CLASSROOM SOUND FIELD AMPLIFICATION, LISTENING AND LEARNING

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Declaration

I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

(Signed)
Acknowledgements

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Dedication

To the children and young people and the many colleagues who have contributed to my learning and teaching.
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Abstract

Sound field distribution is becoming increasingly known as a method to overcome problems associated with noise, distance, and reverberation in classrooms. No robust research on this intervention has been conducted in the New Zealand context. Changing pedagogies in the education of New Zealand children and young people have been observed particularly since the 1970’s, resulting in noisier classrooms (Wilson, 2000). Acoustic standards for New Zealand classrooms that were adopted in 2003 apply only to new or renovated classrooms, and not to the majority of existing classrooms (Ministry of Education, 2003a).

This study investigated: (a) the efficacy of sound field distribution in 30 New Zealand classrooms from five schools and compared outcome measures with a representative control group; (b) the variations of benefit for groups from specific populations, in particular children from five different socio-economic backgrounds and those with histories of middle ear dysfunction; and (c) the effects on teachers who use this equipment.

Data were collected from standardized objective measurement tools and from the teachers and students who were participating in the study.

Results revealed that sound field distribution, with the equipment configuration of boom microphones and four speakers, can enhance the
listening and learning environment resulting in significant positive benefits in raising the achievement levels of children and young people. These results were observed in listening comprehension, which has a flow-on effect on the overall scholastic achievement of all students. Evidence of improved outcomes in areas with a strong link to mastery of literacy were significant, in particular in the areas of phonologic skills, reading comprehension, and reading vocabulary.

Results of the study strongly support the use of sound field distribution in all mainstream school settings irrespective of whether the children and young people belong to a particular ethnic group, have had a history of middle ear dysfunction, or attend schools of a particular socio-economic status. Classroom sound field distribution seemingly benefits all children and young people.

As a result of the positive results of this study and given the stated goals for education by the New Zealand Ministry of Education (Ministry of Education, 2003b), sound field distribution needs to be considered at a policy level as an intervention to assist in reducing disparity and to improve learning outcomes for all young New Zealanders in mainstream school settings.
Chapter 1

Introduction to the Research

Introduction

This research project investigated the effect of using sound field distribution in classrooms as a tool to enhance learning outcomes for children and young people.

Background to the Research

Personal amplification systems or hearing aids for students who are deaf or hearing impaired have been used successfully for decades to provide access to acoustic information (Flexer, 1997). It has been shown that hearing aids used in isolation are inadequate at solving the challenging acoustic conditions found in a typical classroom situation (McCracken & Laoide-Kemp, 1997). Due to increasing demand from the market and available technology, personal frequency modulation (FM) systems were developed to minimize these effects for students who are deaf. A further development of these FM amplification systems, similar to a small public address system, was made so that they evenly distributed sound in general mainstream classrooms to improve sound distribution to all students. Their use, however, in benefiting all students has not yet been researched robustly in the New Zealand setting—even though lamented or commented
upon by educators, audiologists, and officials of the Ministry of Education (DEANZ, 2003).

Classroom FM amplification systems, called sound field distribution systems or simply sound field systems, or by a manufacturer’s identification as Active Learning Systems, diminish the negative effects of common learning environments by overcoming problems associated with noise, reverberation, and distance. Mild hearing losses associated with the high incidence of otitis media with effusion (OME) in the general population, and even higher incidence within the indigenous Māori population reported in Whakarongo Mai (1989), and Valentine et al. study (2001) reporting on the unacceptable acoustic conditions in the majority of New Zealand classrooms, suggest that it is both relevant and appropriate with regard to improved educational achievement for students in general, to research sound field distribution of classrooms within the New Zealand context.

The developmental and educational implications of OME, commonly called “glue ear” or middle ear dysfunction, were researched by the author in 1991 (Heeney, Hill, & Trubovich, 1991). The high incidence of otitis media in New Zealand from this study in 1991 is consistent with the reported incidence internationally by Crandell, Smaldino, and Flexer (1995). Crandell et al., in an expansion of the incidence study, suggested that between 76% and 95% of all children in the United States of America experience at least one episode of OME by 6 years of age and that a third of these children
develop persistent or recurrent OME during the first 3 years of life. Crandell et al. also linked “recurrent OME to compromised speech, language, intellectual, attentional, learning, and psycho-educational and/or psycho-social development” (p. 60). By extension, these serious educational issues would surely apply in the New Zealand context as it does in other developed nations.

From research in the USA, Flexer (1999) discussed the differences in listening abilities that children and adults bring to a communication/learning situation. The child's auditory brain structure is not fully mature until about 15 years of age, so that a child does not bring a “complete” neurological system to the listening situation. They also do not have the years of language and life experiences that enable adults to use the processes of linguistic redundancy and auditory/cognitive closure, to fill in the gaps of missed or inferred information. Flexer suggested that an invisible filter effect operates for any level of hearing impairment which distorts, smears, or eliminates incoming sounds and that it has negative effects on verbal language acquisition.

Crandell et al. (1995) have suggested that noise levels and reverberation times for normal hearing children should be those recommended for listeners who are hearing impaired, with signal-to-noise ratios surpassing +15 dB and reverberation times not exceeding 0.4 seconds. Blake and Busby (1994) observed and recorded the acoustic
conditions present in a large number of junior classrooms (N = 126) in Wellington, New Zealand. The median signal-to-noise ratio was +6 dB. Only 4% of the junior classrooms in Wellington were found to be adequate for children with normal hearing to hear clearly, when sitting within three meters of the teacher. Analysis revealed that poor signal-to-noise ratios were associated with high background noise levels and multi-functional teaching activities.

The present research examines an intervention that enhances the listening environment to overcome (a) the poor acoustical conditions documented in New Zealand classrooms, and (b) the detrimental effects on listening and learning of mild but educationally significant hearing loss caused by otitis media. An outline of this research follows.

**Overview of the Research**

This year-long extended study, as a primary focus, investigated the effects that sound field classroom amplification may have had on the achievement levels of 438 children and young people. The intervention, the installing and use of the sound field distribution systems, involved 30 classrooms in Rotorua, New Zealand. A further 188 students in a control group were also part of the study. Achievement levels for listening comprehension, reading comprehension, reading vocabulary, phonologic skills, and mathematics were all measured quantitatively. Additional qualitative measures were completed by the participating cohorts of
teachers and students. These measures will be presented in Chapter Three.

This present study, as will be elaborated in this document, suggested that sound field distribution seemingly benefits all students regardless of socio-economic background, ethnicity, or whether or not they have had treated middle ear dysfunction. Furthermore, the author of this research will argue that the sound field distribution system achieves this in classrooms that have had only basic acoustic treatments by overcoming problems associated with noise, distance, and reverberation.

**Research Objectives**

The present research has four principal objectives.

1. To document the efficacy of sound field distribution in 30 New Zealand classrooms from five schools and compare outcome measures with a representative control group.

2. To determine whether or not there is a variation in benefit for groups from specific populations, in particular children from five different socio-economic school-environment/backgrounds and those with histories of middle ear dysfunction.

3. To determine the effects on teachers who use this equipment, including, for example, absenteeism rates, and perceived health benefits.

4. To provide data which may be used by the Ministry of Education to substantiate policy development and resources to
remove potential barriers to learning in New Zealand schools.

**Research Questions**

1. Is there significant improvement in achievements of primary-aged children in the area of listening following a 12 month period of learning in classrooms equipped with a sound field distribution system?

2. Is there significant improvement in achievement of primary-aged children in the area of reading following a 12 month period of learning in classrooms equipped with a sound field distribution system?

3. Is there significant improvement in achievement of primary-aged children in the area of mathematics following a 12 month period of learning in classrooms equipped with a sound field distribution system?

4. Are achievements by students who have been treated for otitis media or otitis media with effusion (OME) significantly different following learning in a sound field amplified classroom?

5. What comparisons and observations can be made between learners from a variety of socio-economic backgrounds?

6. Is there any significant difference in the absenteeism of teachers who use sound field distribution equipment from those who do not?
Significance of the Research

The key significance of this research is that it provides information and an insight into an area that has been previously neglected. This research is important since it provides information previously unavailable—with particular reference to the New Zealand context. It is believed that the results and data in this research will form a foundation for further related investigations and influence New Zealand researchers, teachers, educators, administrators, and government agencies so that they are better aware of a physical environmental adaptation that can make a significant impact on raising the educational achievement of children and young people. This research should provide a significant contribution to current knowledge in the following five critically important areas:

(1) This research will provide quantitative and qualitative information on the benefits to classroom learning of using four speaker and exclusively used boom microphone sound field distribution systems.

• Prior to this study there was limited research on this particular intervention.

(2) This research will provide quantitative and qualitative information on an intervention to make a positive difference to students’ learning. The Educational Review Office (1999) has stated that schools must, in order to fulfill the requirements of their Achievement Statement, make a positive difference to students’ learning.
• All hearing loss in young children should be treated as educationally significant. The problem of poor listening and poor hearing impinges upon the schools’ ability to fulfill this function. The Secretary for Education has stated that the challenges to improving learning outcomes involve reducing disparities in student outcomes and that effective teaching is the most important thing that will bring about a significant lift in student achievement (Fancy, 2004).

(3) This research will facilitate a more comprehensive understanding of the implications of classroom acoustics resulting from changes in teaching methods.

• Changing pedagogies have been observed in New Zealand particularly since the 1970’s. A more interactive teaching style has replaced the more traditional teacher dominated style of the past (Wilson, 2000). This interactive teaching style is characterised by more movement of teachers and students, a less formal classroom tone, accommodation of students’ individual learning styles, and more group and individual instruction in contrast to the previous methods of whole class instruction. Classroom noise has increased correspondingly, yet appropriate acoustic modifications to the changed listening environment have largely been ignored.

(4) This research should provide previously unavailable data for
specific populations on factors contributing to achievement levels in listening and literacy.

- Evidence-based practices, with a focus on quality teaching, are currently supported by the Ministry of Education (2004), yet a dearth of research exists on academic achievements of children and young people who have histories of middle ear dysfunction which, after the common cold, is one of the most prevalent ailments of young children (Flexer, 1999).

- New Zealand schools in different socio-economic communities receive differing levels of funding from one another. Potential links to student learning through acoustic adaptations of the learning environments in varying socio-economic communities have not been researched (Oticon Foundation in New Zealand, 2002).

(5) This research potentially provides data which contribute substantially to reducing the economic, social, and educational costs of underachievement in New Zealand society.

- High rates of underachievement result in large numbers of children and young people being inadequately prepared to enter the workforce. This underachievement has particular implications for Māori students who have been identified as the largest cohort to enter the workforce (OECD, 1993) and also have the highest incidence of OME, “glue ear” (Whakarongo Mai, 1989). Furthermore Māori students are
currently recognized as being one of the largest groups of underachievers in the New Zealand educational system (Fancy, 2004).

**Definition of Key Terms**

The following terms have been used in this research:

*Adviser on Deaf Children (AODC)*

- Usually a qualified teacher of the deaf or hearing impaired, who has received additional specialist training in working with children and their families. In most cases, an “Adviser” will be a family’s key contact person. The Adviser can work with family members to help them to understand the implications of their child’s hearing loss, and to assist them as they consider the options available to them. They can also work with other professionals to make sure children receive all the services they are entitled to. Advisers can also provide assessments or information about child development and behaviour (Deaf Education Aotearoa New Zealand, 2005).
Asian (Children)

- In the New Zealand context, within the broad category of “Asian”, there are many individual ethnic groups with distinct characteristics. In the 2001 Census the largest was the Chinese ethnic group accounting for 44% of the Asian population, followed by the Indian ethnic group at 26%, Korean (8%), Filipino (5%), Japanese (4%), Sri Lankan (3%), Cambodian (2%), and Thai (2%) (Statistics New Zealand, 2001a).

Improving Classroom Acoustics Pilot Project (1994)

- The Improving Classroom Acoustics (ICA) pilot project (Rosenberg, Blake-Rahter, Allen, & Redmond, 1994) compared the effects on student behaviour, listening skills, and academic achievement in four Florida school districts. This study consisted of 855 kindergarten to second grade students in sound field distribution (N = 430) and control classrooms. Significant positive differences were noted after 6 weeks of sound field distribution intervention, with kindergarten (year one) students achieving the greatest gains over the 12 week observation.

Learning Outcomes

- The knowledge, skills, attitudes, and values a student has achieved as a result of an educational programme-learning, teaching, and other forms of intervention (Ministry of Education, 2006b).

Listening

- Understanding speech and environmental sounds by attending to
auditory clues; detection, discrimination, recognition, identification, and comprehension of speech and environmental sounds (Flexer, 1999).

**Literacy**

- Individual’s ability to read, write, speak in English, compute and solve problems at levels of proficiency necessary to function on the job, in the family of the individual, and in society (Workforce Investment Act of 1998, 1998).

**Māori**

- A term describing the indigenous or native people of New Zealand and their native language (Reed Dictionary of Modern Māori, 1995).

**Mainstream Amplification Resource Room Study (MARRS Project)**

- (MARRS Project), conducted in Illinois from 1977-1980 (Ray, 1988; Ray, Sarff, & Glassford, 1984; Sarff, 1981). This investigation was primarily intended as a means of helping students with mild or fluctuating hearing losses compensate for poor classroom acoustics, enabling them to remain in the mainstream without expensive referral and identification procedures. The project made comparisons of students in grades four to six who received instruction under different amplification conditions. Groups of students were examined for minimal-to-mild hearing loss, co-existing learning deficits, and normal learning potential. The researchers found that 30% of mainstream students and up to 75% of students with special education needs have educationally significant hearing loss and failed a 15 dB “low-
fence” hearing screen. Target students were divided into three instructional groups: (1) typical classroom setting, (2) combination of regular classroom instruction with additional withdrawal instruction in a resource room, and (3) regular mainstream instruction making use of a sound field distribution system.

**Middle Ear Dysfunction**

- A physical or structural problem that keeps the middle ear from working correctly. The most common dysfunction seen in children is an improperly working eustachian tube which may result in otitis media (OM) or otitis media with effusion (OME) (St Jude Children’s Research Hospital, 2003).

**Minimal/Slight/Mild Hearing Loss**

- A minimal/slight to mild hearing loss ranges from 16-40 dB (Martin & Clark, 2002). In an educational setting such a hearing loss is characterised by students having difficulty hearing faint or distant speech, hearing subtle conversational cues, tracking fast paced conversations, and hearing word-sound distinctions.

**Pacific Island (Children)**

- Pacific Islanders are the New Zealanders who identify with or feel they belong to one or more Pacific ethnic minorities. In the New Zealand context the seven largest ethnicities among Pacific peoples are Cook Island Māori, Fijian, Niuean, Samoan, Tokelauan, Tongan and Tuvaluan peoples (Statistics New Zealand, 2001a).
**Pakeha**
- The Māori word, for non-Māori, European, or Caucasian people (Reed Dictionary of Modern Māori, 1995).

**Pasifika**
- Pasifika is a commonly accepted umbrella term, used in New Zealand, to identify Pacific people.

**Project MARCS**
- Project MARCS was a three-year longitudinal study in Ohio (Flexer, 1989; Flexer, Richards, & Buie, 1993; Osborn, Vonder-Embese, & Graves, 1989). The investigation targeted regular mainstream lower elementary students—K-3 (equivalent to New Zealand years 1-4) with teachers using lapel microphones in 17 un-amplified and 17 two-speaker sound field distribution treatment rooms. The Iowa Tests of Basic Skills, American standardized tests, were administered to measure achievement levels in the cohort being studied. The unpublished results, although reported in other literature, have shown a general trend for the younger students in the treatment group to make greater achievement gains over the control group. It has not been possible to verify the level of statistical significance of this. Higher achievement levels were recorded for the areas of listening and language in the kindergarten and grade one treatment group, vocabulary in grade one students, mathematics concepts in the grades two and three children, and mathematics computation in the grade three students.
**Phonologic and Phonemic Awareness**

- The ability to hear and manipulate the sounds in spoken words and the understanding that spoken words and syllables are made up of sequences of speech sounds which can be represented alphabetically (Yopp, 1992).

**Progressive Achievement Tests**

- New Zealand standardised tests designed to assess the skills and abilities of students (New Zealand Council for Educational Research, 1993).

**Rotorua Energy Charitable Trust**

- The Trust was established in 1994. It was created so that some of the funds born out of the privatisation of the Rotorua Electricity Company could be retained and used for the benefit of the community in Rotorua and surrounding districts. The Trust's original capital of $32 million has grown to more than $134 million in 2006, with more than $57 million having been invested back into the local community. The Trust is governed by a six member Board of Trustees, who are elected every three years by those people who are eligible to vote and reside in the Rotorua District (Rotorua Energy Charitable Trust, 2006).

**School Decile Rating**

- A scale used by the New Zealand Ministry of Education to classify schools based on socio-economic factors, and is then used for resource purposes (Ministry of Education, 2004).
Sound Field

- A space where sound is propagated (Flexer, 1999).

Sound Field Distribution

- Using frequency modulation (FM) microphone technology along with a receiver/amplifier and a speaker system to achieve mild amplification and an even distribution of sound throughout a room (Phonic Ear, 2002).

Whakarongo Mai

- The title of a report to the Minister of Māori Affairs in 1989, which discussed hearing impairment amongst Māori people (Ministry of Māori Affairs, 1989).

Whānau

- The Māori word for both nuclear and extended family (Reed Dictionary of Modern Māori, 1995). In New Zealand it is also commonly used to describe groupings across age levels, as in composite age classes (Ministry of Education, 2001).

Organisation of the Thesis

This thesis is presented in six chapters. The current introductory chapter provides the background to the research and identifies the key aspects under investigation.
Chapter Two presents a review of the literature. This chapter includes studies relating to the rationale for sound field distribution; studies in general classroom populations; studies in specific populations, schooling, and demographics of students with hearing impairments in New Zealand; and the effects of sound field distribution systems on teachers.

Chapter Three follows with the method and design of the project. Included in this is a description of the intervention, of the cohorts being measured, and of the measurement tools used.

Chapter Four provides results of the effectiveness of this intervention which was measured both quantitatively and qualitatively.

Chapter Five presents a discussion on the use of this intervention. This chapter integrates the results of the research into the New Zealand educational context with particular emphasis on literacy and improving achievement levels to remove disparity amongst students.

Chapter Six comprises a summary of the results, presented together with limitations of the study, implications of the research findings, and suggestions for further research. And finally, conclusions are made on the efficacy of this intervention from the evidence presented in this thesis.
A comprehensive list of references used and appendices related to the research methodology and design complete this thesis.
Chapter 2

Review of the Literature on Classroom Sound Fields

Introduction

This literature review focuses on five areas: (a) studies relating to the justification of classroom sound field distribution; (b) studies in general classroom populations; (c) studies in specific populations; (d) schooling and demographics of students who have hearing impairments in New Zealand; and (e) the effects of using sound field distribution systems on teachers.

The present review is limited to investigations of children in the primary school sector who are not users of personal FM systems. Robust research supports personal FM systems for students who are hearing impaired and while they benefit from classroom sound field distribution, the degree of their hearing loss and additional assistive listening equipment are confounding variables.

