GOOD LISTENING CONDITIONS ARE ESSENTIAL TO CHILDREN'S AUDITORY DEVELOPMENT AND GENERAL LEARNING. A child's ability to hear words, phrases and instructions is vital to them being able to process information and understand concepts[1].

Research shows that excessive noise levels impair children's speech perception, reading and spelling ability, behaviour, attention and overall academic performance[1]. Studies have also found classroom noise to be an issue in most New Zealand schools[2, 3].

Sound-field classroom amplification systems can provide a practical and cost-effective solution. Sound-field systems use FM technology to transmit and amplify a teacher's voice (signal) above the classroom noise, with the aim of making it easier for students to hear the teacher no matter where they are in the classroom at the time.

This study aimed to establish whether sound-field amplification:

- significantly improved educational achievement in the areas of listening, reading vocabulary, reading comprehension, mathematics, and phonological awareness
- was particularly useful for children of certain socioeconomic backgrounds, ethnic groups and/or for those who have a history of middle ear dysfunction ('glue ear')
- made a difference to teachers' health and absenteeism levels.

A total of 626 students in their first to sixth year of schooling participated in this research project, which took place during the 2002 school year. The students, from five schools in Rotorua, were split into intervention (438 students in 30 classrooms) and control (12 classrooms of 188 students) groups. Figures 1, 2 and 3 show details of students by year of schooling, school decile* and ethnicity. The classrooms in the intervention group were fitted with Phonic Ear Easy Listener sound-field systems and the teachers were trained in how to use them at the end of the 2001 school year.

Performance measures for the study included Progressive Achievement Tests (PATs), phonological awareness tests, a survey of teachers and feedback from students (Appendix).

Figure 1: Students by year of schooling

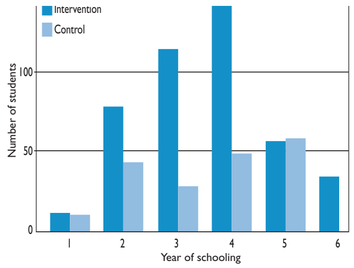


Figure 2: Students by school's decile rating

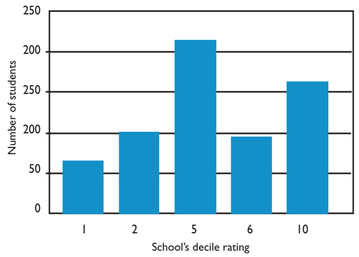
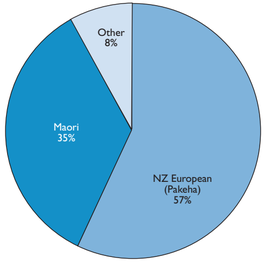


Figure 3: Students by ethnicity



* Decile – All state schools in New Zealand are rated by the Ministry of Education on a socio-economic scale of 1 to 10. A low decile rating indicates a school with a significant number of disadvantaged children.

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FINDINGS

Sound-field dramatically improves listening and reading

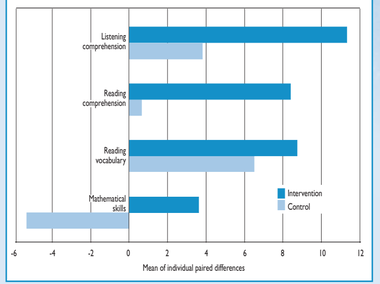
PAT percentile rankings are normally stable for each child from year to year. Significant improvements were noted in the intervention group's scores in the PATs for listening comprehension, reading comprehension, reading vocabulary and mathematics (Figure 4, Table 1).

A significant improvement was noted in mean difference of the control group's 2002 versus 2003 scores in reading vocabulary. The improvement in the control group's listening comprehension and reading comprehension scores was not statistically significant. The deterioration in the control group's scores for mathematical skills was statistically significant.

