate hearing loss, fitted with only personal hearing aids, heard the least. Educational support for this group of children is crucial if they are to achieve good educational outcomes. Half of this group scored less than 20 percent and very few heard more than half of what the teacher said.

• Classroom noise can be reduced

The classrooms that had been rated as acoustically poor by the teachers were tested after they had been modified using acoustic ceiling tile products supplied by the building industry. Three different types of acoustic ceiling tiles were used. Each type had particular features that make it more suitable in different styles of classroom situations. Figure 3 shows the reverberation times for the 'good' and 'poor' rooms (A) and the effect of the modifications (B) to make the 'poor' rooms exactly like the 'good' ones. Results showed that reverberation time had been reduced to within the recommended guidelines.

Teachers were enthusiastic about the changed environment, mostly rating it significantly better than before. They commented on less noise, more on-task behaviour, less yelling, absence of voice strain and less rain noise.

Other teachers asked if they could have the same in their rooms. Unprompted comments from children included better hearing, less noise, and a more peaceful environment. With the classrooms becoming quieter, floor noise had become more noticeable as was noise from adjacent classrooms.

When the speech tests were repeated the class activity noise levels were significantly lower in the modified rooms. The team observed that when the acoustics in the room were improved, making them less reverberant, it appeared to have a calming effect and reduced noise escalation in the room (described as the café effect).

The Ministry of Education's Health and Safety Code of Practice for State Schools (1998) covers minimum legal requirements for schools such as egress, lighting and ventilation. Minimum legal requirements for acoustics in schools are currently those under relevant legislation such as the Building Act. The research team believes that acoustic standards specifically for the school environment should be addressed.

TABLE 1:

Definition of categories of classroom in the study	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Type	Relocatable	Relocatable	Permanent	Permanent	Permanent	Permanent	Open Plan
Ceiling	hard	acoustic	acoustic	hard	acoustic	hard	acoustic
Floor Construction	timber	timber	concrete	concrete	timber	timber	concrete
Floor covering	carpet	carpet	carpet	carpet	carpet	carpet	carpet
Walls-overlay	hessian faced soft-board	hessian faced soft-board	hessian faced soft-board	hessian faced soft-board	hessian faced soft-board	hessian faced soft-board	hessian faced soft-board
Number of Responses (subjective rating of classroom listening environment) in each category	**1**	**2**	**3**	**4**	**5**	**6**	**7**
SUBJECTIVE RATING							
Good or Very Good	2	23	19	3	5	0	0
Acceptable	7	9	15	8	0	0	1
Poor or Very Poor	12	2	3	4	1	3	2
Total number rooms of this type	**21**	**34**	**37***	**15**	**6**	**3**	**3**

** Includes 8 partially open plan classrooms (6 rated as "acceptable", 2 rated as "very good")*

The Ministry of Education's classroom Design Standards Guidelines outlines some standards for acoustics which the Ministry recommends, but which are not legal requirements. Further to the results of this study, the Ministry advises that these publications will be reviewed.

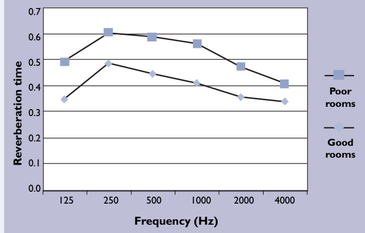
An exciting development that occurred during the research was that two of the researchers in this study were able to specify 'satisfactory' (35 dBA) and 'maximum' (40 dBA) unoccupied noise levels and reverberation times (04/0.5s) for Primary School Teaching Spaces in a new Australian and New Zealand Standard published in December 2000: *AS/NZS 2107:2000, Acoustics—Recommended design sound levels and reverberation times for building interiors.*

• So what were the team's recommendations?

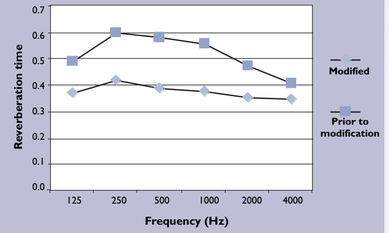
- **The research team believes all new teaching spaces in New Zealand schools should be designed to meet acoustical standards specified in AS/NZS 2107:2000.**
- Teacher training and in-service should include more information on: the incidence and effects of hearing loss in NZ primary schools, the importance of acoustics in learning environments, vocal strain and techniques to avoid its onset.
- For the predominant teaching methods of primary school teachers of group work and mat work, an absorptive ceiling (moderate broadband absorption to central ceiling) is strongly preferred. All new primary classrooms should be designed with absorptive ceilings. A reverberation time of 0.4 seconds which is flat across the frequency range 500–2000 HZ in occupied classrooms is recommended. When retrofitting of an acoustic ceiling is required, one of the designs used in this study will provide satisfactory reverberation times.
- Prioritise classrooms with untreated high or vaulted ceilings for retrofitting of acoustic ceiling tiles. Ensure that relocatable classrooms meet the same acoustic design standards as permanent construction rooms.
- In the siting of classrooms/school design, consideration should be given to outside noise sources, both within and outside of the school e.g. proximity to the bus stop, main roads, school hall, playing fields etc. Rooms should have a design (unoccupied noise level) sound level of 35 dBA.
- School staff and administration should be made aware of the risk of noise entering the classroom from outside, e.g. consider the possibility of scheduling lawn mowing outside school hours.
- External decks need to be supported independently from classroom structure, so that footfall on the deck is not transmitted into the classroom.
- Do not site relocatable classrooms on markedly sloping land so that high-piled foundations are avoided.
- Carpet over underlay is the recommended floor covering to reduce noise from footfall and furniture movement. However, we should note that some countries (e.g. Switzerland) do not recommend the use of carpets in classrooms because of their findings that their use results in a significant rise in the incidence of asthma and allergies in children.

FIGURE 3:

A: Average occupied reverberation time Measurements for good and poor classrooms.



B: Average reverberation time in occupied classrooms before and after modification.



- Further investigation into the optimisation of classroom furniture and fitting design to achieve acoustic performance requirements is desirable to avoid problems such as floor scrape with chairs.
- Purchase computers with the lowest noise ratings.
- Investigate noise levels of any heating/air conditioning system that is going to be installed and ensure that noise generated by the system in the classroom does not exceed the recommended design sound level for the classroom.
- Before sound reinforcement systems (soundfield amplification systems) are considered for use in classrooms, all possible avenues to improve the room acoustics and insulation against noise should be followed.
- A solid floor construction is recommended to reduce the drumming associated with light timber framed construction—two layers of particleboard or a concrete slab is recommended instead of one.
- All children who wear personal hearing aids should be considered as potential candidates for FM systems, regardless of their degree of hearing loss.
- Further recommendations from a Canadian standard are:
  1. open plan classrooms should be avoided
  2. provide a double stud wall between the washroom and instructional space. Ensure structural separation is maintained between each wall and specify that piping is attached to washroom side only.

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FURTHER INFORMATION

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