Justification for use of Classroom Sound Field Systems

The premise for using sound field distribution systems in classrooms is based on enhancing acoustic conditions which are important factors in the psycho-educational and psychosocial achievement of children (Crandell & Smaldino, 1996). Three considerations are central to the present review (1)
acknowledgement of hearing and listening as a basis for learning, (2) distance hearing and incidental learning, and (3) listening-impeding classroom acoustics and school architecture.

Following is a review of studies providing a justification of using sound field distribution which relate to these three considerations or features.

**Hearing and Listening as the Basis for Achievement**

While an individual student’s preferred learning style may be visual, auditory, tactile/kinesthetic, or a mixture of these learning styles and up to 80% of learning may be through the eyes (M. Steer, personal communication, December, 2004), New Zealand junior school classrooms are essentially auditory-verbal learning environments as children rely on understanding the verbal instruction of teachers through listening, until they develop good reading skills, typically by year five (Matkin, 1996). Flexer (1999) has suggested that the auditory neurological foundations for language, reading, and learning are critical to expanding children’s opportunities: “Even a slight hearing impairment can interrupt a child’s language-learning process and interfere with his or her development” (p. 3). Flexer also stated that “human beings are neurologically wired to develop spoken language and reading skills through the central auditory system” (p. 7). Hearing, then, is a first-order event for classroom learning (Crandell et al., 1995). The underlying assumption is that children can hear and pay attention to a teacher’s speech. If they cannot hear consistently and clearly,
their acquisition of language and the development of literacy is compromised. Children and young people who are hearing impaired range from those with minor-temporary hearing losses due to common colds through to students who severe and profound losses who use personal assistive listening equipment in the form of hearing aids or cochlear implants. Children are usually categorized as being hearing, hearing impaired, or deaf. Hearing children typically develop spoken language through audition. With an increasing vocabulary at ages three, four, and five, children typically begin to master the rules of their oral language. Children who are hearing impaired are referred to in some parts of the world as hard-of-hearing. These children typically develop a spoken language for communication. Their success is often reflective of the quality of audiological and academic support they received. Generally they will make use of hearing aids and personal amplification systems to maximise any residual hearing they have. They may also benefit from the support of specialist teachers trained to work with them and their mainstream teachers. Students who are deaf are those with very significant hearing impairments who may not receive much benefit from even the best acoustic amplification devices or who use a visual-manual language as their preferred means of communication. When these students identify with a Deaf community with its own culture, they are commonly identified as being part of that group by use of the capital “D”. Anecdotally, teacher made adaptations to their own instructional methods in order to provide these students with better access to class instruction are rare. Indeed this situation has been similarly
described by others (Ling, 1988; Panckhurst, Panckhurst, & Elkins, 1987). Many children classified as normally hearing may, at times, have a fluctuating functional hearing impairment from either the common cold or otitis media. These conditions affect the child’s ability to hear and understand spoken language.

Flexer (1997) has highlighted the distinction between hearing or audibility of spoken language and that of understanding or intelligibility. She described audibility as being able to detect the presence of speech but not its individual components and intelligibility as the ability to discriminate individual phonemes and to hear word/sound distinctions.

The importance of hearing in the communicative and educational process tends to be underestimated because hearing loss is invisible. In addition to a reduction in volume, sounds are often smeared together or filtered out entirely. Speech might be audible but not intelligible. (Flexer, p. 135)

Children and young people may not know that they are operating with an invisible handicap. Their teachers may also be unaware of their invisible handicap, unless they are tuned into indicators such as the child being inattentive, using a louder than normal voice, appearing shy, dreamy, or withdrawn.

**Incidental Learning**

Initially children learn spoken language from direct and intentional
exposure to the auditory-verbal message (Owens, 1996). As they develop competency in the language, children incidentally learn many skills and concepts passively, by overhearing what people say from a distance (Ling, 1988). Flexer (1997) has stated that a child with even a minimal hearing loss cannot casually overhear what people say because of the reduction of distance hearing. This is the distance over which speech sounds are not merely audible, but intelligible. Flexer also claimed that implications of reduction in distance hearing included the inability to monitor environmental events and to “overhear” conversations, a reduced access to the redundancy of instructional messages, and a lack of access to social cues. These are important because they support meaningful communication and normal language and literacy development. In foreshadowing the next section, the ability to listen over distance within a classroom environment may be compromised by poor acoustic conditions. Prior to the adoption by the Ministry of Education (2003a) of a New Zealand and Australian Standard (AS/NZS 2107:2000) for renovated or new teaching areas, the effects of classroom acoustics on the learning by children and young people had largely been ignored (Oticon Foundation in New Zealand, 2002).

**Classroom Acoustics and School Architecture**

Classroom acoustics impact on children’s learning. The signal-to-noise (S/N) ratio, sometimes called the speech-to-competition ratio, gives the difference between the signal level measured in decibels (dB) and the noise level also measured in dB (McCracken & Laoide-Kemp, 1997). A teacher’s
voice needs to be at a sufficient positive level above the noise level for children to hear the teacher. Noisy classrooms can provide a negative S/N ratio, where the noise is louder than the teachers’ voices. Another measure of classroom acoustics, reverberation time, is a measure of the time for reflected sounds to decay. Reverberation times are affected by such features as classroom design, materials used, and furniture within the classroom.

Poor acoustic design in schools exacerbates the problems of noise in modern classrooms and increases the difficulty children and young people have in understanding their teacher. Classroom building design and construction varies in New Zealand with subsequent effects on classroom acoustics (Valentine et al., 2001). At the time of this study, the Ministry of Education’s Health and Safety Code of Practice for State Schools (1993), updated in (1995), outlined requirements for lighting, heat, ventilation, and egress but did not include acoustic standards for all classrooms (Ministry of Education, 1993 & 1995).

A mixture of permanent and re-locatable or “prefab” classrooms is common in New Zealand. Permanent classrooms are typically built with a mixture of metal and timber framing with brick external walls and having a concrete base. The re-locatable rooms are constructed using lightweight timber framing and are usually elevated well above the ground on supports. They are designed to be moved to another school when the demographics
of the school age population changes in a particular area. This design increases the negative effects of reverberation (Wilson, 2000). Both building designs generally include iron roofing materials with no internal acoustic tiling. The effect on these materials, from living in an island country with a sub-tropical climate, particularly rainfall, frequently results in the partial and sometimes complete masking of a teacher’s voice by the noise of rain on the roof. In an earlier study, Coddington (1980) documented the acoustics in New Zealand classrooms using a limited sample in Auckland. Coddington reported the S/N ratio as low as +1 dB and not higher than +8 dB. Reverberation times were generally around 1.0 second at low frequencies and 0.4 seconds at high frequencies. Coddington also stated that the ideal S/N ratio for children with impaired hearing should be +10 dB and with reverberation times less that 0.5 seconds. With regard to this New Zealand study, Crandell et al. (1995) in America were more conservative and suggested that noise levels for normal hearing children should be the same as those recommended for students who are hearing impaired with S/N ratios surpassing +15 dB and reverberation times not exceeding 0.4 seconds. Blake and Busby (1994) observed the acoustic conditions present in Wellington classrooms. The median S/N ratio was +6 dB. Their study showed that 4% of junior classrooms were quiet enough for children with normal hearing, sitting three meters from the teacher, to hear clearly.

Several developments in classroom sound field distribution technology have been derived from experience with the personal systems of hearing
aid users. Teachers and children who are deaf or hearing impaired have used personal frequency modulation (FM) systems for decades to improve the signal reaching the child’s hearing aid. Matkin (1996) stated that, “in the late 1950s there was a move away from stationary hardwired systems” (p. 311). Matkin also reported the increasingly popularity of these wireless FM systems in the late 1960s. These systems became smaller with advancements in technology and involved a teacher wearing a microphone attached to a portable transmitter and the students attaching portable receivers to their hearing aids. McCracken and Laoide-Kemp (1997) stated that FM systems “have provided the most effective technological support in the integration of hearing-impaired children into mainstream schools” (p. 175). Thus, FM systems are used to help children who are hearing impaired discriminate speech by overcoming poor classroom acoustics, particularly difficulties associated with noise, distance, and reverberation.

In the 1970s, a time in New Zealand when the methods of delivering instruction to students were becoming less formal, the impact and problems associated with noise, distance, and reverberation were not generally well understood. It was at this time that FM technology was being adapted for use in general classrooms in the United States of America. Initially this technology involved the teacher’s use of a lapel microphone attached to a portable transmitter and to having a receiver and at least two speakers placed strategically in the classroom. These systems worked in a manner similar to a public address system in an attempt to overcome poor
classroom acoustic conditions. Bess, Gravel, and Tharpe (1996) reported that it is uncommon for acceptable acoustic conditions to exist in typical American educational settings, which is similar to the findings previously reported in New Zealand.

Sound field distribution systems using two or more speakers have been used in educational settings to overcome problems associated with noise, distance, and reverberation. There are, however, no studies exclusively using the boom microphone, four-speaker paradigm as was selected in the current research. It is the researcher’s hypothesis after reviewing New Zealand-available equipment that the four speaker configuration would likely provide a more even distribution of sound throughout the classroom than the two speaker systems, and that the boom microphone would provide a consistent and higher quality of speech input than the lapel or neck microphones. The S/N ratio with a boom microphone should be enhanced significantly because the microphone is strategically placed centimetres from the mouth. (Comparison of specifications on this equipment will follow in Chapter 3.)

The following section presents a review of the literature of studies where the researchers conducted studies using sound field distribution systems that used at least two speakers and lapel or neck loop microphones.
Sound Field Systems in General Classroom Populations

The impact of classroom sound field distribution on aspects of listening, literacy, numeracy, and basic skills have, over the past two decades, been shown to improve outcomes for students (Arnold & Canning, 1999; Crandell, 1994; Crandell & Bess, 1986; Flexer, 1989, 1997; Gilman & Danzer, 1989; Matkin, 1996; Osborn et al., 1989; Ray et al., 1984; Rosenberg et al., 1994; Sarff, 1981; Schermer, 1991; Zabel & Tabor, 1993). The Mainstream Amplification Regular Classroom Study (Project MARCS) in 1989 and the Improving Classroom Acoustics pilot project in 1994 are significant benchmark studies using sound field distribution with two and then four speaker configurations and both with lapel or neck microphones. Following is a review of these studies.

Project MARCS was a three-year longitudinal study in Ohio (Flexer, 1989; 1993; Osborn et al., 1989). The investigation in nine rural schools in Ohio targeted regular mainstream lower elementary students—K-3 (equivalent to New Zealand years 1-4) with teachers using lapel microphones in 17 un-amplified and 17 two-speaker sound field distribution treatment rooms. The study investigated using sound field amplification for improving the quality and consistency of oral instruction for this cohort. The Iowa Tests of Basic Skills are American standardized tests and were administered to measure achievement levels for these cohorts. Crandell et al. (1995) reported higher achievement levels for students in the sound field rooms than in the control group in listening and language for kindergarten
and grade one students in the first year, word analysis for kindergarten and grade one students in their second year, vocabulary for grade one students in their first year, and mathematics for grades one through three students. A general trend reported was for the younger students in the treatment group to make greater achievement gains over the control group. Project MARCS included classroom observations as part of its research design. Observations recorded more teacher mobility with increased numbers of students participating and better transitions between classroom activities. A limitation of this study may be in its informal qualitative data collection from teachers. The evaluation recorded positive benefits including more consistent student attending skills, reduction in teacher vocal strain, and increased versatility in instructional techniques. The following study was of much shorter duration and also recorded positive benefits to the younger children.

The Improving Classroom Acoustics (ICA) pilot project (Rosenberg et al., 1994) compared the effects of sound field amplification on student behaviour, listening skills, and academic achievement in four Florida school districts. The project involved 2,054 kindergarten-to-grade two students in 33 schools. Sixty-four classrooms were amplified with Phonic Ear Easy Listener systems and a further 30 classrooms served as control (unamplified) classrooms. This study consisted of 855 kindergarten to second grade students in sound field distribution (N = 430) and control classrooms (N = 425). Measurements were made when sound field
distribution equipment was installed and 6 and 12 weeks later. This study used both lapel and boom microphones and a four-speaker configuration for distributing sound. Teachers were offered choice on microphone style with 77% choosing boom microphones and 23% choosing lapel microphones. Significant positive differences were noted after 6 weeks of sound field distribution intervention, with kindergarten (year one) students achieving the greatest gains over the 12 week observation. Students demonstrated significant improvement in listening and learning behaviours and skills, and progressed at a faster rate than their peers in the unamplified control rooms. Other smaller American studies on the benefits of using classroom sound field distribution have focused on listening related behaviour and learning.

Smaller populations were used for these other studies. Crandell and Bess (1986) sampled 20 students in sound field amplified conditions and found the students’ ability to recognise sentences improved significantly. Gilman and Danzer’s (1989) study included pre-and post-assessments on behavioural characteristics of sound field amplification on second and fourth grade students. The students in amplified settings displayed increased attentiveness to verbal instruction and ability to hear and follow instructions. This study was based on a population of nine treatment and nine control classrooms. Zabel and Tabor’s (1993) study investigated if sound field amplification in classrooms improved the spelling performance of upper elementary students. A cohort of 145 third, fourth, and fifth grade students in a small Midwestern elementary school were administered tape recorded
spelling tests that were balanced for difficulty. One test condition was presented in a sound field amplified classroom of +12 dB signal-to-noise ratio while the other was in a classroom with a signal-to-noise ratio of 0 dB. Statistically significant improvement was achieved by all students in the sound field amplified classroom. The Iowa Spelling Scale spelling lists used may be a limitation of this study. Lists were selected form the final seven spelling lists for each grade level and so had not yet been taught. They were balanced first for length of word and degree of difficulty and then for number of phonemes “s, f, and th”. The first two criteria were the most critical in creating the lists. With the limited set of spelling words to choose from, an attempt was made to balance the number of low intensity, high frequency phonemes (“s, f, th”). Other phoneme characteristics such as positioning within a word were unable to be matched in both lists. While all the smaller studies were of relatively short duration and positive effects over time were not measured, they all reported similar findings from the two major studies which suggest classroom sound field distribution can enhance the learning of students in mainstream settings.

New Zealand has followed a trend noted in many countries where, following Government legislation (New Zealand Legislation, Education Act, 1989a), children and young people with specific learning needs are increasingly educated within mainstream classrooms. The inclusion policies of recent governments have generated funding for some specific populations, in particular those with special education high or very high
needs, but as yet have not targeted specific funding for acoustic modifications of mainstream classrooms to improve learning outcomes. To follow is a review of studies of benefits of using sound field distribution with specific populations, many of whom as has been reported in the New Zealand context, are educated in mainstream classrooms.

**Sound Field Systems in Specific Populations**

Studies into the efficacy of using sound field distribution in mainstream classes have highlighted the numbers of students in mainstream classes with mild, minimal, or fluctuating hearing loss resulting from middle ear dysfunction (Blair, Myrup, & Viehweg, 1989; Flexer et al., 1993; Neuss, Blair, & Viehweg, 1991; Ray, 1992; Sarff, 1981). New Zealand has been reported as having higher rates of mild hearing losses than either the United Kingdom or Australia (Ministry of Health, 2006). There have, over the years, been a number of important studies relative to classroom sound field distribution in specific populations.

A benchmark three-year longitudinal study on the use of sound field distribution in the United States was the Mainstream Amplification Resource Room Study (MARRS Project), conducted in Illinois from 1977-1980 (Ray et al., 1984; Sarff, 1981). A two-speaker, lapel microphone configuration was used in this study and students in the sound field group received instruction though the system for an average of three hours per day. This investigation was primarily intended as a means of helping students with mild or
fluctuating hearing losses compensate for poor classroom acoustics, enabling them to remain in the mainstream without expensive referral and identification procedures. The project made comparisons of students in grades four to six who received instruction under different amplification conditions. Groups of students were examined for minimal-to-mild hearing loss, co-existing learning deficits, and normal learning potential. The researchers found that 30% of mainstream students and up to 75% of students with special education needs have educationally significant hearing loss and failed a 15 dB “low-fence” hearing screen. Target students were divided into three instructional groups: (1) typical classroom setting, (2) combination of regular classroom instruction with additional withdrawal instruction in a resource room, and (3) regular mainstream instruction making use of a sound field distribution system. Scientific Research Associates Achievement Series test data were used to measure improvements. Both treatment and non-treatment groups demonstrated improvements with the greatest achievements being made by students in the treatment group. Significant improvement (> .05 level) in academic achievement test scores were recorded by students with minimal hearing loss in the sound field distribution rooms, without the stigmatizing labeling and expense of withdrawal instruction. These improvements were achieved to a higher level and at a faster rate than the gains typically made by those students requiring special help in a typical resource room. Significant increases in scores of students in the typical resource room were not observed. The increases in test scores for the students in the sound field
rooms in the same time interval were significant, increasing by 33% or over
one standard deviation. Ray (1992) along with other researchers to follow
have also found positive benefits to literacy development when using sound
field distribution with specific populations.

The benefits of using sound field distribution to raise the literacy
related functions of students with mild hearing loss (most commonly
associated with middle ear dysfunction), students with specific learning
disabilities, and other specific populations were targeted in the early 1990s
(Benafield, 1990; Flexer, Millin, & Brown, 1990; Flexer et al., 1993; Neuss et
al., 1991; Ray, 1992). With the exception of Ray’s (1992) validation of the
MARRS project, smaller cohorts have been targeted for shorter duration
studies. The collective results following this treatment supported sound field
distribution use to produce higher achievements in listening, word
recognition, and reading. Of particular relevance were the positive changes
in attending behaviours and on-task behaviour of students in sound field
sampled a population of 20 native English speaking children and 20 non-
native English children under classroom conditions and measured their
speech recognition. Speech recognition for both groups in quiet
environments was equivalent. The non-native English speakers, however,
performed significantly poorer as the listening environment deteriorated.
Learners with the invisible handicap of mild fluctuating hearing impairment
also have a deteriorated listening ability in poor acoustic environments.
The terms minimal, slight, or mild hearing loss are frequently highlighted in much of the literature. Flexer (1996) defines these as thresholds from 16 to 25 dB hearing loss. Flexer states that these terms imply “without consequence-insignificant” (p. 321), because they are the least measurable of hearing losses. Their effects on learning indicate that they are educationally significant as they impact, “on hearing faint or distant speech, hearing subtle conversation cues, tracking fast paced communicative interactions, and hearing word-sound distinctions that form morphological markers for plurality, tense and possessives” (Flexer, p. 322). Flexer has also suggested that children with these hearing losses may appear immature or more fatigued due to the increased effort to listen and hear. These factors are also commonly experienced by students with greater hearing losses who use hearing aids.

The high incidence of educationally significant hearing loss, particularly among Māori and Pacific Island cohorts is noted in New Zealand (National Audiology Centre, 2000; Whakarongo Mai, 1989). Perhaps because of its often-fluctuating nature, the minimal (15-25 dB HL), using accepted New Zealand audiologist’s classifications, and to a lesser degree the mild (26-40 dB HL) educationally significant hearing loss, infrequently receive appropriate intervention. In 2001 there were “an estimated 18,300 children who were deaf or had a hearing limitation that was not corrected” (Statistics New Zealand, 2001b, p. 1). In this New Zealand Disability Survey
Snapshot 6 it was reported that hearing aids or other listening devices were used by 9% of these children. Children who are deaf or hearing impaired in New Zealand are provided, at government cost, personal assistive devices in the form of hearing aids and personal FM systems to maximise their auditory input in mainstream settings. As the majority of the estimated group reported by Statistics New Zealand does not receive any amplification, it is assumed that they either have a unilateral hearing loss which is usually unaided, are profoundly deaf and have little residual hearing left to aid, or belong to the group of children in the minimal to mild classification. National statistics do not routinely record data on the largest group, those with a hearing loss of up to 26 dB HL. The database statistics are recorded annually for children with a hearing loss greater than 26 dB HL that may benefit from personal amplification systems or hearing aids.