Table 1: Progressive Achievement Tests Results

PATs	Group	Students	Mean Change	Significance
Listening Comprehension	Intervention	233	11.3	>0.0001
	Control	98	3.8	0.056
Reading Comprehension	Intervention	104	8.37	>0.0001
	Control	60	0.64	0.797
Reading Vocabulary	Intervention	100	8.74	>0.0001
	Control	58	6.46	>0.0001
Mathematics	Intervention	107	3.62	0.044
	Control	45	-5.34	0.037

Figure 4: Progressive Achievement Tests



Sound-field dramatically improves phonologic skills

Phonologic awareness and skills are indicators of a student's development and are linked to mastery of literacy. Statistically significant (Figure 5) improvements were noted in the intervention group on all ten sub scores, with the improvements by the intervention group greater than that of the control group in all aspects of the tests.

High acceptance of sound-field by teachers

Some 90 percent of teachers reported using the sound-field systems consistently throughout the year-long study. Sixty-three percent used the equipment consistently for most teaching sessions while 27 percent used it consistently for selected sessions.

Quieter classrooms

Sixty-six percent of teachers reported lower noise levels, resulting in greater student attention.

"It is easier to keep noise levels down as all children can hear and lower their noise level. I am not competing with them."

"The biggest help/improvement I have seen is the ability of children to hear the teacher regardless (just about!) of what children are doing beside and around them. The distraction level is halved. Even noises from outside don't affect the children inside the room as much."

Increased on-task behaviour

Seventy-three percent of teachers noted increased on-task behaviour, with learners remaining on-task for longer periods. Off-task behaviour was reported as easier to address as the teacher used a friendly voice at a lower volume.

"Children remained on-task for longer periods when using the system and it was easier to refocus when they went off-task."

"I have noted some learners make exceptional progress – they are auditory learners! This has really helped them learn."

Reduced disruptive behaviour

Teachers commented on the quieter calmer classroom tone and that it was easy to refocus behaviour without disrupting the routines of others.

"Behaviour is easier to manage and refocusing of students easier to do by the teacher."

Improved understanding of instructions

Two thirds of teachers noted improved understanding of teacher instructions. More positive benefits were noted by the group that used the systems for most teaching sessions than those who used it for selected sessions.

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Teachers found that fewer students needed instructions clarified or repeated. Students were also able to hear instructions more clearly no matter where the teacher or they were in the classroom.

Improved student cooperation

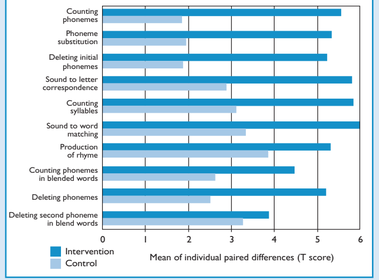
Sixty percent of teachers reported improved student cooperation.

"Sound-fields promote a calmness and well-being. They help to promote a positive tone within the room."

Students find it easier to hear

Some 98 percent of the students who provided feedback about the sound-field systems were positive about them. Most students commented that it was easier to hear the teacher and that the teacher's voice was clearer. Students also commented that it was easier to hear when sitting at a distance from the teacher and that it was easier to hear over competing noises either from inside or outside the classroom.

Figure 5: Phonological awareness tests



"It is easier to hear when you are sitting at the back of the room."

"If you are stuck on something and so is someone else and the teacher answers to the other person, you can hear and don't have to ask the teacher yourself."

Enhanced classroom harmony

Both teachers and students commented on the enhanced learning environment when the sound-field was used consistently. Students noted that teachers could discipline students without raising their voices and that it was easier to hear teachers when they read stories.

"Spelling test words are easier to hear."

"When the teacher has to growl she doesn't have to shout!"

Reduced vocal strain

In a previous study of classroom acoustics, 35 percent of teachers claimed that the level they need to speak at to be heard strained their voices[3]. Sound-field systems address the issue of voice strain by reducing the effort required by teachers to project their voice.

Over half of the teachers involved in this study identified being able to speak naturally at reduced voice intensity levels and the ease of communication as key factors in feeling less tired and being able to maintain energy reserves.

"Vocal strain is completely minimised."

"I feel far less tired after a day at school as I am not having to battle to be heard and the classroom is much quieter and calmer."

Over 50 percent of teachers who used the systems consistently for all teaching sessions noted reduced irritability levels in themselves and in their students. One teacher enthusiastically considered it a teacher-altering intervention with 100 percent reduction in stress levels.