The 2001 Census population statistics for children aged 19 and under showed percentages of European/Pakeha, Māori, Asian, and Pacific Island peoples to be 64.1%, 19.5%, 6.7%, and 8.9% respectively. Māori and Pacific Island children are over represented in the notifications. Figure 1 to follow includes raw data illustrating the degree of newly diagnosed hearing loss (N = 144) in 2003 recorded for major ethnic groups in New Zealand (National Audiology Centre, 2004).
The incidence of minimal and mild hearing losses in New Zealand are acknowledged by health care professionals and audiologists from their observations as being disproportionate amongst the indigenous Māori population. While medical intervention is common for children and young people with minimal hearing loss, audiological intervention is rare—indeed as Greville reported only 9% ever received technological support (Greville, 2005). Otitis media (OM) and otitis media with effusion (OME) are the primary causes of hearing loss in children with most of it in the minimal or slight to mild classification (Flexer, 1996; Bess, Gravel, & Tharpe, 1996). Studies of Aboriginal and Torres Strait Islander children in Australia have found OM and OME to be highly prevalent (McPherson, 1990; Foreman, 1995). Socio-economic factors are a controversial issue when discussing...
groups at risk. Socio-economic and environmental factors may not be direct causal aspects but they may contribute to explaining the prevalence of OM, and OME in certain communities. The following study reports on one Australian community with a recorded high incidence of OM and OME (Thorne, 2004).

Walker (2001) investigated the difference in phonological awareness skills, and reading and spelling skills of Aboriginal children with and without OME. Her small study supported the suggestion that OME and associated hearing loss may have deleterious effects on children’s academic performance. Unfortunately, it was not possible to determine this position significantly.

**Schooling for Deaf Students in New Zealand**

The personnel at the University of Manchester influenced deaf education in New Zealand in the 1950’s as the first lecturer in Deaf Education in New Zealand, at The Christchurch College of Education, was Betty Woods who had received her training from that university. Large numbers of children and young people attended New Zealand’s two residential schools for the deaf during the 1960’s when a group deafened from a rubella epidemic progressed through the educational system. These schools were aware of the benefits and need to enhance the classrooms acoustically and following recommendations from research projects at the University of Manchester, classrooms were built to superior acoustic
specifications at that time (John & Thomas, 1957). There are still two residential schools, now known as Deaf Education Centres, which accommodate approximately 40 residential students. Presently, a group of 85 children and young people are educated at these Centers. The northern site, Kelston Deaf Education Centre at Auckland is made up of junior children (N = 28) developing either spoken English or New Zealand Sign Language in order to access the national curriculum, or young people (N = 21) who have completed their high school years and are transitioning into a workforce. The 36 students in the southern site, Van Ash Deaf Education Centre in Christchurch, are either in junior classes or within the majority group identified as being from year 7 through to high school years. Students educated in mainstream settings form the larger group of deaf students and these receive itinerant resource teacher of the deaf support from the two Deaf Education Centres. Most of these mainstream environments have similar poor acoustic conditions to those previously reported (Oticon Foundation in New Zealand, 2002).

Figure 2 to follow presents a breakdown of children and young people with mild and greater hearing losses in 2002-2003 as reported by the National Audiology Centre (2004). Not included is the larger cohort, those with fluctuating or minimal hearing loss categorised as being between 16-26 dB HL, which from the 2001 snapshot data is suggested to be approximately 16,500 children and young people (Department of Statistics, 2001).
Currently the majority of children, who are deaf or hearing impaired, continue as has been previously reported, to attend local mainstream schools. Communication approaches used in deaf education over the centuries reveal swings of the pendulum with oralism gaining favour at certain times and pure signing gaining prominence at other times. From the time New Zealand established the first government funded residential school for deaf children in the world at Sumner, in Christchurch, in 1880, these changes in philosophy have been a feature of deaf education in New Zealand (DEANZ, 2002).

For most of the 20th century, the Western world was dominated by the oral approach which followed from the “Viva la Parola” resolution passed at the second international congress on deaf education held in Milan in 1880.
(Moores, 1996). The popularity of oralism was reinforced by the emergence of the new science of audiology and the technological developments in measurement and aiding of hearing (DEANZ, 2002). It was optimistically believed that through the use of specialist techniques and equipment and more individual attention, deaf children would be afforded the same educational opportunity and the same broad curriculum as was available to school children everywhere.

The Babbidge Committee in the United States in the 1960s (Babbidge, 1965), and the Lewis Committee in the United Kingdom produced reports which questioned the continued use of oral-only approaches in the light of the poor educational attainment of deaf children (McLoughlin, 1987). New Zealand responded to the re-examination of the oral-only approach by introducing Total Communication in 1979 in the belief, as had been suggested in the United States, that this would improve communication and accelerate verbal language development of deaf children (McCay, 1972). During the 1980s it was increasingly acknowledged that many Deaf people were completing their schooling with substantially lower level of achievement compared to their hearing peers (Power & Leigh, 2000).
An introduction of bilingual/bicultural programmes was subsequently made and New Zealand Sign Language (NZSL) was recognized as a community language in 1992. In 2004 a bill recognising NZSL as the third official language of New Zealand was introduced to Parliament and ultimately became legislation in 2006 (New Zealand Legislation: NZSL Act 2006).

While there was a move away from an oral-only approach to the education of deaf children in the 1970s, oral approaches continued with spoken English being the principal language for deaf students to access the curriculum, particularly in mainstream settings. A central principle of the modern oral approach is that maximum use must be made of the deaf child’s residual hearing (Ling, 1988). In recent years there have been marked technological advances in personal hearing aids. They have become more powerful over a wider range of speech frequencies and improved developments in ear mould technology no longer limit the performance of high-powered hearing aids (McCracken & Laoide-Kemp, 1997). In addition, the improved performance of personal FM systems has been particularly useful in mainstream settings. The development of the cochlear implant represents yet another significant technological advance. The effectiveness of these devices is enhanced when their learning environment is acoustically superior (McCracken & Laoide-Kemp, 1997).
A sound field distribution system is an acoustical environmental adaptation to enhance the classroom and studies of the effects of this intervention on children have been reviewed. Following are studies that review the effect on the other classroom participants: the teachers who use the intervention.

**Effects on Teacher Health of Using Sound Field Systems**

As reported earlier many effects of sound field distribution to enhance learning outcomes of students have been studied. Teachers naturally work in these amplified setting and a few studies have examined the effects on this group (Crandell et al., 1995; Flexer, 1989; Gilman & Danzer, 1989; Pekkarinen & Viljanen, 1991).

In non-amplified classrooms, Pekkarinen and Viljanen (1991) found that in order to maintain an acceptable S/N ratio in classrooms with a high background noise, teachers increased their vocal effort. Gilman and Danzer (1989) observed reduced teacher voice fatigue in the nine classrooms where sound field distribution systems were studied. Similar observations were made in the ICA project where teachers enjoyed using the equipment and identified decreased vocal strain as being their primary benefit. Other, less frequently mentioned benefits were being less physically tired following use (Eriks-Brophy & Ayukawa, 2000), being able to hear own voice more clearly (Lederman & Hendricks, 2000), and increased teaching efficiency by providing more teaching time, resulting from fewer repetitions (Flexer, 1997).
Conclusions

The literature has highlighted several salient points concerning the effects of classroom sound field distribution. First, limited research is available in the New Zealand context with its unique population, teaching strategies, and acoustic learning environment. Second, research on the effects on specific groups with disproportionately high educationally significant hearing loss, and particular socio-economic groupings and indigenous populations is minimal. Finally, effects on teachers using these systems in their classrooms are supported by anecdotal and qualitative data however there is a lack of quantitative data in the literature.

In conclusion, the benefits of using sound field distribution in an educational setting centre are discussed from the perspective of removing barriers to learning. Sound distribution systems are not a panacea for the diverse problems in modern education, but they can help overcome problems associated with noise, distance, and reverberation.
Chapter 3

Method and Design

Introduction

This chapter presents the method and design used in conducting the present research. Information in this chapter has been presented in the following sections: (a) Participants, Students, and Teachers, (b) Equipment, (c) Schools and Settings, (d) Instrumentation and Procedure, (e) Ethical Considerations, and (f) Data analysis.

The purposes of this study were to investigate:

(1) The effects on students' listening, reading, and mathematical achievement when learning in a sound field amplified classroom.

(2) The extent to which listening achievement results varied from the general population for the following specific populations:
   a. Children and young people who had previously been treated for otitis media or otitis media with effusion,
   b. Indigenous children and young people,
   c. Learners from five different socio-economic backgrounds.
(3) The extent this intervention effected teacher absenteeism and health.

Major components of the research design as a means to achieve the purposes of the study are presented in Figure 3.

Figure 3. Flow-chart of major research design components.
Participants

Children and young people in year one-to-six schools in the south western area of Rotorua were invited to participate in the study. The letter of invitation in the form of an Information Letter and Consent Form for Parents may be found in Appendix A. This city was selected as it is typical of many provincial New Zealand cities in terms of socioeconomic status and ethnic groups (Statistics New Zealand, 2001a). Participating schools, which will be discussed further later in this chapter, were selected as being representative of five different decile or socioeconomic ratings (Wylie & Baker, 2002). The students are typical of other children and young people in many New Zealand cities (ERO, 2001).

The principals of each participating school made decisions on which classes to include in this study based on the following factors; (a) student and school demographics, (b) willingness of teachers to participate, and (c) on the acoustics of classrooms. While not “random assignment to treatment” as classically described in textbooks on research methods neither was it likely that the principals where specifically thinking about selection from the perspective of trying to influence the results of the research in a particular direction. Six classrooms in each of the five different schools were identified by the school principals to have sound field distribution equipment installed. These classrooms are referred to as intervention classrooms in this study, those not having sound field systems are referred to as control classes. Thus two groups of students were
observed, a group targeted with the sound field distribution intervention which accounted for 70% of the population (N = 438) of the five schools and the control group which accounted for 30% of the population (N = 188). In addition to the learners, the 30 intervention classroom teachers and control group teachers were invited to participate in the study. The letter of invitation in the form of an Information Letter and Consent Form for Teachers may be found in Appendix B.

**Students**

Invitations to participate in this study were distributed to all children and young people in the intervention classes (N = 650) and control classes (N = 260) through the letter of invitation and consent they delivered to their parents. The school roll numbers of participating schools ranged from 219 to 620 students and was a determining factor in deciding not to have matched groups. A greater number of intervention classes than control classes was part of the design of this study as the size of the control group was not considered to be a limiting factor. The response rates to the invitation to participate, was 67% for the intervention group and 72% for the control group. Ultimately, the children and young people and their parents who gave informed consent to participate in this study came to a total of 626. In a broad description they spanned the range of students found in typical New Zealand primary schools. New Zealand schools are classified as being primary schools with students from year 0 to year 6, intermediate schools for years 7 and 8, and high schools which include students from
year 9 to year 13. Students in the present study include those aged from 5 to approximately 10 years of age being in years 0 to 6 of formal schooling.

**Characteristics of Sex, Age, Grade, Ethnicity, History of Middle Ear Dysfunction, and Language**

Fifty two percent of the students were male (N = 328) and 48% female (N = 298). This gender ratio matches with the usually resident population count in the New Zealand 2001 Census, for children aged 5 to 9 years for the Rotorua district of Pomare. This district encompasses the majority of students participating in the study (Statistics New Zealand, 2001a).

An overview of the grade characteristics of the children who participated in the study can be seen in Figure 4 which illustrates that the majority of the students were in years two, three, or four (N = 457) with the smallest yearly cohorts being year one (N = 21) and year six (N = 34). Unfortunately no control group for year six was available.
Figure 4. Summary of student data by year of schooling for Intervention and Control groups.

Figure 5, to follow, shows that the majority of children and young people in the study (almost 60%) were New Zealanders of European decent. Over a third (35%) identified their heritage as Maori and 8% of the children were self-identified as Pacific Islander or Asian heritage. These proportions reflect the ethnic distribution of the area as reported in the 2001 Census.
Parents/caregivers were questioned on the individual children and young people’s ethnicity and history of middle ear dysfunction in the questionnaire accompanying the participation consent forms (Appendix A). These questions were included in this study as claims in the literature are of a disproportionately higher incidence of middle ear problems with New Zealand’s indigenous Māori ethnic group (Whakarongo Mai, 1989). The question relating to treated middle ear dysfunction was broad quoting examples as being otitis media with effusion, or “glue ear”. The Ministry of Health has targeted “glue ear” in much advertising and awareness throughout the nineties. It was believed that the general parent population would interpret this question in a similar manner and not interpret it as being
just ear infections, which are, after the common cold, the most prevalent condition affecting young children (Flexer, 1999).

The incidence of treated middle ear dysfunction as reported from the parent/caregiver responses to the questionnaire, varied with each ethnic group. While the combined incidence was reported at 32%, Pakeha reported this as 28%, Māori as 39%, and other ethnicities (Pacific Islander/Asian) had a lower rate of 25%.

English was the dominant spoken language. Two bilingual classes participating received instruction in Māori and English, with English being the dominant language for this group in both the home and playground.

Teachers

Demographics

Forty three teachers agreed to participate in the study. Thirty taught in the sound field amplified classrooms during the school day and 13 taught in the un-amplified control classrooms.

All 43 teachers were registered with the New Zealand Teachers’ Council as trained teachers. One was granted long term maternity leave, another health leave, and two others left their school during the 2002 academic year. Of the 43 original teachers, four were male and 39 were female. Three of the male teachers taught in the control setting and one in
the intervention group.

The overall average length of teaching service between the five schools varied by four years, with the typical teacher having taught for 10 years. The average length of teaching service in the control group was 10 years and in the intervention group the average was 11 years.

The ethnic ratio of the teachers did not reflect the same proportion as the students. Figure 6 shows that 82% of teachers were NZ European/Pakeha and 18% were Māori teachers.

Figure 6. Teachers by ethnicity.
**Equipment Selection**

Numerous brands of sound field equipment are now available internationally since the initial MAARS study in Illinois in 1979. Comparative studies on available systems in the USA were discussed by Crandell (1995) with teacher appraisal determining that of four brands, the Phonic Ear Easy Listener Freefield System was most cost-effective and maintenance–free while delivering high sound fidelity. In 1993 Crandell studied speech recognition abilities of 20 children and found Radio Shack and Lifeline systems had produced significantly higher speech recognition scores than Comtek OMNI 2001 or Phonic Ear systems. Consideration was given to repair and maintenance and so choice in the current study was limited to the three suppliers who import the equipment into New Zealand. The technical features of the sound field distribution systems of the three suppliers in New Zealand were analysed and compared to guide equipment selection. Other factors taken into consideration included: (a) price for a base unit; a quote for 400 units, being a recurring purchase of 133 units for 3 years; (b) warranty; (c) sound quality rating; (d) ease of use rating for transmitter; (e) microphone options; (f) ease of use rating for receiver; (g) overall flexibility rating/special team-teaching features; (h) compatibility with other hearing technology; (i) approved frequency/possible interference; (j) ease and cost of installation; (k) battery options; and (l) instructions for use/customer service.
Cost for Single or Multiple Units

The cost for a single base unit of each of the sound field systems was perhaps the easiest information to gather in this equipment selection process. The average price for a single unit of the systems from MSL, Phonic Ear, and Sitech was $1621. with an upper and lower price of the single unit price of \( \pm $122.00 \). This information, however, needed to be taken into account along with the requested price quotes from the manufacturers on either (a) a one-time quote on 400 units, or (b) a staggered quote of 133 units each year for three years as there was the potential for future developments.

The manufacturers provided quotes that reflected their individual policies. These policies included different flat-rate increases over the time period, variation in price if the order was staggered over three years or placed as one order, and variation in price for other than the models quoted. While there were variations in the three suppliers’ quotes, the information supplied, was still of significant interest. MSL, in quoting on 133 units a year (installed, freight included), identified a unit cost of \$xxxxxx plus GST in the first year; with a 5% increase in the identified total in the second and third years. Phonic Ear gave a quote between \$xxxxxxx and \$xxxxxxx plus GST (freight included) depending on the number ordered and the terms of payment. Sitech offered a multi-unit price of between \$xxxxxxx for the base unit and \$xxxxxxx plus GST for the flexible channel unit which the other suppliers were quoting on (freight of \$xxxx not included).
**Warranty**

The warranties provided by each manufacturer varied significantly on both their major components and on their accessories.

On the major components of the system MSL extended their cover from their normal period of 12 months to 24 months for this quote. The Phonic Ear warranty was for 36 months while the Sitech quote offered 12 months warranty.

The accessories used in each system included headphones and rechargeable batteries and charging units. MSL offered a 24 month warranty on accessories other than batteries. Phonic Ear offered a 12 month warranty on all component accessories while Sitech did not provide warranty information in their quote.

**Sound Quality Rating**

Three measures were applied to compare sound quality from each of the three suppliers: These were (a) the level the systems increased speech intelligibility over ambient noise levels; (b) ability to adjust amplified sound characteristics or tone (pitch and quality); and (c) the ability to adjust volume. One supplier provided partial responses to these questions,
another detailed specifications, and one was either unwilling or unable to provide any information.

The MSL and Sitech systems were reported to provide very good enhancement of speech levels of 10 dB over ambient noise levels. The Phonic Ear rating was considered excellent with a reported 10-12 dB gain over ambient noise levels. The Phonic Ear system also reported having an emphasis on high frequencies to deliver full, audible, clear, natural voice reproduction. Additionally Phonic Ear allowed adjustment between low/medium and high frequencies according to classroom acoustics and ambient noise: This feature Phonic Ear calls OptiVoice. Their system also had strong adjacent channel and inter-modulation rejection and a 12 band graphic equalizer. The strong adjacent channel/inter-modulation rejection provides a system which is less likely to experience FM interference between classrooms. The 12 band equalizer feature is beneficial because it allows the systems signal’s frequency response to be tuned to the room to give a perception of clearer speech.

**Ease of Use Rating for Transmitter**

The transmitter and microphone are the single most important physical features in gaining teacher compliance in use of the equipment (Crandell et al., 1995). Manufacturer details on transmitters varied from no data, to thorough specifications. Phonic Ear provided information on size and weight which indicated it to be both small, measuring 5.9 x 8.2 x 2 cm, and
lightweight at 74.8 grams. The Phonic Ear charging system is from the receiver which means an extra power point is not required. It also has a fail safe system built in that means it cannot accidentally charge alkaline batteries. From the author’s experience many other units have been ruined when incorrect batteries have been inserted into a re-charging device. There is a built in dial-up of 21 frequencies which can be easily changed if a child arrives at the school with a frequency-set personal FM, of the type used by many hearing aid users. The Phonic Ear LED on the transmitter indicates on/mute or low battery. It also has an auxiliary input which allows connection to most audio-visual equipment such as television or CD player. MSL and Sitech provided no information on assess their transmitters.

**Microphone Options**

Two of the manufacturers provided information on the microphone options available with their product. The MSL system microphones included three styles; behind the neck, lapel, and over the head. To suit user comfort preferences, Phonic Ear, in addition to the previous three styles, also have available an ear-hook microphone and a collar microphone.

**Ease of Use Rating for Receiver**

Manufacturer details on receivers varied from no or sketchy data, to comprehensive assessment data. Measuring 21.9 x 5.4 x 16.2 cm the Phonic Ear system is both small and lightweight, weighing 1.11 kg. For tone
control it has a band equalizer which allows sound to be tuned to room acoustics. The tone control in the front of the unit allows the tone to be tuned easily according to the teacher’s voice and the level in the room. The MSL system has a volume control to boost output. The Phonic Ear system had their volume control located in the front of the unit to easily adjust both to the teacher’s voice and to the noise level in the classroom. The Phonic Ear receiver is similar to their transmitter in that it has a dial-up of 21 frequencies which can easily be changed if a child who is hearing impaired arrives at the school with a frequency-set personal FM. Bright LED indicators are built into the Phonic Ear system to indicate whether the system is switched on and also to show the presence or absence of a FM signal. An auxiliary input is located on the Phonic Ear receiver to allow for connections to most audio-visual equipment.

**Overall Flexibility Rating/Special Team-Teaching Features**

The overall flexibility rating varied significantly on the number of channels, the ability to change channels, and on whether they could be adapted to team teaching situations.

The MSL system had access to 18 discrete frequencies. The Phonic Ear system can have 21 frequencies with the channels changed on either their transmitters or receivers. The Sitech base system has one fixed frequency channel. Their advanced unit has a changeable 64 channel system.
Two manufacturers provided information on whether their products had features that allowed for team teaching. The Phonic Ear system has as standard features that allow for this teaching approach. The MSL system can be adapted and modified to cater for a second microphone.

**Compatibility with Other Hearing Technology**

It has been previously mentioned in this study that the technology under examination is an extension into mainstream classes of an intervention commonly in use by students with hearing impairments who are users of personal hearing aids and also often users of personal FM systems. The compatibility of these systems is a critical element of design of this project.

There are currently six commonly used personal FM systems in New Zealand. These are the Phonak MicroLink, Phonak MicroVox, Sennheiser FM, Phonic Ear Solaris, Phonic Ear Easy Listener, and the Oticon Lexis. The Sitech manufacturer information claimed their systems were compatible with all hearing aid systems, MSL claimed their systems to be compatible and that they would assist schools to adapt to cater for children with hearing aids. Phonic Ear provided detailed compatibility claims for each of the FM systems identified by the researcher.
Approved Frequency/Possible Interference

While there are a wide range of frequencies that will work for FM systems, the New Zealand Government regulations prescribe who may use particular frequencies (New Zealand Legislation, Radio-communications Act 1989b). The regulations detail that only channels in the 173 MHz range (173.000-174.000) are authorised for use with hearing aid or sound field distribution systems. Product knowledge of bandwidth is important to allow for the required spacing of frequencies to prevent interference. Examples using two of the products listed above demonstrate that Lexis has a 50 kHz bandwidth while a MicroLink has a 150 kHz bandwidth.

Phonic Ear confirmed their systems operated in the Government approved 173 MHz range. No data were provided by MSL or Sitech. MSL stated that their systems would not interfere with existing systems. Phonic Ear stated it was very unlikely their system would get interference from other FM users, and no data was provided on the Sitech product.

Ease and Cost of Installation

While each of the systems is relatively easy to install, similar to the wiring involved in setting up a home audio system, care is needed in positioning of the speakers and in the aesthetics of wiring placement. The MSL quote included full installation carried out by their appointed personnel. The Phonic Ear design for speakers includes a drop-n-click design with 180 degree directionality. Their quote included free training of school caretakers to enable them to confidently install the equipment. Additionally they
offered, if requested, the outsourcing of a technician to install the units at an additional charge of $xx.xx per system at the time of writing. Sitech stated anyone with limited technical knowledge could install the units and that if required they could install at a cost of between $xx and $xxx per unit, plus travel.

Battery Options

Each of the systems’ transmitters operates on batteries. The Phonic Ear system operates on AAA batteries, other brands did not specify the size of battery used. Both MSL and Phonic Ear can use rechargeable batteries. The Phonic Ear charger has built in fail safe charging which means that it will not be damaged if instead of rechargeable batteries, normal alkaline batteries are accidentally inserted into the charging unit. Both MSL and Phonic Ear claimed that the rechargeable batteries should last approximately two years. Additionally Phonic Ear provided an estimated length of battery life between charges, of 12 hours. Sitech did provide information on batteries.

Instructions for Use/Customer Service

Teacher acceptance and use of a sound field amplification system was always acknowledged as being an integral part of this study. The instructions on using the equipment together with the back-up support to the teachers were as important to the project as were the specifications of the
equipment itself. Sitech offered one free training session if required. MSL offered two training sessions, one group session and one individual session. They also offered manuals and a written user guide. Phonic Ear provided the most comprehensive training sessions including free initial training of one to two hours per school and on-going whenever needed for the life of the product. Additionally they provided materials on rationale for use of the equipment, user guide, and trouble shooting tips. Sitech did not provide information on how to access them for customer support.

MSL were prepared to appoint a local area technician if their quote was successful. Additionally they provided a 0-800 Help Desk and were able to draw on experience of seven electronic engineers or technicians.

Phonic Ear provided a 0-800 Help Desk with 12 electronic engineers or technicians, three of whom were dedicated exclusively to Phonic Ear service and support. Additionally they were able to draw on the experience of four audiologists who were available to assist with more complicated technical support.

While all features were analysed and assessed, critical variables guiding selection recommendations of this intervention were related both to audiological measurements and to teacher support. The ability of the equipment to deliver at least 10 dB gain over ambient room noise was essential as were microphones that would deliver a consistent signal-to-
noise ratio. Following comparison and assessment of each of the three available manufacturer’s products in their entirety, the Phonic Ear product was chosen.

The Phonic Ear Easy Listener four-speaker, boom microphone sound field distribution system was used in all classrooms in the current research to maximise the even distribution of sound and increase the S/N ratio. This unit is designed for classrooms and facilities with 30 or fewer installations. The four 8-ohm speakers were strategically placed within the classrooms. The four speakers were fixed to classroom walls in accordance with specifications which took into account student seating plans and the dominant teaching style and use of teaching spaces. These speakers were wired to an amplification unit close to the electric mains outlet (Details of set up followed the Equipment User Guidelines that may be found in Appendix F). Microphones used were the ear-hook boom or “Madonna” style headsets. Transmitting amplification and receiving equipment included multi channel, FM narrow-band modulation, and individually adjusted controls for enhancing speech frequencies/tone and the FM volume (Expansion of information may be found in the Equipment User Guidelines in Appendix F). A written trouble-shooting summary and brief guide (copies found in Appendix I) was distributed to all intervention class teachers to enable them to have an “on-hand” reference.

The current research design differs from initial studies as it utilises
technology that has been further developed and provides increased S/N ratios through “boom” microphones and more evenly distributed sound within a classroom by using a four speaker paradigm. Specific professional development sessions covering the rationale for use of this intervention, with an explanation of how sound distribution systems work with summaries of expectations and responsibilities of the participating teachers were prepared for teachers in the current study. Teachers were requested to use the sound field equipment in most teaching sessions, and to consciously decide when to choose to turn it off, rather than decide when to turn it on. Observational checks and unannounced “drop-in” visits during the first six weeks of the project were scheduled to all classrooms to measure teacher use of the equipment and correct functioning of the equipment. (Handouts of the professional development sessions may be found in Appendix H).

**Schools and Settings**

**Location and Type**

All schools were in close proximity being in the central south and western south area of the city of Rotorua, New Zealand. All schools were year one to year six schools. Four of the schools were State operated schools and one was a private Catholic school which had been integrated into the state system. In New Zealand, while these schools have a special character in terms of emphasis on Catholic-religious values and practices, they are funded nationally at the same level as state schools and follow the same state curriculum using the same resources. Thus, the inclusion of this
private Catholic school in the study was not considered a significant limiting factor.

**Class Size**

The class size of the intervention classrooms where sound field distributions systems were installed as well as the control classrooms ranged from 16 to 31 pupils. Class sizes were uniformly lower in the first two years of school and higher in years five and six. The average class size for both control and intervention classes at the commencement of this study was 22 pupils. Figure 7 presents the total number of students in the participating classes compared to the total school roll for each of the participating different decile schools.

![Figure 7. Total student population in study classes and total school roll for each of the decile schools (Deciles 1, 2, 5, 6, and 10).](image-url)
Decile Ranking

All schools in the compulsory sector in New Zealand are rated by the Ministry of Education on a socio-economic scale of 1 to 10 (Ministry of Education, 2004). This decile rating for a school is used to determine resources the school receives. Factors taken into account to determine a school’s decile rating include the number of families with school-aged children, ethnic makeup, household income, state/government benefit dependency, and household crowding. A low decile rating indicates a school with a significant number of disadvantaged children. The learners’ families may also be disadvantaged with difficulty for the parents or caregivers to support the learning process.

This study included schools with five different decile ratings, including the most disadvantaged being decile one (1 school, N = 165 students agreeing to participate in the study), decile two (1 school, N = 181 study-participating students), decile five (1 school, N = 216 study-participating students), decile six (1 school, N = 174 study-participating students), and the most advantaged group, decile ten (1 school, N = 234 study-participating students).

Board of Trustees and Principal Support

A proposal to support children’s listening in selected Rotorua schools was presented to the Rotorua Energy Charitable Trust by the participating school principals (A copy of the proposal located in Appendix C). This
proposal was coordinated by one of the school principals. Funding for the equipment used in this research was requested from the Rotorua Energy Charitable Trust. The Trust agreed to the equipment being owned by the individual school for their continued use at the termination of the study. All Boards of Trustees and principals agreed to trial the equipment in their schools over the 2002 academic year, and to support and participate in this research study. Regular updates from the investigator were planned to ensure continued support from the schools (Distributed school updates presented as Appendices 4.0-4.6), and from the parents, Boards of Trustees, and other stakeholders (Presented as Appendices 5.0-5.2).

Acoustic Characteristics

In design and construction, the classrooms were typical New Zealand classrooms being a mixture of solid concrete base construction and “relocatable” rooms built on timber supports with lightweight (timber frame) construction. Wood formed the main structural building component for all supports and framing. The control and intervention classrooms were equally distributed between these various building constructions with their unique acoustic properties. None of the classrooms had fitted acoustic tiles in their ceilings or made other acoustic property changes for the duration of the project. Acoustic modifications were uniformly limited to installation of carpet flooring, and net curtaining over the window surfaces. It is common in New Zealand junior classrooms to hang children’s work and reference charts from rafters, beams, or wires approximately two meters from the ground.
This practice was discouraged unless they were strategically placed to limit classroom reverberation.

In architecture and design the classrooms in this study have similar acoustic properties to those previously researched. There have been several studies researching acoustic conditions in New Zealand classrooms (Blake & Busby, 1994; Coddington, 1980; Harper 1995). These studies have shown noise levels and S/N ratios similar to those found in international studies. Signal-to-noise ratios have been recorded in New Zealand classrooms from -5 dB up to +10 dB in classrooms with improved acoustic conditions. American researchers (Sieben, Crandell, & Gold, 1997) found classroom S/N ratios ranged from -7 dB to +5 dB.

Classroom reverberation times have also been recorded in New Zealand averaging 0.74 seconds (Coddington, 1980) and in another study of classrooms that had been identified by an Adviser on Deaf Children (AODC) as having better than average acoustics at a mean of 0.43 seconds (Harper, 1995). Reverberation times in some American and European studies ranged from 0.4 to 1.2 seconds (Sieben et al., 1997).

**Quality of Teaching**

The Education Review Office (ERO) is the New Zealand Government department that reports publicly on the quality of education in all New Zealand schools. The Education Review Office’s regular review schedule
observed schools in this study up to three years prior to the project and one school had had an additional discretionary review during that period. At the time of the reports there was no national assessment system through which improvements in student learning could be evaluated in comparative or individual school or student terms. Most classroom environments were ones that encourage and support students in their learning but in one school there was variation “from stimulating and exciting to mediocre” (ERO, School Report Number 1970, 2000).

**Instrumentation and Procedure**

Since this study consisted of both quantitative and qualitative measures (As presented in Figure 3) a variety of instruments were used. The instruments employed for the quantitative measurements are described below. Following this is a description of the questionnaire instrumentation used to collect the qualitative data.

A pre-test/post-test control group quazi-experimental design was used (Campbell & Stanley, 1966). This design involved an experimental or intervention group and a control group. Both groups were selected through randomisation procedures which ensured that any differences between the groups are probably quite small and due entirely to chance.

Age percentile ranks for the standardised *Progressive Achievement Tests* were analysed, these tests are fully described later in this section.
Individual student’s percentile ranks from the tests in 2002 were paired with those in 2003. The Paired Samples t-test was used to compare the means of the intervention group, pair one, with the control group, pair two. The difference between these two variables was computed for each case and tested to determine if the average difference was significantly different from zero. In testing the null hypothesis, the assertion is made that the difference between the means of the populations from which the samples were drawn is zero. Where the difference between the means of the samples is among those that would occur rarely by chance when the null hypothesis is true, the null hypothesis can be rejected and the results are statistically significant. Where there is a significant difference between the two variables it may be suggested that the intervention was a cause (Moore & McCabe, 2002).

**Progressive Achievement Tests**

The *Progressive Achievement Tests* of Listening Comprehension, Reading Comprehension, Reading Vocabulary, and Mathematics (NZCER, 1991) were administered (Sample pages have been included as Appendix J). The tests were developed by the New Zealand Council for Educational Research and standardised in March and April of 1993.

Protocols for classroom group administering and marking of these standardized tests require that they be administered exactly according to the directions in the relevant Teacher Manual, as any departure from the directions may invalidate the test results. The directions specify that
teachers are to plan for administering the tests, which includes their study of test materials, the method of announcing the test sessions and when and where to test. For students in the sound field amplified rooms, all tests are administered in their amplified classroom and the control group tests are administered in their un-amplified classrooms. Testing materials for each of the tests include a Teacher’s Manual, a Student Test Booklet, and a Student Answer Sheet. Standardised test procedures are used when administering the tests. The procedures are explicit on which directions are to be read aloud verbatim by the teacher administering to his/her own class. Directions on pace of reading instructions, and on timing and pausing are also explicitly stated. The same protocols and conditions are applied for the follow-up tests by the next year’s teacher the following year.

The age percentile rank norms indicate the typical or normal performance, in each of the areas tested, of representative samples of New Zealand children at the time the test was standardised. Assigned age percentile ranks were the benchmark measure used in this study. Derived scores such as the percentile ranks provide relative not absolute information. They compare the performance on the sample of questions with that of other students of the same age who took the test at the time of standardisation.

The tests were designed to assess attainment rather than having a diagnostic function. The test battery is progressively introduced each year
from year three upwards. These tests are administered annually by the
majority of New Zealand teachers according to the test procedures
contained in the Teacher’s Manual for the respective tests. Senior teachers
and management within each school were accountable for the adherence to
test protocols by the teachers.

**Phonological Tests**

There are currently no New Zealand standardised tests of literacy
available for administering to children in their first years at school.
Phonologic awareness skills are, for many children, the basis for their
literacy development (Gillon, 2004). Performances on 10 phonologic skills,
from letter-sound relationships to the ability to substitute phonemes, were
measured.

The *Phonological and Phonemic Awareness Tests* and protocols for
administration (Appendix K) were developed by Allcock (1997) with
reference to research by Lehr and Osborn (1994) and the *Sutherland
Phonological Awareness Test* (Neilson, 1995). These tests were
administered to the intervention group in classrooms that included sound
field amplification systems and the students in the control group were
administered the test in non-amplified classrooms. The same testing
conditions were applied at the follow-up tests at the end of that school year.
A marking sheet for these tests was locally developed to ensure
consistency in scoring (Presented as Appendix L). The Paired Samples $t$-
test was also used to compare the means of the intervention and control
groups for the phonological skills tests.

Teachers of classes who receive instruction in a bilingual setting were
provided copies of the test in English and in the Māori language. A Kuia or
respected female elder, who is a first language speaker of Māori and
teacher from the Rotorua tribe of Te Arawa translated these tests for that
cohort (Translated test presented in Appendix M). Eight of the 10 subtests
were translated but two were deemed by the Kuia as not appropriate in the
Māori language. The two bilingual setting teachers determined, however,
that the appropriate version of this test for their students was the English
version.

**Teacher Absence**

Each school submits weekly returns to the Ministry of Education’s
payroll service on teacher absence. Data from these were collated for the
teachers who consented so that the information could be used as part of the
study (Presented as Appendix B).

**Questionnaires**

Qualitative data were collected from parents/caregivers, the children
and young people participating in the study, and from their teachers using
questionnaires.
Data on the history of middle ear dysfunction and ethnicity were collected from parents/caregivers at the time that ethical approval to participate in the study was secured (Letters in Appendix A). This served to aggregate data used in responding to the fourth research question.

Students were invited to share their perceptions on any changes to listening to directions, noise levels in the classroom, and on the effort to listen to teachers. At the classroom teacher discretion, older students were invited to make written comments while younger students had their oral comments transcribed by their teachers or teacher aides.

The researcher developed questionnaires for teacher comments. These were trialed with an education lecturer and principal who discussed it with his senior staff at a school in another city centre. The questionnaire was critiqued on:

1. Appropriateness and relevance of the information requested,
2. Length of the questionnaire,
3. Other comments.

Suggestions for improvement made by the two senior educational colleagues focused on re-grouping of questions into five areas, so that each area had a specific focus.
The revised questionnaire (Presented as Appendix I) was then trialed with four teachers who all responded to the five focus areas.

**Ethical Considerations**

Four categories of ethical issues were researched prior to submitting the application to the Ethics Committee for this research study. These focused on protection from harm, informed consent, right to privacy, and honesty with professional colleagues. A certificate of approval for a research project involving humans was granted by the University of Newcastle Human Research Ethics Committee (Certificate presented as Appendix N).

Participants were not subjected to harmful or invasive procedures. The letter accompanying the consent form clearly highlighted the participant’s right to elect not to participate in the study or to withdraw from it at any stage.

Complete anonymity was preserved for all participants in the study. Data collected on each participant were stored in a secure database with each participant identified only by an assigned number. No individual or group of participants are named or easily identified in any research report or publication. With regard to privacy—all questionnaire data were stored on a secure database.
All graduating teachers in New Zealand are expected to uphold the New Zealand Teachers’ Council Code of Ethics (New Zealand Teachers Council, 2004). In fulfillment of their obligations to the teaching profession, teachers strive to advance the interests of the teaching profession through responsible ethical practice. Honesty with professional colleagues is a positive attribute of professional conduct that characterises strong and effective teaching and is expected of all teachers.

**Data Analysis**

Statistical software, SSPS, (SPSS Inc., Graduate Pack 11.0 for Windows, 2001) was used for purposes of quantitative data analysis and descriptive statistics were used to present the quantitative data obtained in the study. The quantitative data in this study included *Progressive Achievement Test* data, *Phonologic and Phonemic Awareness Test* data, teacher absenteeism data, middle ear dysfunction data, ethnicity data, socio-economic data, and personal data on the teachers, children, and young people participating in the study.