The majority of teachers did not feel the equipment had a significant impact on their absence from teaching during the

intervention period. The benefits of less vocal strain when they had a cold, sore throat, or had an asthmatic condition meant that some were able to remain teaching rather than taking time off.

Sound-field use was most beneficial for low decile schools

The results of the PAT for listening comprehension was analysed for the each of the different decile rated schools. The means for all decile schools improved markedly (Figure 6). While there was no significant difference between the deciles, those in the lower decile schools improved more than those in high decile schools.

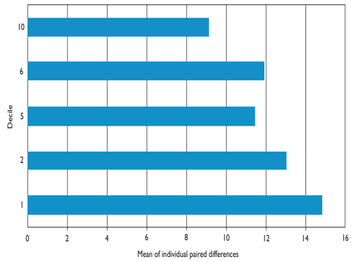
Sound-field improved listening comprehension for both Maori and Pakeha

The means for listening comprehension of both ethnic groups improved markedly. There was no significant difference between the improvements for Maori and for Pakeha.

Improved listening comprehension for students with middle ear dysfunction

Some 32 percent of students in the intervention group were identified as having a history of middle ear dysfunction. There was no sufficient difference between the improved results for those students that had previously been treated for middle ear dysfunction and those that had not.

Figure 6: Progressive Achievement Test, listening comprehension by decile



SUMMARY

- Sound-field improves learning and literacy outcomes, creates enhanced classroom harmony and improved student behaviour, and reduces voice strain among teachers. Sound-field achieves this by overcoming problems associated with noise, distance and reverberation.
- Sound-field is not a panacea for all problems in modern education. Effective teaching practices need to be considered, as well as other environmental factors such as acoustics, lighting and ventilation.
- Sound-field should not be reserved for children with special needs, as it benefits all students, regardless of school decile, ethnicity, or whether or not they have middle ear dysfunction.
- Sound-field is one of the most cost effective interventions a school can invest in to increase literacy outcomes.

RECOMMENDATIONS

- All classrooms should be fitted with sound-field systems to support good teaching practice. Other research shows that the benefits of sound-field are equally relevant to early childhood centres, intermediate and secondary schools.
- Teachers in classrooms with sound-field should use the system consistently to maximise the benefits that sound-field can provide.
- Teachers and schools should take advantage of opportunities to trial and experience sound-field in a classroom setting so they can experience the benefits for themselves.
- Schools should install sound-fields that are compatible with deaf and hearing impaired students' personal FM systems.
- Trainee teachers should be made aware of the issues associated with classroom acoustics and the benefits that sound-field can provide.
- All classrooms should have basic acoustic treatment, including carpets and curtains, to reduce noise levels.
- All schools should consider more advanced acoustic treatment such as absorptive ceilings.
- Issues associated with the user comfort of sound-field microphones should be proactively addressed.

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Appendix: Performance measures

1. Progressive Achievement Tests (PATs) – are standardised to New Zealand students and are group-administered to all New Zealand students from year three. Children's percentile rankings are not expected to change significantly from year to year [4,5,6]. The following PATs were undertaken for this study:
   - listening comprehension – to year three and above students
   - reading vocabulary and reading comprehension – to year four and above students
   - mathematics – to year five and above students.
2. Phonological awareness tests – were developed by Joy Allcock for New Zealand children based on the Sutherland Phonological Awareness Test[7]. The tests measure achievement in ten specific phonologic areas from letter-sound relationships to counting phonemes and the ability to substitute phonemes in blend words. Children in year one and two junior classes that were too young to participate in the standardised PATs took these tests at the beginning and end of the 2002 school year.
3. Teacher questionnaires – teachers in the intervention classrooms were surveyed using a written questionnaire. Teachers were asked to focus on the frequency of using the equipment and its effect on student behaviour, the learning environment, and their health and wellbeing.
4. Student perceptions – teachers were asked to invite students to comment on the sound-field systems from their perspective. Students were asked to focus on their ability to listen to directions, noise levels in the classroom, and the effort to listen to the teachers.
5. Parents provided information on ethnicity and history of middle ear dysfunction.
6. Absenteeism was recorded from each school's weekly returns to the Ministry of Education.

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The benefits of sound-field amplification systems

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