Questionnaires, using open-ended survey questions, were employed to gather qualitative data from parents/caregivers, teachers, and the children and young people participating in the intervention classes. Creswell’s data analysis spiral (1998) was applied to this qualitative data. This is a visual model for data analysis and representation. The spiral was used as a conceptualisation to further explore the analysis procedures of
this research.

**Teacher Absence**

SSPS analysis using the Paired Samples t-test was used to compare the teacher absenteeism means of the control and intervention groups. Additional qualitative data on teacher perceptions relating to health effects was recorded on the teacher questionnaires (Appendix I) and analysed using Creswell’s (1998) data analysis spiral.

**Summary and Conclusion**

In this chapter consideration has been given to the characteristics of the variables in the study and these have been described in detail. These variables included descriptions of both students and teachers as the participants in the study, an analysis leading to the equipment selection, the schools and their settings including acoustic characteristics and the quality of teaching in each school, and the testing materials used.

This study employed a descriptive research paradigm using both quantitative and qualitative measures in a quazi-experimental design. Quantitative measures, in particular standardised tests, were used to answer listed research questions. Additionally, qualitative measures including questionnaires were used to answer questions on listening and teacher health. The teacher questionnaires were piloted by professionals
who gave consistent answers to the variety of questions designed to measure the same construct.
The following chapter will present the results of the quantitative and qualitative measures organized in the sequence of the identified research questions described earlier.
Chapter 4

Results

Introduction

This chapter presents the results of the study in six parts. Part One reviews participant and teacher demographics or presents demographic data or possibly relevant information not previously reported that reflects on the results. Following this the results for each of the research questions of this study are presented.

Part Two presents the results of listening comprehension tests for children and young people who had commenced their third year of schooling. Listening comprehension was measured quantitatively using standardised tests and qualitatively using questionnaires for teachers and for the students.

Part Three reports on quantitatively measured improvements in reading. Standardised tests for reading comprehension and reading vocabulary were used. Standardised tests of phonologic skill development were made of children in their first two years at school.

Part Four presents results on the quantitatively measuring of
achievements in mathematics for children and young people from year five.

Part Five of the study presents results relating to significant variations in listening achievement from the general population for three specific populations: Those children and young people who had been treated for otitis media or otitis media with effusion; for New Zealand’s two major ethnic groups; and for learners from different socio-economic backgrounds.

The sixth part presents quantitative measures of teacher absenteeism and qualitative measures effecting absenteeism and teacher health from those teachers who used the sound field distribution systems.

A detailed discussion of the implications of the results is presented in Chapter Five.

Part One: Demographic Review and Relevant Information

**Students**

Of a total cohort of 626 children and young people who participated in the study, 70% were in the sound field intervention group and 30% in the control group. The majority of students were in years two, three, or four (N = 457) with the smallest yearly cohorts being in year one (N = 21) and year six (N = 34). No control group for year six students was available. The majority (57%) of the children and young people in the study were New Zealanders of European decent with Maori and Other (Pacific Islander/Asian)
accounting for 35% and 8% respectively.

The *Progressive Achievement Tests* (NZCER, 1991) were standardised to New Zealand students and their administration protocol relies on them being administered at various stages of a pupil’s schooling. When interpreting the results which follow it is important not to overgeneralise to all students in the study, but to acknowledge the progressive introduction of tests and note that the subtests were administered from year three to increasingly smaller cohorts as the children’s ages increased. The test for Listening Comprehension of the *Progressive Achievement Tests* is introduced to year three students and in this study students in years three, four, five, and six completed this test. Of all the testing, the greatest number of participants (N = 453) were administered this test in 2002. This group included both the intervention group (N = 321) and the control group (N = 132).

The Paired Samples *t*-test was used to compare the means of two variables. The two variables were the individual student’s results for 2002 and 2003. Each paired sample resulted from comparing a student’s test data in 2002 with data collected for the same student and test in 2003. The total population to be administered the tests in both 2002 and 2003 was 392. The two main reasons for students not being administered the second test in the series in 2003 (N = 61) were (a) their absence from school when their class was administered the test or (b) that they were transient and had
relocated to another school. Table 4-1 summarises the frequency of students administered each of the *Progressive Achievement Tests* for the intervention and control groups.

Table 4-1: Summary of Student Data by Frequency of Administration for Each of the *Progressive Achievement Tests* for Intervention and Control Groups

<table>
<thead>
<tr>
<th>Test administered*</th>
<th>Paired samples 2002/2003</th>
<th>Transient/absent after 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention</td>
<td>Control</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>277</td>
<td>115</td>
</tr>
<tr>
<td>Reading Comprehension</td>
<td>156</td>
<td>69</td>
</tr>
<tr>
<td>Reading Vocabulary</td>
<td>151</td>
<td>68</td>
</tr>
<tr>
<td>Mathematics</td>
<td>90</td>
<td>58</td>
</tr>
</tbody>
</table>

* Not all subtests are given to all years.

**Teachers**

A total of 43 teachers, originally participated in this study. Four were granted long term leave or left their school during the 2002 academic year. Only four of the teachers were male and three of those taught in the control setting.

The typical teacher in the study was experienced, with an average of
10 years experience for the control group and 11 years for the intervention group.

The ethnic ratio of the teachers did not reflect the same proportion as the students with 82% of teachers being NZ European/Pakeha and 18% were Māori teachers. (As discussed earlier the student proportions were 57% NZ European, 35% Maori, and 8% Other.)

The leadership changed in two of the five schools during the project. Two of the five principals were newly appointed to their school during the 12 month period from the commencement of the project to October 2002.

The Education Review Office (ERO) is the New Zealand government department that reports publicly on the quality of education in all New Zealand schools. As previously reported, the Education Review Office’s regular review schedule observed schools up to three years prior to the project and one school had had an additional discretionary review during that period. At the time of the reports there was no national assessment system through which improvements in student learning could be evaluated in comparative or individual school or student terms.

The overall quality of teaching between the schools was reflected in the individual school’s reviews. Schools were reported as having a “consistently good quality of teaching”, “consistently good quality throughout
the school with some outstanding examples”, or where “teachers are dedicated and committed to providing the best education possible for students”. One report noted the quality of teaching variance between individual teachers within that school. In many classrooms there was “high quality teaching practice” but in three classrooms “students are being disadvantaged in their learning”. This was primarily where a “teacher focus on student behaviour was at the expense of quality teaching and learning”. With attrition and implementation of previous ERO recommendations, the accuracy of their comments in relation to current teachers in the project cannot be verified.

**Consistency of Use of Sound Field Equipment**

Thirty sound field distribution systems were used in classrooms with 27 or 90.0% being used consistently throughout the year-long intervention period. Just over 63% of classroom teachers reported that they used the equipment consistently for most teaching sessions (N = 19), 26.7% consistently used the equipment for selected sessions (N = 8), and just 10% reported using the equipment inconsistently (N = 3).

Those teachers that used the equipment for specific teaching sessions stated they used it primarily for whole class instruction (N = 8) and for story reading (N = 7). Those who used it inconsistently used it primarily for spelling and other testing (N = 2). Reasons for using it inconsistently related to teacher maintenance issues of forgetting to recharge the unit (N = 2) and
personal appearance and perceived quality or distortion of own voice (N = 2). Justification comments recorded on the teacher questionnaire for lack of compliance included…

- “My ears stick out when wearing the headset.”
- “I find it weird because I can’t hear myself-my voice is far away.”

**Part Two: Listening Comprehension**

Part Two of this chapter presents the results from the data for listening comprehension as a response to the proposed listening comprehension research question.

**Research Question:**

- Is there significant improvement in achievement of primary aged children in the area of listening following a twelve month period of learning in classrooms equipped with a sound field distribution system?

**Progressive Achievement Tests**

As previously stated testing conditions followed the protocols in the Teacher’s Manual and were administered in sound field amplified classrooms for students in the intervention groups and in un-amplified classrooms for the control group. The standardised *Progressive Achievement Test* of Listening Comprehension results are based on the
difference between the means of percentile ranks for 2002 and 2003. Statistical $t$-tests were used to present these data. Table 4-2 provides the analysis data for Pair 1, the intervention group and Pair 2, the control group. Descriptive statistics for the paired differences between the two variables have been calculated and includes the mean, standard deviation, standard error of the mean, and the upper and lower boundaries of the confidence interval for the difference. The $t$-values have been calculated to determine the significance level of the result in order to accept or reject the null hypothesis.
Table 4-2: Analysis of Data for Pair 1, the Intervention Group and Pair 2, the Control Group for the *Progressive Achievement Test* of Listening Comprehension

<table>
<thead>
<tr>
<th></th>
<th>Paired Differences</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Standard Error of Deviation</td>
<td>95% Confidence Interval of the Difference</td>
<td>t-score</td>
<td>df</td>
<td>Significance (2-tailed)</td>
</tr>
<tr>
<td>Pair 1</td>
<td>Intervention</td>
<td>11.30</td>
<td>15.278</td>
<td>0.918</td>
<td>9.49</td>
<td>13.11</td>
<td>12.310</td>
</tr>
<tr>
<td></td>
<td>2002-2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 2</td>
<td>Control</td>
<td>3.80</td>
<td>21.080</td>
<td>1.966</td>
<td>-0.9</td>
<td>7.69</td>
<td>1.933</td>
</tr>
<tr>
<td></td>
<td>2002-2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both the intervention and control groups exhibit positive mean differences (i.e., improvement in listening comprehension) from 2002 to 2003. The intervention group mean for paired differences demonstrates a significant positive change of 11.3 compared to the control group mean change of 3.8. The control group $t$ value is 1.9. The probability of obtaining a value of at least 1.9 is 0.056, which is above the 0.05 significance value indicating there is no significant difference in the control group. In contrast, the intervention group $t$ value is 12.3. The probability of obtaining such a value by chance is negligible, which is indicative of a significant difference. It is suggested that the intervention group significantly improved their listening comprehension achievement.
The effect of this intervention on students’ listening is fundamental to the research questions. An additional analysis of the listening data was planned to determine correlation of conclusions. The Wilcoxon Signed Ranks test for the *Progressive Achievement Test of Listening Comprehension*, Table 4-3, was conducted to confirm or question results from the Paired Samples test.

Like the *t*-test for correlated samples, the Wilcoxon Signed Ranks test applies to two-sample designs involving repeated measures, matched pairs, for “before” and “after” measures. It is a non-parametric alternative to the *t*-test for correlated samples. The observed Z value for the intervention group is 10.9 and 1.5 for the control group, based on positive ranks of the students’ percentile ranks. The null hypothesis being tested here states that there is no change in the group results from 2002 to 2003. For the control group, the probability of obtaining a value at least as high as the figure shown is 0.136, so the null hypothesis is accepted. However, for the intervention group, the probability of obtaining a value at least as high as the figure shown is negligible and thus the null hypothesis can be rejected. It can therefore be suggested that the intervention made a significant difference to listening achievement.
Table 4-3: Wilcoxon Signed Ranks Test Results\textsuperscript{1} for the Progressive Achievement Test of Listening Comprehension

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>10.905\textsuperscript{a}</td>
<td>1.490\textsuperscript{a}</td>
</tr>
<tr>
<td>Asymp.Sig.(2-tailed)</td>
<td>0.000</td>
<td>0.136</td>
</tr>
</tbody>
</table>

\textsuperscript{1} Based on positive ranks

The *t*-tests and the Wilcoxon Signed Ranks provide strong evidence using the listening comprehension data. This gives added credibility to the conclusions being made in Chapter 5 on the efficacy of the intervention on listening comprehension.

The research hypothesis presented at the start of Part Two of this Results chapter questioned whether the means of percentile rankings for listening comprehension will demonstrate difference between the intervention and control groups. The null hypothesis for the intervention group arising from the research question is that the observed difference between the means of that group at the start of the program, and after a period of one year, would be zero. Similarly, the null hypothesis for the control group would be that the observed difference between the means of that group at the start of the programme, and after a period of one year, would also be zero.
For the intervention group the test statistic, \( t = 12.3 \), gives extremely strong evidence to reject the null hypothesis. For the control group the test statistic, \( t = 1.9 \), does not give sufficient evidence to reject the null hypothesis at the .05 significance level. These results are summarised in Table 4-4 and suggest that the use of this intervention has a significant effect on listening comprehension.

Table 4-4: Progressive Achievement Test Percentile Ranks Results--Listening

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Subjects</th>
<th>Mean Change</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listening Comprehension</td>
<td>Intervention</td>
<td>233</td>
<td>11.3</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>Control</td>
<td>98</td>
<td>3.8</td>
<td>0.056</td>
</tr>
</tbody>
</table>

An interesting subset result concerned the improved achievement of this intervention for children and young people who were in the lower achieving quartile of the Intervention group. Learners below the lower quartile and learners above the upper quartile improved dramatically and significantly with changes in mean percentile ranks of 17.63 and 11.30 respectively. Learners below the median improved by a mean percentile rank of 16.28 while those above the median improved by a mean percentile rank of 6.06. This would suggest that while this intervention improves
outcomes for all learners, it has particular benefits for lower achieving learners.

**Students’ Perceptions of Listening in Sound Field Environments**

A research update distributed to all teachers invited them to seek student comment and perspective on the sound field system. This data collection was conducted towards the end of the scholastic year which is a busy time for teachers and students and may explain the low response rate (N = 65).

Students were invited to comment on changes in being able to listen to directions, noise levels in the classroom, and the effort to listen to the teachers (Appendix D.). Self-written student responses were made by the students in year 3 and above. Students in year one and two had their comments recorded by their teachers or teacher aides.

All student respondents, with one exception, noted positive outcomes to this intervention. The exception noted static problems as a distraction when the teacher inadvertently knocked the on/off button. Most commented on the ease of hearing the teacher or on the perceived clarity of the teacher’s voice.
The student’s comments commonly reflected the themes of ease of hearing when seated a distance from the teacher, and the ease of hearing over competing noises either inside or outside the classroom. The following comments were typical.

- “It is easier to hear when you are sitting at the back of the room.”
- “Even with noise outside we can hear the teacher.”
- “It is easier to hear over the noise of other children fiddling.”

One 6 year-old child commented on the improved classroom environment.

- “The talking by the teacher and hearing easily make it peaceful.”

Feelings of importance and confidence when using the microphone were noted by students in rooms where the teacher allowed this. Two of the student’s comments representing this theme were:

- “When we are sharing our ideas with the class our teacher lets us use the headset and everyone can hear us. We feel important.”
- “When we did our speeches our teacher let us use the headset. Everyone heard me.”

The enhanced learning environment was observed by some students when the sound field was used consistently. Students noted the benefits during spelling tests, such that teachers could discipline students without raising their voices, and that it was easier to hear teachers when they read
stories. Typical student comments were:

- “Spelling test words are easier to hear.”
- “When the teacher has to growl she doesn’t have to shout!”

Students also commented on being able to listen to a teacher’s answer to other children’s questions, thus eliminating the need for them to ask themselves. One student’s comment was:

- “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.”

In summary, children and young people were enthusiastic about learning in the sound field environment. Their perceptions included noting the positive benefits of overcoming classroom noise and that the negative effects of hearing the teacher from a distance were mitigated by the sound field environment. The subtle effects of enhancing the classroom working atmosphere and their own empowerment in the learning process were also observed by the students.

Teacher Perceptions of Improving Listening in Classrooms

Part of the teacher questionnaire specifically guided the teachers to provide comments that reflected their thoughts on (a) students’ listening comprehension of teacher instructions; (b) changes in student cooperation;
and (c) effective classroom practices. All 30 teachers using the intervention completed the questionnaire.

**Better Listening Comprehension of the Teacher Instructions**

A majority (73.3%) of teachers noted positive benefits to the learners' comprehension of teacher instructions while using the sound field system (N = 22). More positive benefits were noted by the group that used the systems for most teaching sessions than those who used it for selected sessions. They reported that fewer students needed to seek clarification or repetition of instructions. The negative effects relative to positioning in the classroom was also noted as improved as students heard instructions more clearly no matter where the teacher or they were in the classroom. The following statements about the listening comprehension benefits of using the sound field distribution systems by these three teachers were typical.

- “Yes definitely so. No one has the excuse they didn’t hear, so the children take more responsibility for listening to instructions.”
- “Less ‘demanding’ teaching.”
- “Children are able to all clearly hear instructions. They find it easier to listen to instructions using the sound field. They appear to have improved comprehension of instructions.”

No contributing effect to comprehension was noted by three teachers.
**Improved Student Co-operation**

Two-thirds (66%) of teachers noted improved student cooperation (N = 20). More positive benefits were noted by the group that used the systems for most teaching sessions than those who used it for selected sessions. The use of a normal speaking voice level was identified as promoting a positive tone and having a calming effect on students within the classrooms (N = 9). The following comments by the teachers were typical of the comments made about improved classroom co-operation by the students.

- “Children are more at ease because their teacher uses a ‘normal’ voice.”
- “When you are ‘quiet’ it is easier to say positive things. Sound fields promote a calmness and well-being. They help to promote a positive tone within the room.”
- “It has been wonderful to note the improved all round impact on students. They tell me if it is not turned on. They follow directions easier, respond quicker, can listen in to others having tuition and gain assistance.”

Three teachers again noted no change in student co-operation.

**Effective Practices**

Some teachers identified that students benefited when they were given the microphone to use. The student’s advantage was evident during class discussions and presentations where children were speaking to the
large group, sharing their written work, or asking questions. The use of the microphone was of particular benefit to those students with quiet voices, shy children, and speakers whose first language was not English. It was commented that they all received a confidence boost from being easily heard. Outcomes for a slower reading group, particularly in self-monitoring and performance, were observed to be enhanced by using the sound field system.

Using the system for teachers’ story reading sessions was identified as a time when students benefited, especially if they were sitting at a distance from the teacher. The ability to whisper for dramatic effect while reading a passage and yet be heard by the entire class was favourably noted.

It was noted that there had been a change in teacher-pupil contact while using the system. In particular with those students, both reserved and more able students, that sat on the perimeter or in a less visible position.

Teachers commented on the effectiveness of using the system to improve literacy outcomes especially with junior students who were developing/learning phonologic skills.

An awareness of incidental learning in the classroom environment was noted. This related to students who overheard instruction, or answers to
questions, while the teacher gave explanations to another group or
individuals. It was perceived that this reduced the teachers’ need for
repetition.

Two negative aspects were noted by many teachers either through the
questionnaire or in face-to-face meetings during the intervention period.
Initially, the setting up of routines to ensure the equipment was fully charged
was frequently reported. Second the lack of comfort of the type of headset
issued for this trial was also commonly reported. The majority of these
teachers had used the production-shaped head band but had not made the
possible personal head band adjustments.

This intervention has resulted in gains in listening achievement levels
of children and young people, and has been accepted well by both the
students and teachers who have reported beneficial effects on the
classroom environment and on learning.

Part Three: Reading

Part Three presents results from the data for reading comprehension,
reading vocabulary, and phonologic skills as a response to the proposed
research question concerning reading.

Research Question:

- Is there significant improvement in achievement of primary aged
children in the area of reading following a twelve month period of learning in classrooms equipped with a sound field distribution system?

**Progressive Achievement Tests**

**Reading Comprehension**

The research hypothesis arising from the research question suggests that means of percentile rankings for reading comprehension will demonstrate a difference between the intervention and control groups. The null hypothesis for the intervention group states that the observed difference between the means of that group at the start of the programme, and after a period of one year, would be zero. The null hypothesis for the control group states that the observed difference between the means of that group at the start of the programme, and after a period of one year, would also be zero. The results of the *Progressive Achievement Test*, Percentile Ranks for Reading can be seen in Table 4-5.
Table 4-5: Progressive Achievement Test Percentile Ranks--Reading

<table>
<thead>
<tr>
<th>Group</th>
<th>Subjects</th>
<th>Mean Change</th>
<th>t-score</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Comprehension</td>
<td>Intervention</td>
<td>104</td>
<td>8.37</td>
<td>5.656</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>60</td>
<td>0.64</td>
<td>0.258</td>
</tr>
<tr>
<td>Reading Vocabulary</td>
<td>Intervention</td>
<td>100</td>
<td>8.74</td>
<td>6.214</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>58</td>
<td>6.46</td>
<td>4.167</td>
</tr>
</tbody>
</table>

For the intervention group’s reading comprehension the test statistic, \( t = 5.7 \), gives very strong evidence to reject the null hypothesis. For the control group the test statistic, \( t = 0.3 \), does not give sufficient evidence to reject the null hypothesis.

The mean percentile ranks for reading comprehension improved for both groups although not significantly so for the Control group. The mean of paired differences of those in the control group improved 0.6 while those in the intervention group improved significantly by 8.4. It was anticipated that the results of this intervention would demonstrate an improvement from the control group. The magnitude of the improvement however was much greater than expected. The results of this research project provided very strong evidence to suggest that reading comprehension achievement improves significantly with this intervention.
**Reading Vocabulary**

The research hypothesis poses that means of percentile rankings for reading vocabulary will demonstrate difference between intervention and control groups. The null hypothesis for the intervention group states that the observed difference between the means of that group at the start of the programme, and after a period of one year, would be zero. The null hypothesis for the control group states that the observed difference between the means of that group at the start of the programme, and after a period of one year, would also be zero.

With reference to the mean differences in percentile ranks for the intervention group as shown in Table 4-5, the test statistic, $t = 6.2$, gives very strong evidence to reject the null hypothesis. For the control group the test statistic, $t = 4.2$, also gives strong evidence to reject the null hypothesis.

An expected outcome of this phase of the research was that there would be an improvement in reading vocabulary in the intervention group compared to the control group. The means for reading vocabulary improved for both groups. The mean of paired differences of those in the control group unexpectedly improved 6.5 while those in the intervention group improved by 8.7. The results of this research on reading vocabulary are statistically significant. They provide positive evidence to suggest that reading vocabulary achievement improves with the intervention of using sound field amplified classrooms.
Recap of PAT Reading Results

Paired $t$-test analysis was the basis for comparing the students’ achievement results between the intervention and control group for their reading comprehension. Table 4-5 shows the analysis data for both of these groups. The $t$ value for the control group is 0.3 which does not give sufficient evidence to reject the null hypothesis. The result for the intervention group with a $t$ value of 5.7 gives very strong evidence to reject the null hypothesis.

The information in Table 4-5 provides strong evidence to suggest that reading comprehension achievement improves with this intervention. The mean for the control group improved by 0.6 over the 12-month intervention period, while the mean improvement for the intervention group improved significantly by 8.4.

Paired $t$-test analysis was the basis for comparing the students’ achievement results between the intervention and control group for their reading vocabulary. Table 4-5 shows the analysis data for both of these groups. The $t$ values for both groups give strong evidence to reject the null hypotheses.

The mean for percentile ranks for both groups improved from 2002 to 2003 with the mean for the intervention group improving 2.3 more than the
control group. These results suggest when compared to students who the standardised tests are normed against, this intervention has a statistically significant effect on reading vocabulary achievement.

*Phonologic and Phonemic Awareness Test*

Year one and two students’ performance in 10 phonologic skill areas was measured. These skills ranged from letter-sound relationships to the ability to substitute phonemes. Results of the percentile mean change data for each sub-skill is presented in Table 4-6.
Table 4-6: Phonologic and Phonemic Awareness Subtest Results of Percentile Mean Change for Intervention and Control Group Students

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Group</th>
<th>Subjects</th>
<th>Mean Change*</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound to Letter Correspondence</td>
<td>Intervention</td>
<td>84</td>
<td>5.766</td>
<td>0.044</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41</td>
<td>2.751</td>
<td>0.007</td>
</tr>
<tr>
<td>Counting Syllables</td>
<td>Intervention</td>
<td>84</td>
<td>5.801</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>40</td>
<td>3.083</td>
<td>0.004</td>
</tr>
<tr>
<td>Sound to Word Matching</td>
<td>Intervention</td>
<td>84</td>
<td>5.964</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>40</td>
<td>3.306</td>
<td>0.002</td>
</tr>
<tr>
<td>Generating Rhyme</td>
<td>Intervention</td>
<td>84</td>
<td>5.284</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41</td>
<td>3.824</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td>Counting Phonemes</td>
<td>Intervention</td>
<td>84</td>
<td>5.526</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41</td>
<td>1.83</td>
<td>0.075</td>
</tr>
<tr>
<td>Counting Phonemes in Blend Words</td>
<td>Intervention</td>
<td>84</td>
<td>4.447</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41</td>
<td>2.604</td>
<td>0.013</td>
</tr>
<tr>
<td>Deleting Initial Phonemes</td>
<td>Intervention</td>
<td>84</td>
<td>5.204</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41</td>
<td>1.84</td>
<td>0.073</td>
</tr>
<tr>
<td>Deleting Phonemes in Blend Words</td>
<td>Intervention</td>
<td>84</td>
<td>5.176</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41</td>
<td>2.499</td>
<td>0.075</td>
</tr>
<tr>
<td>Deleting Second Phonemes in Blend Words</td>
<td>Intervention</td>
<td>84</td>
<td>3.838</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41</td>
<td>3.249</td>
<td>0.002</td>
</tr>
<tr>
<td>Phoneme Substitution</td>
<td>Intervention</td>
<td>84</td>
<td>5.319</td>
<td>&gt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>40</td>
<td>1.918</td>
<td>0.062</td>
</tr>
</tbody>
</table>

* t- Score

Overall, a significant improvement in mean change of percentiles was
noted on all 10 subtests within the intervention group with their greatest improved achievement being in counting phonemes, substituting phonemes, and on their ability to delete initial phonemes in blend words. The *t* values do not give the same consistent evidence of significant change in the control group as they do for the intervention group—with only six of 10 subtests exceeding a level of significance of > .05. The 10 subtests of the *Phonologic and Phonemic Awareness Test* will be discussed separately in the text to follow.

**Sound to Letter Correspondence**

It is interesting to note that in this study significant differences were found in both the intervention group and control group in their achievement in sound-letter correspondence. Of all the phonologic skills tested this phoneme-grapheme relationship is perhaps the most readily understood by non-professionals as a preparation for literacy development and perhaps the most often taught in home settings or on entrance to school. Table 4-6 presents data indicating that the difference in mean improvement for the intervention and control groups were both significant in this study.

**Counting Syllables**

The achievement in listening to and then cognitively counting the number of syllables in a word was expected to be significantly different between the control and intervention groups. The results of the study
presented in Table 4-6 for achievement in counting syllables show that while there was a significant difference in improvement for both groups, there was a greater improvement in the mean for the intervention group.

**Sound to Word Matching**

Sound to word matching is another early phonologic skill of listening to words and identifying the common long or short vowel phonemes. Students’ achievement was expected to be significantly different between the control and intervention groups. The findings presented in Table 4-6 for achievement in sound to word matching subtest show that while there is a significant difference in improvement for both groups, there was a greater improvement in the mean for the intervention group.

**Generating Rhyme**

The ability of students to generate rhyming words by adding to examples presented is another early phonologic skill. A significant difference was noted in Table 4-6 for both control and intervention groups in achievement of this skill as measured by the Generating Rhyme subtest.

**Counting Phonemes**

Conscious recognition of the number of sound units within a word demonstrates a cognitive function of using and interpreting a listening related skill and applying this to oral language. The ability to break a word
into its individual sound units is a foundation skill for literacy development. Students in the intervention group demonstrated this skill at a significantly higher level than those students who did not benefit from the sound field distribution intervention.

**Counting Phonemes in Blend Words**

Counting phonemes in blend words is a phonologic skill where students’ achievement was expected to be significantly different between the control and intervention groups. Unexpectedly, there was significant improvement in both the control and intervention groups. The findings presented in Table 4-6 for achievement in counting phonemes in blend words show that there was more improvement in the mean for the intervention group and the $t$ score result was evidence of a significant change.

**Deleting Initial Phonemes**

Deleting phonemes is a phonologic skill where students’ achievement was expected to be significantly different between the control and intervention groups. The findings presented in Table 4-6 for achievement in deleting phonemes show that there was more improvement in the mean for the intervention group.
**Deleting Initial Phoneme in Blend Words**

A more advanced phonologic skill in literacy development is the ability to listen to a blend word and then delete the initial phoneme or sound unit. This involves both the ability to hear and selectively listen to the sound units of a blend such as the “tw” in “twink” and then to cognitively delete the initial “t” sound to make “wink”. The students in this study who had received instruction in classrooms with amplification demonstrated significantly increased ability to apply this skill.

**Deleting Second Phoneme in Blend Words**

Deleting second phonemes in blend words is considered to be a more advanced skill than deleting the first phoneme in blend words. This again involves both the ability to hear and selectively listen to the sound units of a blend. In this instance, however, the task involves a blend such as “pl” in “play” and then to cognitively delete the initial “l” sound to make “pay”. Table 4-6 shows that the mean difference for the intervention group and the control group varied only slightly for their achievement in deleting the second phoneme in blend words. Although both achieve significantly higher means, the control group’s mean was only slightly less than the intervention group.

**Phoneme Substitution**

Phoneme substitution is another pre-cursor to mastery of literacy at a
progressive skill level beyond that of being able to count sound units. A student listens to a word, identifies individual sound units, and then substitutes a sound unit with another. The results included in Table 4-6 shows that while the $t$ values do not give evidence of any significant change in the control group, they do give evidence of a significant difference in the intervention group.

**Recap of PAT Results**

This sound field distribution intervention has resulted in gains in reading achievement levels of children and young people, particularly in the areas of reading comprehension and phonologic skill development which is commonly identified as a pre-cursor to mastery of literacy.

**Part Four: Mathematics**

Part Four presents the results from the data for the standardised test in mathematics that form part of the *Progressive Achievement Tests*. The cohort for this test was smaller than the previous standardised tests as Mathematics testing is not administered until year five.

**Research Question**

- Is there significant improvement in achievement of primary aged children in the area of mathematics following a twelve month period of learning in classrooms equipped with a sound field
distribution system?

The research hypothesis arising from the research question suggests that means for mathematics will demonstrate a difference between the intervention and control groups. The null hypothesis for the intervention group states that the observed difference between the means of that group at the start of the programme, and after a period of one year, would be zero. The paired $t$ test analysis was used to compare the students’ achievement results between the intervention and control group for the mathematics subtest of the *Progressive Achievement Test*. Table 4-7 presents the findings for Pair 1, the Intervention Group and Pair 2, the Control Group for the PAT: Mathematics.

<table>
<thead>
<tr>
<th>Group</th>
<th>Subjects</th>
<th>Mean Change</th>
<th>$t$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>Intervention</td>
<td>3.62</td>
<td>2.041</td>
<td>0.044</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>-5.34</td>
<td>-2.142</td>
<td>0.037</td>
</tr>
</tbody>
</table>

The $t$ value of 2.0 for the intervention group gives evidence to reject the null hypothesis at the .05 level and to suggest the intervention had a positive effect on mathematics achievement. Table 4-7 shows a positive change in mean for the intervention group of 3.6. The mean change for the control group, however, decreased by 5.3. This will be discussed in more
depth in the next chapter. By way of brief explanation, the *Progressive Achievement Test* for Mathematics is introduced in year five and there were fewer students in this cohort than in the listening or reading tests. The control group (N = 58) consisted of students from two separate year five classrooms while the intervention group (N = 90) consisted of six classes with a mixture of single and composite or more commonly known in New Zealand, Whanau classes.

**Recap of PAT Mathematics Subtest Results**

This intervention has resulted in gains in mathematical achievement levels of children and young people. The results highlight a significant variation in achievement between the intervention classes, which improved, and the control classes, which regressed. Possible reasons for this will be discussed in the following chapter.

**Part Five: Effects on Specific Populations**

Part Five of the study presents results relating to significant variations in listening achievement for three specific populations as measured by the standardised *Progressive Achievement Test* of Listening Comprehension results. The three populations were (a) in children and young people who had been treated for otitis media (OM) or otitis media with effusion (OME); (b) in New Zealand’s two major ethnic groups, Māori and Pakeha; and (c) in learners from different socioeconomic backgrounds. The three research
questions were:

*Research Questions*

- Are listening achievements in students who have been treated for otitis media (OM) or otitis media with effusion (OME) significantly different following learning in a sound field amplified classroom?

- What comparisons and observations can be made for improvements in listening comprehension between Pakeha and New Zealand’s other major ethnic group, Māori, who have a reported disproportionate incidence of OM and OME?

- What comparisons and observations can be made for improvements in listening comprehension between learners from different socio-economic backgrounds?

*Listening Improvement for Learners With/Without Treated Middle Ear Dysfunction (OM or OME)*

The Paired Samples $t$-test was used to compare the listening improvement mean scores for children who previously had been treated by a medical practitioner for ear infections (OM or OME) and those who had not. The mean improvement for these groups is shown in Table 4-8. The means for listening comprehension improvement for both groups improved markedly during this study as highlighted earlier.

<p>| Table 4-8: Listening Improvement by Treated Middle Ear Dysfunction |</p>
<table>
<thead>
<tr>
<th>Treated Middle Ear Dysfunction</th>
<th>No. tested Listening</th>
<th>Mean Listening Improvement</th>
<th>t-score</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>78</td>
<td>13.653</td>
<td>7.67</td>
<td>77</td>
</tr>
<tr>
<td>No</td>
<td>277</td>
<td>11.299</td>
<td>12.3</td>
<td>276</td>
</tr>
<tr>
<td>Total</td>
<td>355</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The derived $t$-score for the difference in mean listening improvement was 1.17. This $t$-score does not provide sufficient evidence to state that there is a significant difference between the results for those children and young people who have previously been treated for middle ear dysfunction and those who have not.

**Listening Improvement for Māori and Pakeha**

The Paired Samples $t$-test was used to compare the listening improvement means for Māori and for Pakeha. The mean improvement for these groups is presented in Table 4-9.
Table 4-9: Listening Comprehension Improvement t-test for Māori and Pakeha/European Groups

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Mean Listening Improvement</th>
<th>t-score</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakeha/European</td>
<td>10.00</td>
<td>8.34</td>
<td>163</td>
</tr>
<tr>
<td>Māori</td>
<td>14.86</td>
<td>9.9</td>
<td>83</td>
</tr>
</tbody>
</table>

The means for listening comprehension of both ethnic groups improved markedly. The derived t-score for the difference in mean listening improvement was 1.92. This does not give sufficient evidence to state that there is a significant difference between the results for Māori and Pakeha/European groups.

**School Decile Ratings and Listening Improvement**

In review, the school decile ratings are based on government criteria used to determine resource allocation. Schools classed as decile 1 schools draw their students from areas of greatest socio-economic disadvantage while decile 10 schools draw students from an area of least socio-economic disadvantage. The breakdown of schools by decile ratings in this study with the numbers of participating children and young people at each are illustrated in Figure 8.
Analysis of the improvement in mean on the *Progressive Listening* Test for Listening Comprehension was made for the each of the different decile rated schools. Table 4-10 presents the frequencies in each of the decile groups for the number of students who increased their percentile rank by 10 or more. The mean change among the total cohort receiving this intervention was 11.3 and so for the group under discussion analysis of increases in percentile ranks of 10 or more were calculated. The observed data and expected frequency data for mean increases of 10 or more were then used as the basis for calculating the chi-square value. A chi-square value of 5.2 was calculated with 4 degrees of freedom. To be significant at the .05 level the chi-square value should exceed 9.49.
Table 4-10: Frequencies of Observed and Expended Mean Increases of 10 or More for the Different Decile Designated Schools

<table>
<thead>
<tr>
<th>Decile</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>6</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>23</td>
<td>14</td>
<td>44</td>
<td>32</td>
<td>42</td>
</tr>
<tr>
<td>Expected</td>
<td>19</td>
<td>12</td>
<td>54</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>O-E</td>
<td>4</td>
<td>2</td>
<td>-10</td>
<td>7</td>
<td>-3</td>
</tr>
<tr>
<td>(O-E)2/E</td>
<td>0.842</td>
<td>0.333</td>
<td>1.85</td>
<td>1.96</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The underlying research question to this analysis was to make comparisons between learners from a variety of socio-economic backgrounds with the research hypothesis suggesting a significant difference in listening achievement between the intervention groups for each of the different decile groups. The null hypothesis for the intervention group states that there is a significant difference between the listening comprehension percentile ranks between each of the decile rated schools. The chi-square test does not provide sufficient evidence to reject the null hypothesis and it therefore cannot be stated that there is a significant difference in improvement between the different decile groups.

Figure 9 to follow illustrates that the means for all percentile rankings for listening comprehension in each different decile school improved markedly. The mean of paired differences of those in the lower decile schools (decile 1 & 2) improved more than those in higher decile schools (decile 5, 6, & 10). The mean for decile 1 improved by 14.8, decile 2 by
13.0, decile 5 by 11.4, decile 6 by 11.9, and decile 10 by 9.1. Although a trend was observed statistically analysis did not provide evidence that the magnitudes of these differences between the various decile schools are significantly different.

![Figure 9. Progressive Achievement Test-Listening Comprehension mean paired differences for students in decile-designated schools 1, 2, 5, 6, and 10.](image)

**Recap of Specific Population Results**

An interesting result of this research is the benefit of using sound field distribution on specific populations. While there were variations within the groups identifying as Māori and Pakeha, those treated for middle ear dysfunction, and those students from various socio economic communities, they were not at a significant level of difference. This would tend to support current thinking (Ministry of Education, 2005a) that there is more variation in
achievement due to the effectiveness of individual teachers in schools, rather than between the schools themselves (Alton-Lee, 2003).

Part Six: Teacher Absenteeism and Health

The sixth part of this research-results chapter involved quantitative measures of teacher absenteeism and qualitative measures effecting absenteeism and benefits to those teachers who used the sound field distribution systems. The linked research questions to follow had their genesis in and received their motivation from the review of the literature.

Research Questions

- Is there any significant difference in absenteeism of teachers who use sound field distribution equipment? What teacher benefits are attributed to using the sound field equipment?

Teacher Absence

Fifteen teachers using the intervention for the duration of the study participated in this section of the research. Two teachers with particular health issues, but not related to voice disorders, necessitated leave of 30 and 20 days for each. They were not included in the teacher absence statistics. Of the 40 classes participating in this project, 28 of their teachers agreed to release data on teacher absenteeism.

The Paired Samples t-test was used to compare the teacher
absenteeism means of the control and intervention groups. The mean absence for teachers in the control classes for the 2003 academic year, and the mean absence for intervention teachers for the same period is shown in Table 4-11. The derived $t$ score was 2.9 and thus no significant difference was established between the absenteeism of teachers in the control and intervention classes.

Table 4-11: $T$-test Data for Number of Teacher Days Absent for both Control and Intervention Group Teachers.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Number</th>
<th>$t$</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>5.8077</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention Group</td>
<td>4.1538</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both Groups</td>
<td>1.6538</td>
<td>26</td>
<td>2.859</td>
<td>12</td>
<td>0.014</td>
</tr>
</tbody>
</table>

**Reported Teacher Benefits**

Questionnaires were distributed to all 30 teachers who had sound field distribution systems installed in their classrooms. All teachers returned their form although not every section on the form was completed by every teacher. The questionnaire eliciting information on teacher benefits asked them to focus on their absenteeism from school, on vocal strain, tiredness/energy levels, and irritability levels. These results are summarised in Figure 10.
Figure 10. Teacher perceptions of teacher-benefits from using a sound field distribution system.

**Absenteeism from School**

The majority of teachers did not believe 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 some (N = 5) felt they were able to remain teaching when they were in such a condition. The following are a sample of the comments concerning the effects of the sound field distribution systems on absenteeism made by teachers who choose to do so.

- “No effect that is noticeable. This would be a difficult one to trace.”
- “I’m sure I would have been away earlier without the set.”
- “I am hardly ever away but it has helped several times when I have
had a cold/sore throat.”

**Vocal Strain**

The majority (80%) of teachers commented favourably that they had less vocal strain while using the sound distribution equipment (N = 24). Additional comments identified perceived benefits to the vocal cords, a less raspy voice, and the observation that previously a sore throat usually resulted in a loss of the teacher’s voice. This loss did not occur while using the sound field system. The following comments on vocal strain are a sample of the typical comments made by the teachers.

- “I found it helped me with the level of my voice. I do not have as many headaches.”
- “Vocal strain is completely minimised.”
- “As an asthmatic this has been very useful as inhalers cause voice issues.”
- “It is nice not to have to raise your voice. You can just speak quietly.”

**Tiredness/Energy**

An ease of communication and speaking naturally at reduced voice intensity levels was identified by the teachers as an important contribution to feelings of being less tired and being able to maintain energy reserves (N = 17). The following are a sample of positive teacher comments on fatigue or
tiredness/energy levels related to using a sound field distribution system from the questionnaire.

- “I have a voice that doesn’t normally carry, and so I much appreciate being able to speak at a greater volume and yet not use up all my energy reserves.”
- “It is that much less of an effort to teach with the amplifier—every teacher should have one.”
- “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.”

**Irritability Levels**

It was commented upon by teachers who completed the questionnaire that with the use of sound field system it was much easier to remain energetic and enthusiastic especially in oral test activities as the learners all heard the first time without the teacher needing to repeat questions (N = 16). Many teachers who used the systems consistently for all teaching sessions noted reduced irritability levels in themselves and in their students. The following sample comments made by the teachers on the questionnaire were typical.

- “Being able to speak quietly and still having my voice heard above any working noise reduces any tendency to irritability.”
- “Far less stressed in class activities that are a little noisy.”
- “Generally less irritable because of use of natural voice levels.”
One teacher in their written comment enthusiastically considered it a teacher-altering intervention with 100% reduction in stress levels.

Recap of Teacher Absenteeism and Health Results

The quantitative results presented on the health effects on teachers of using sound field distribution do not support significant variation in absenteeism between the teachers in the intervention group and those in the control group. The qualitative comments made by the teachers in the study do, however, suggest a significant perceived benefit to teachers in terms of teacher vocal strain, tiredness, and energy levels, and decreased irritability when using the sound field system.

Summary

The quantitative and qualitative results of this study have been presented in a framework that addresses each of the research questions originally posed in Chapter 1. These results demonstrate significant improvement in the achievement levels of children and young people in the areas of listening, reading, and mathematics when the environment for learning is enhanced with a sound field system. Benefits, from the use of a sound field distribution system, however, are not just to the learners, but also to their teachers who qualitatively reported that the equipment reduced their vocal strain, irritability, and tiredness. A discussion of these results in an educational context to improve student outcomes follows in Chapter 5.
Chapter 5

Discussion

Introduction

This chapter presents a discussion of the major results of the effects on children and young people’s listening and learning in classrooms with sound field distribution equipment with consideration, where relevant, to results reported in the literature. The results will be discussed by focusing on the research questions. This Discussion chapter will follow the original order of the research questions from Chapter 1 and the framework that was established Chapter 4 where the results were presented.

Until this study there has been no comprehensive information, other than anecdotal evidence, to support the use of sound field distribution equipment as specified in this study in the New Zealand context. The results from this study support the positive benefits previously reported in the literature through use of other sound field configurations (Arnold & Canning, 1999; Crandell, 1994; Crandell & Bess, 1986; Flexer, 1989, 1992; Gilman & Danzer, 1989; Matkin, 1996; Osborn et al., 1989; Ray et al., 1984; Rosenberg et al., 1994; Sarff, 1981; Schermer, 1991; Zabel & Tabor, 1993). Additionally, these results provide new evidence to this growing body of research through the study’s unique focus on benefits when using “boom” or
“Madonna” microphones and a four speaker system. The magnitude of the positive change in percentile rank for listening comprehension provides solid evidence to support the growing acceptance and use of this configuration of sound field distribution as an intervention for enhancing classroom listening conditions.

Strategic goals of the New Zealand Government through the Ministry of Education target raising achievement and reducing disparity. The Secretary for Education stated that “our biggest challenge lies in reducing the disparity in outcomes between our top and lowest achievers” (Fancy, 2004). Fancy further commented that effective teaching is the single most important thing that will bring about a significant lift in achievement and that above all it requires all of us to focus on the one thing that really matters—student achievement. Given that the improvement of educational outcomes for students is a national priority, the results of this research have important ramifications.

Thus, in this chapter the discussion will focus on how the results of this research into using sound field distribution systems in classrooms will contribute to (a) removing a barrier to learning, (b) reducing achievement disparity, and (c) improving student outcomes. To restate, the sequence of the discussion will follow the originally numerated research questions and the presentation sequence of the Results chapter.
Research Question 1: Listening in General

- Is there significant improvement in achievement of primary aged children in the area of listening following a twelve month period of learning in classrooms equipped with a sound field distribution system?

Listening Comprehension

The effect of this intervention using sound field distribution on students' listening comprehension is fundamental to the first and other research questions and represents a major finding of this study. The quantitative test data suggest that there is evidence of significant improvement (> .05 level) in students' listening achievement for the group that experienced learning in a sound field distribution classroom. These results support a previous benchmark three-year longitudinal study in Ohio (Flexer, 1989, 1992; Osborne et al., 1989). The magnitude of positive change in percentile ranks, with a mean of 11.3, was unexpected and exceeds that previously reported in the American studies. Interestingly the control group also demonstrated a positive percentile rank mean change of 3.8. The difference in the positive change in mean percentile ranks for sound field intervention and the non-amplified control rooms, of 7.5, supports the suggestion that classroom sound field distribution appreciably improves students' listening comprehension. Two unique features of the current research design were the use of four speakers to distribute sound, coupled with the exclusive use of boom microphones to enhance the signal-
to-noise ratio. While other studies have used this paradigm to varying degrees, it is suggested that these features may have contributed to the magnitude of the achievements measured.

It was expected that the benefits would be greater for young children as was reported in the Ohio study. Interestingly, this was not observed in the current study. The only test of listening standardised to New Zealand populations commences in year three with a total cohort of 484 students participating. Students in years three, four, and five formed the majority of this group (N = 450). Significant improvements were observed for each year level with year four students making the greatest gain as shown in Figure 11.
Figure 11. Listening comprehension percentile rank mean for sound field intervention and control classrooms by age of schooling.

**Incidental Listening**

Children learn many skills and concepts passively or incidentally, by overhearing what people say in their environment. Flexer (1997) stated that a child with even a minimal hearing loss cannot casually overhear what people say because of the challenges to distance hearing (e.g., background noise, reverberation, etc.). In elaboration, Flexer described distance hearing as the distance over which speech sounds are not merely audible, but intelligible. Flexer also claimed that implications of reduction in distance hearing included a lack of redundancy of the instructional message and a lack of access to social cues.
This study supports findings in the literature of benefits to students’ attending behaviours and the on-task behaviour of students (Benafield, 1990; Flexer et al., 1993). In the current study the benefit of overhearing teacher explanations to other student’s questions was commented upon qualitatively in the questionnaires by both teachers and students. Teachers seemingly perceived this by reporting that there was a reduced need for repetition. The students were most likely to comment on incidental learning with a statement like this previously identified quote… “If you are stuck on something and so is someone else and the teacher answers the other person, you can hear and don’t have to ask the teacher yourself.” The benefits of overhearing instructions can be of particular benefit to those students who, for cultural or personality reasons, often give an appearance in the classroom of being passive learners. In New Zealand, teacher’s frequently anecdotally report that this is the case with Māori students.

In this study the working tone in the classroom was commented upon positively by both teachers and students. Teachers felt that because the students could hear easily, they took more responsibility for listening to instructions. They also felt the sound field distribution system had contributed significantly to learning sounds and improved phonetic skills leading to success in literacy. Some teachers also noted the improvement in the children’s oral language, particularly clarity of speech and their improved performance in spelling tests. This supports the positive findings reported in a previous study which examined student’s spelling (Zabel & Tabor, 1993).
Students commented on the more relaxed learning environment created by using the sound field distribution system. The students also felt teachers were more relaxed and natural and their disciplining of other students was quieter. The majority of teachers using the sound field distribution systems noted the positive benefits to the learners’ comprehension of teacher instructions. They also noted that fewer students needed to seek clarification or repetition of instructions.

**Recap for Research Question 1: Listening**

Children and young people’s improvement in listening comprehension is basic to the research objectives. This discussion has highlighted the magnitude of improvement in listening comprehension. It has been suggested that the design features of this research study, of a configuration of four speakers coupled with a “boom” microphone, have contributed to this magnitude of improved learning outcomes. This study adds to the body of knowledge on sound field intervention and is in agreement with findings from previous studies on the effects of this intervention on listening including the well known studies of Flexer (1989), Rosenberg et al. (1994), and Crandell and Bess (1986). Of particular significance is the support the study provides for sound field amplification in the local New Zealand environment. Although there is limited current Australian research, most previous research has been conducted in North America and Europe where
classrooms have diverse building design, materials, and acoustics and where curriculum and teaching techniques also vary.

**Research Question 2: Reading Achievement**

- Is there significant improvement in achievement of primary aged children in the area of reading following a twelve month period of learning in classrooms equipped with a sound field distribution system?

**Reading Comprehension and Reading Vocabulary**

A significant finding from this study was the strong evidence to suggest reading comprehension and vocabulary achievement improves for children and young people who are taught in classrooms that use sound field distribution. This confirms the similar findings that were found in the three-year longitudinal study in Ohio (Flexer, 1989; Osborn et al., 1989). A significant and interesting result in the current study is the magnitude of improved achievement in the students' reading comprehension. It is suggested that this distinctive finding is attributed to a unique aspect of the current research. While both the current and the Ohio study used four speakers, a choice of lapel or boom microphones was offered to teachers in the Ohio study. The improved S/N ratio provided by the boom microphone configuration, which was used exclusively in the current research helps ensure an optimal S/N ratio is maintained.
An interesting finding in this study was the statistically significant (> .05 level) positive effect on reading vocabulary achievement. Interesting also is the statistically significant increase in vocabulary for the group that was in a regular un-amplified classroom. The degree of change for the control group is unexplained and unusual in a standardised test. The positive benefits from analysis of the mean for percentile ranks were greater for the group in the sound field intervention than for those in the control group.

**Phonologic Skills**

Phonologic awareness and skills are indicators of a student’s development and are linked to their mastery of literacy (Gillon, 2004). Emergent reading skills are enhanced when children are exposed and taught the sound structure of their language (Tunmer, Chapman, & Prochnow, 2002b). A study (Flexer, Kemp-Biley, Hinkley, Harkema, & Holcomb, 2002) suggested that the sound structure of literacy can most effectively and efficiently be taught in amplified classrooms to four and five year old preschool and kindergarten children. The students in the current study who undertook the phonologic tests were aged five and six. A significant and interesting finding in the current research is that these results seemingly support those suggested by Flexer and others in 2002 and extend through to children aged six.

Despite having a homogeneous education system with a uniform
approach to reading instruction and intervention, New Zealand has for several years now consistently shown comparatively high levels of variability in the test scores from international surveys of literacy achievement (Tunmer et al., 2002b). Their study found that incorporating phonologic awareness and alphabetic coding skills into existing classroom literacy programs resulted in an improved average difference in reading age of 14 months by the end of year two.

The current study measured achievements on 10 phonologic skill areas for students in both the sound field intervention and control groups in years one and two. Table 4-6 reported results for the mean of individual paired differences for both the sound field intervention and control groups’ performance on the phonologic awareness tests. It was interesting that the results in all 10 phonologic skill areas were greater for the group that had experienced learning in a sound field environment.

An interesting and statistically significant finding of this study was the magnitude of improvement recorded for the sound field intervention group on their achievement in counting phonemes, achievement in substituting phonemes, and on their ability to delete initial phonemes in blend words. The results reported in the previous chapter do not provide evidence of any significant change in the control group but they do provide evidence of a significant difference in the intervention group.
There exists a body of research that has demonstrated a powerful relationship exists between phonological awareness and literacy development and describing a child’s phonological awareness as the best predictor of reading performance (Liberman, Shankweiler, & Liberman, 1989; Lundberg, Olofsson, & Wall, 1980; Sterne & Goswami, 2000). Enhanced phonological sensitivity is an oral language skill that may support students in reading skills development. While reading levels were not assessed for year one and two students, a significant finding of the current study is that enhanced phonological sensitivity is achieved in classrooms that use sound field distribution systems.

**Recap of Research Question 2: Reading Achievement**

This study has demonstrated the statistically significant benefits in the development of phonological sensitivity in young learners and literacy development in students who have received instruction in classrooms that use sound field distribution. This study clearly suggests that reading comprehension improves significantly and reading vocabulary achievement also improves with this intervention. Phonologic skills, which are a precursor to mastery of literacy, were also enhanced in the classes that used sound field distribution.

The final standardised test administered to the children and young people in this study was the *Progressive Achievement Test* for Mathematics. The effects of sound field distribution on mathematics
Research Question 3: Mathematics Achievement

- Is there significant improvement in achievement of primary aged children in the area of mathematics following a twelve month period of learning in classrooms equipped with a sound field distribution system?

Effects on Mathematics Achievement

This research adds significantly to the body of knowledge on sound field intervention and achievement in mathematics. The only known longitudinal study using sound field distribution equipment to include mathematics improvement data was the Mainstream Amplification Resource Room Study, known as Project MARRS (1989). That study targeted students in Kindergarten to Grade 3 using a two-speaker paradigm. The cohort of students differed considerably in that study from those in the current investigation. Project MARRS was primarily geared to students who had mild or fluctuating hearing loss to enable them to remain in the mainstream settings whereas the current study cohort were all regular mainstream students. Although the current study was of a shorter duration it included a wider range of students—year one-to-six and the sound field equipment used four speakers and the different Madonna-microphone arrangement. In Project MARRS the researchers reported finding higher
general mathematics achievement for the sound field group in grades two and three (New Zealand years three and four) and in particular better achievement in grade three in mathematics computation.

The only available standardised test of mathematics for New Zealand populations commences with year five students. A significant finding in the current research was that the sound field intervention group’s mean for percentile ranks recorded improved positive achievement in the composite strands of the curriculum including mathematical recall, mathematical computation, mathematical understanding, and mathematical application.

An interesting finding was the negative or decrease in mean percentile rank for the control group, that is without the sound field intervention. Further analysis and speculation on this result may provide an understanding for this. The control cohort was smaller (N = 58) and was made up of students in two different classrooms. Both of these classes were composed of exclusively year five students. Conversely the intervention group’s composition (N = 98) was from six classrooms with a mixture of single and composite or whanau (family) classes which have a variety of different-year students.
Other reasons for this unexpected result may include the effectiveness or style of the teachers in the control settings or the varying groupings of students. The teaching of mathematics may have been taught at a year five level although current pedagogy would suggest that not all students would have a single mathematical age just as they would not all have a uniform year five reading age. It is the author’s experience that while most year five teachers would have several reading groups, they would have fewer, if any, differential mathematics groupings. This of course means that if basic understanding is lacking then there is no alternative to develop a student’s understanding at the next progressive level.

The effects of class composition of single cell class level as opposed to composite or whanau (family) classes warrants further study. Both students and teachers highlighted the benefits of overhearing group instructions and explanations which it is suggested occurs more frequently in whanau or grouped lessons where teachers may teach a single topic but at different levels.

**Recap of Research Question 3: Mathematics Achievement**

Research literature into the benefits of sound field distribution systems on mathematics achievement is limited. This discussion has highlighted the significant improvement for students learning in a sound field environment for all four strands of the mathematics curriculum: mathematical recall, mathematical computation, mathematical understanding, and mathematical
application. Questions have been raised regarding the most effective practices regarding the composition of instructional groupings for teaching of mathematics.

**Year 6 Students**

The design of the research required all students taking benchmark assessments to be tested in amplified settings. A cohort of 22 students in year 6 moved to other schools for their final *Progressive Achievement Test* assessment at the commencement of year 7. Although these students had received instruction for a full year in amplified settings, their final assessments were in un-amplified classrooms. The magnitude of their improvement may have varied had they been re-tested in a sound field amplified setting. Alternatively it may indicate that following a year’s immersion in learning in the sound field environment that academic benefits are sustained.

The next three sections concern the research questions what effects sound field distribution has on different groups of students—those with a history of middle ear problems, those of different ethnicity, and those from different socio-economic backgrounds as reflected in decile school attended.
Research Question 4: OM/OME and Listening

- Are listening achievements in students who have been treated for otitis media (OM) or otitis media with effusion (OME) significantly different following learning in a sound field distribution classroom?

Effects on Students with Histories of Middle Ear Dysfunction

Data collected to identify these groups is of wide interest—both medically and educationally. The accuracy with which parents can relate incidence of symptoms pertinent to OME is variable, especially since the disease is asymptomatic in many children. Otological questionnaires can be developed and administered to gain specific information on middle ear dysfunction. In this study a very broad question that was unlikely to be interpreted in many ways by a parent reading the question at their own home was asked about incidence of middle ear dysfunction. Data collected from parental report at the beginning of the study indicated that 32% of the cohort had been treated for middle ear dysfunction. This was identified on the parent/caregiver permission slip and questionnaire as otitis media, more commonly known in New Zealand as “glue ear”. Local health professionals suggest that from the children they see, many local children having failed tests for middle ear dysfunction, do not receive the recommended follow-up treatment from medical practitioners. If the health professionals’ position is correct then it would suggest the incidence of middle ear dysfunction in the local population is well beyond the 32% recorded in this study and would tend to support the findings of Crampton, Nelson, and Bandaranayake.
who found that 49.7% of children in an ethnically mixed low socio-economic status population had at least one episode of bilateral OME in a 13 month period. These incidence rates exceed those previously accepted nationally from the Dunedin Multidisciplinary Health and Development Study. This was the only population-based study to have examined the prevalence of OME in New Zealand and it found 8.8% of children’s ears had OME which was reported by Chalmers, Stewart, Silva, and Mulvena (1989).

The variation of recorded instances of middle ear dysfunction and OME rates will benefit from further clarification, the causes for which may be in the instrumentation recording the data or in interpretations of the terminology. The latter point may lie in the fact that three distinct groups of professionals have studied this topic. Doctors are responsible for the medical and surgical implications of hearing impairment; audiologists evaluate hearing sensitivity and behaviours and address the habilitative issues of hearing impairment, while teachers and parents endeavour to facilitate the learning process and environment which may have been improved by the physicians or audiologists.

Ray (1992) found that students with minimal hearing loss who are instructed in un-amplified classrooms perform academically at a level below normal, while those in amplified classrooms performed at, or above, average levels. Children with OME have been shown by Gravel and Wallace (1992), to benefit in noisy environments on speech recognition by requiring a significantly greater S/N ratio (2.9 dB) over those without OME.
Researchers in other countries have linked sound field use with the achievement of students who have mild hearing loss as well as those with normal hearing (Arnold & Canning, 1999; Flexer, 1999, Gilman & Danzer, 1989). In this study the Paired Samples t-test was used to compare the listening improvement means for children who were identified as having previously been treated for middle ear dysfunction and those who had not. Analysis of listening achievement for these groups did not support the suggestion of a difference in listening achievement being demonstrated by those students who had previously been treated for a middle ear condition. In this study improved achievements in listening comprehension were significant for those in the sound field distribution classrooms. One parent reported that her child had grommets to relieve a middle ear condition and found it much easier to hear the teacher when she was in a sound field amplified classroom. A significant and interesting finding in this study is that positive benefits were demonstrated to apply to all students irrespective of whether they had previously had treated middle ear conditions or not.

Direct causal results are difficult to measure for this group and the fluctuating nature of OME and even more so of OM make diagnosis of the condition difficult. The resulting hearing loss may be in effect at some part during the school day but be resolved later in the same day. One of the most prolific and respected researchers on sound field distribution, audiologist Flexer (1999), reported that about 50% of OME episodes are “silent” with children not appearing to be sick, these episodes therefore go
undetected by parents. Fluid in the middle ear causing a hearing loss can be present, but there is no infection in the fluid. Flexer highlights the complexity of the condition with some 30 to 40% of recurrent cases of OME having allergies as a factor.

Perhaps the effects of OM or OME in the classroom are much more tied in with the temporary hearing loss caused by fluid, which may be resolved relatively quickly with medical intervention, or in some cases, resolved naturally. While the condition with subsequent deleterious effects on listening may be of short duration in some children, in others it may be recurring and essentially causing a longer term hearing loss.

**Recap of Research Question 4: OM/OME and Listening**

Research literature into the benefits of sound field distribution systems on the achievement of students who have had middle ear dysfunction is limited. This discussion has highlighted a high variation in the reported incidence of middle ear dysfunction in New Zealand and some of the difficulties in diagnosing and then treating it. While the implications on a child’s academic achievement are difficult to measure, the findings of this study support the use of sound field distribution and demonstrate the significant benefit to all children, including those that have had middle ear dysfunction.
Research Question 5: Ethnic Groups and Listening

- What comparisons and observations can be made for improvements in listening comprehension between Pakeha and New Zealand’s other major ethnic group, Māori, who have a reported disproportionate incidence of OM and OME?

Effects of Ethnicity

Raising the underachievement of Māori students is a targeted priority for the current New Zealand Government (Ministry of Education, 2004). The Paired Samples t-test was used to compare the listening improvement means for Māori and Pakeha.

In this study the means for listening comprehension of both Māori and Pakeha groups improved markedly. The derived t-score for the difference in mean listening improvement was 1.92. This does not provide sufficient evidence to state that there is a significant difference between the results for Māori and Pakeha.

The use of this intervention to improve outcomes for a single ethnic grouping was therefore not supported in this study. The benefits of this intervention on learning were significant and were demonstrated to apply equally to both Māori and Pakeha. In a similar fashion a recent Australian cross-cultural study (Massie & Dillon, 2004) demonstrated beneficial effects of sound field amplification occurred irrespective of whether the children
used English as a native or as a second language.

A previous Massie-led study (Massie, Byrne, McPherson, Smaldino, & Theodoros, 2002) observed improved attention and class participation following use of sound field distribution with Aboriginal and Torres Strait Islander children. Similarly a smaller Canadian study by Eriks-Brophy and Ayukawa (2000), noted significant benefits in speech intelligibility scores and increased on-task behaviour for Inuit first and second language learners of a remote community in Northern Québec. The current study also highlights improved cooperation and on task behaviour with all students as extracted from the qualitative response of the students and teachers to the questionnaires. As previously noted, the student responses, while positive, were from a small sample of the total cohort. Another North American study which focused on children from other cultures also found benefits when sound field distribution was used, by studying speech perceptual abilities in students for whom English was a second language (Crandell, 1996). A central characteristic of programmes that attend successfully to Māori students' achievement may be their “cultural centredness”, as suggested by Macfarlane (2004), together with an auditory environment enhanced with sound field distribution systems.

**Recap of Research Question 5: Ethnic Groups and Listening**

This discussion clearly suggests that sound field distribution in classrooms benefits all children and young people irrespective of their
ethnicity. Additionally, sound field systems may contribute to minimising differences in achievement by students whose cultural practices influence their learning style, or for those who use a different first language.

**Research Question 6: SES and Listening**

- What comparisons and observations can be made for improvements in listening comprehension between learners from different socio-economic backgrounds?

**Effects on Students from Various Decile Schools**

As previously reported, all New Zealand state schools are rated by the Ministry of Education on a socio-economic decile rating scale of 1 to 10. This rating is used to determine the level of resources a school receives. Students in lower decile schools often underachieve more than those in higher decile schools (Hughes & Pearce, 2003), and it had also been hypothesized that sound field distribution may benefit them more.

The findings showed that while the mean for listening comprehension did increase more for students in the lower decile schools than in higher decile schools it was not at a statistically significant level. The findings clearly showed the use of sound field distribution intervention benefited all students irrespective of their school’s decile rating. When examining student achievement, current Ministry of Education thinking (Alton-Lee, 2003) is that
there are greater individual differences between individual teachers in
schools than between individual schools. The previously quoted Education
Review Office reports on schools and teaching in this study concluded that
most classroom environments were ones that encourage and support
students in their learning. While teacher effectiveness measures are outside
the scope of this study, based on the Education Review Office report, it is
concluded that the majority of teachers in the study were effective teachers.
This study suggests that sound field is particularly effective in improving
achievement when used by an effective teacher. It is not suggested that it
will improve achievement by itself, but is effective when used by a good
teacher.

The Government has recently acknowledged through the Ministry of
Education (2005b) that imminent changes to the decile resourcing formula
will benefit student outcomes. There will no longer be a decile-influencing
factor that is based on the ethnicity of students (Māori, Pasifika, and English
for Speakers of Other Languages). At the same time the Government will
introduce specific programmes and resourcing over the next three years to
improve outcomes for this group. It will also continue in 2005 to increase the
amount spent on decile funding.

The Ministry’s targeting of discrete and unique groups of
disadvantaged learners is timely. The professional development to build
capability of in-service teacher educators and to better apply research
findings with what works in classrooms to improve outcomes for Māori and Pasifika is budgeted to cost $11.75 million (NZD) over three years. The possible significant advantages of providing sound field amplification on a non-racially based formula to the entire country’s children and young people attending some 2,000 schools, to enhance their environment in their first eight years of schooling would cost a similar amount.

**Recap of Research Question 6: SES and Listening**

It has been reported that children coming from a lower socio-economic background do not achieve at the same level as those from more advantaged backgrounds. The issues surrounding this are complex especially for a government attempting to address this imbalance. The findings from this study demonstrate benefits of using sound field distribution as an intervention to improve outcomes for all socio-economic groups.

The last sections to follow concern the research questions that queried the effects of sound field distribution systems had on teachers—specifically absenteeism and attributed benefits.

**Research Question 7: Absenteeism of Teachers or Benefits**

- Is there any significant difference in absenteeism of teachers who use sound field distribution equipment? What teacher benefits are
attributed to using the sound field equipment?

Effects on Teachers

Anecdotal evidence from a previous study (Allcock, 1997) had suggested teachers who used sound field distribution systems were more likely to have fewer absence days from school. In an effort to research this possibility, data in this study included quantitative data in the form of individual school’s returns to the Ministry of Education. The quantitative data researched to answer this question did not provide conclusive evidence to support or not support the consideration of providing sound field distribution in an effort to reduce teacher absenteeism.

For those teachers who agreed to release these data there was no significant difference between the intervention and control groups returns on teacher absenteeism. Qualitative data from 18% of the teachers were comparable to the Allcock study with these teachers commenting that they were able to remain teaching when they had a cold, sore throat, or had an asthmatic condition.

The qualitative data, supported by comments from approximately 20% of teachers, emphasized that the use of the equipment had made a difference to the teachers’ ability to teach when feeling slightly physically impaired. Teachers, who used the sound field distribution systems consistently, qualitatively noted benefits both to their own health and to their
general working environment, which also directly impacts on their health.

Sound field distribution systems distribute a teacher’s voice evenly throughout the classroom. The effort by teachers to project their voices is reduced and in this study 88% of the teachers who used the equipment consistently commented favourably that they had less vocal strain. This has also been reported similarly in other studies (Anderson, 2001; Rosenberg et al, 1994). In the current study it was noted that lower noise levels enabled focused student attention and that there was a quieter calmer working atmosphere in the classroom where teachers were not competing with the voices of the learners. Teachers perceived that these factors had contributed to a reduction in their stress levels.

The positive changes in attending and on-task behaviours of students in sound field settings have previously been observed (Benafield 1990; Flexer et al., 1993). The teachers in the current study noted that the quiet working environment encouraged on-task behaviour and that learners remained on-task for longer periods of time.

It is suggested these enhanced working environmental conditions contribute to feelings of stress reduction by 62% of the teachers who used the systems consistently. These teachers noted feeling less tired and being able to maintain energy reserves. Fifty-nine percent of this group also noted reduced irritability levels in themselves and in their students. The quieter,
calmer classroom tone was identified by 37% of the group to support a
decrease in having to manage disruptive behaviour.

A limitation of this study may have been in the design of the
questionnaire used to gain feedback from teachers. It leads a respondent to
answer in a positive direction as evidenced by the previous comments. A
more neutral questionnaire may have yielded different results.

**Recap of Research Question 7: Absenteeism of Teachers or Benefits**

While this study did not provide significant quantitative data that this
intervention reduces teacher absenteeism, the qualitative comments from
teachers taking part in the study demonstrate that they do find it an
enhancing tool to their teaching and to their health and well-being.

**Conclusions**

This study supports the growing body of knowledge world-wide
indicating that sound field distribution improves achievements by children
and young people. This research has used a four speaker, boom
microphone paradigm. When used by an effective teacher it can improve
literacy and learning outcomes, create enhanced classroom harmony, and
improved student behaviour. It can also reduce vocal strain and stress for
teachers.
Sound field benefits all students seemingly regardless of school decile, ethnicity, or whether or not they are reported to have experienced middle ear dysfunction by their parents.

Sound field achieves these benefits in classrooms that have had only basic acoustic treatments by overcoming problems associated with noise, distance, and reverberation.
Chapter 6

Summary and Conclusion

Introduction

An overview of the results of this study is presented in this chapter. Information on the limitations of this study and suggestions for possible future research are included. This is a significant study into the use of sound field distribution in the New Zealand classroom context and its implications are highlighted. Finally, conclusions on the efficacy of this intervention in mainstream classroom environments are presented.

Overview of Results

Sound Field Dramatically Improves Listening and Reading

Progressive Achievement Tests percentile rankings are normally stable for each child or young person from year to year (NZCER, 1991). Significant improvements were noted in the intervention group’s scores in the Progressive Achievement Tests for listening comprehension, reading comprehension, reading vocabulary, and mathematics (Summary of PAT subtest results are illustrated in Figure 12).
Listening is fundamental to the learning process for most children. Further, the references in the literature describing listening as critical to learning oral languages and literacy and then linking these elements to overall scholastic achievement are numerous. The magnitude of benefit to a learner from being in a sound field amplified enhanced classroom demonstrates a prudent use of available technology to address noise issues that have increased with current teaching methods in classrooms that, in terms of acoustics, have changed little in the past 100 years.

**Sound Field Dramatically Improves Phonemic Awareness and Phonologic Skills**

Like listening, more focused phonemic and phonologic skills are indicators of a student’s development and are also consistently linked to mastery of literacy. Improvements were noted in the intervention group on
all 10 sub scores, with the improvements by the intervention group being greater than that of the control group in all aspects of the tests (Summary of Phonemic Awareness and Phonologic skills are found in Figure 13).

![Image of Phonological Awareness Tests summary.](image)

Figure 13. Phonological Awareness Tests summary.

The level of phonemic awareness of a child is a strong determinant in predicting success in learning to read and can be developed through instruction. The observed benefits from using a sound field system could be improved even more by providing professional development to all teachers who use this intervention. This could easily be achieved by providing mainstream teacher in-service courses on techniques of acoustic phonetics which are commonly used practices of teachers of the deaf, including those...
of acoustic highlighting of phonemes, and the effects of modifying temporal features of phonemes.

**High Acceptance of Sound Field Systems by Teachers**

Ninety percent of the teachers reported using the sound field distribution systems consistently throughout the year-long study. Of this percentage, 63% used the equipment consistently for all teaching sessions and a further 27% used it consistently for selected teaching sessions. The level of acceptance during this study has been high with more improved benefits being noted by teachers that used the system throughout the entire day, and not just for selected sessions. The significant results achieved in this study could be even greater if all teachers used the equipment throughout the day, by choosing when to turn the system off, rather than choosing when to turn it on. Microphone comfort was the only negative equipment issue raised. Feedback to the manufacturer on teacher issues of comfort of the microphones has already been addressed with the manufacturer making changes to the product while maintaining the S/N ratio of the boom microphone.

**Quieter Classrooms**

Sixty-six percent of teachers reported lower noise levels, resulting in greater student attention. This outcome was also qualitatively identified by several students in their responses to the questionnaire and none reported
that classroom environment was louder as the result of the sound field system. This is of general interest because some teachers may intuitively worry that overall sound levels will be inadvertently raised even higher because of the inclusion of the amplification equipment in the room.

In a related fashion to general level of noise in the environment, many children and young people live in noisy homes with televisions on for much of the day and night, and with verbal abuse and violence being the norm in some homes. The overall quieter working tone of the sound field classrooms was appreciated and noted by some students with teachers no longer having to raise their voices to be heard by children.

**Increased On-task Behaviour and Reduced Disruptive Behaviour**

In the response to the questionnaire 73% of teachers noted increased on-task behaviour, with learners remaining on task for longer periods of time. Off-task behaviour was reported as easier to address as the teacher used a friendly voice at a lower volume. Sixty percent of teachers reported improved student cooperation that they also attributed to the use of the sound field distribution system.

Teachers commented on the quieter calmer classroom tone and that it was easier to refocus behaviour without disrupting the routines of others. Students observed that is was less distracting and easier to hear the
teacher over background noise either from outside the classroom or inside from movements by other children.

**Improved Understanding of Instructions**

Two thirds of teachers noted improved student 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. Teachers found that fewer students needed instructions clarified or repeated. Students were also reported being able to hear instructions more clearly irrespective of where the teacher or they were in the classroom.

The effort needed by students who are hearing impaired to listen to a teacher is often exhaustive and if allowances are not made for this fact disruptive behaviours or fatigue can result. The ease of understanding instructions benefits both this group of learners as well as hearing children, when learning in an amplified sound field room, as background noise is considerably reduced.

**Enhanced Classroom Harmony**

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

**Students find it Easier to Hear**

Ninety-eight percent of students who provided feedback about the sound field distribution 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 also easier to hear over competing background noise.

Changes in teaching styles have been evolving particularly since the 1960’s. Current pedagogy now include children and young people as active participants in the learning process with them often being aware of their personal preferred learning style. The students in this study have strongly acknowledged their preference for learning in a sound field amplified classroom. The provision of this learning environment adaptation would seem a logical step if children and young people are truly valued participants in their own learning process.

**Reduced Vocal Strain**

In a previous study of New Zealand classroom acoustics (Valentine et al., 2001) 35% of teachers claimed that the level they needed to speak to be heard strained their voices. Over half of the teachers in the current 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. Over 50% of teachers who used the systems consistently for all teaching sessions noted reduced irritability levels in themselves and in their students.

The majority of teachers did not feel the equipment had a significant impact on their absence from teaching during the study. The benefits of less vocal strain when they had a cold, sore throat, or had an asthmatic condition, however, meant that for some that they were able to remain teaching rather than taking time off.

Local teachers who present with vocal problems caused by their working environment are funded by central government either in the form of sick leave entitlements, benefits, or by funding to hospitals and medical physicians to perform costly surgery. At the same time the government agency that approves this expenditure, the Accident Compensation Commission (ACC), is actively addressing prevention of workplace related claims. As a preventative measure, ACC assistance in providing sound field distribution systems is a positive step it could initiate to lower the incidence of vocal problems amongst teachers.

**Effects Beneficial to All Populations**

Analysis was made on the effects of this intervention on specific
populations: For learners who identified as belonging to Māori rather than Pakeha or other ethnic groups; those who had previously been treated for middle ear dysfunction; and those who attended different socio-economic decile rating schools. The results highlight that there was no significant benefit to any one of these cohorts over another for the methodology used.

The results, however, highlight that this intervention benefited all learner populations. There was a possible trend suggesting that learners in the lower quartile demonstrated the most gain in listening, which suggests that this intervention may have particular benefit for that group.

The discrete potential factors influencing a child’s or young person’s educational achievement that were observed in this study highlight that in fact there are a myriad of factors that influence educational attainment. Effective teachers do not focus on social categories; instead they give their attention to an individual student in an environment that is conducive to learning. Sound field distribution can enhance the learning environment for all students irrespective of their ethnicity, socio-economic status, abilities or disabilities, or gender. For such countries as New Zealand that follow the social and educational ideology of full inclusion, sound field distribution seemingly is an effective tool to assist in supporting those goals.

Limitations

It is important to acknowledge the limitations of the present study as
they assist in guiding the application of the findings of the study as well as possible future investigations. These limitations are discussed in terms of the study’s design.

**Classroom Acoustics**

At the time of this study, the Ministry of Education’s Health and Safety Code of Practice for State Schools (1993), updated in (1995), outlined requirements for lighting, heat, ventilation, and egress but did not include acoustic standards for classrooms. A New Zealand and Australian Standard (AS/NZS 2107:2000) has since been adopted for renovated or new teaching areas by the Ministry of Education (June, 2003a).

The classrooms in the study did not have mechanical ventilation and air conditioning systems which produce high levels of background noise which are perhaps more typical of classrooms in North America or Europe (American Speech-Language-Hearing Association, 1995). In order to adequately ventilate the classrooms, particularly in summer, it is common to open the numerous windows found in New Zealand classroom design. This can add to variations in background noise levels due to external noises from sources such as other classrooms, playgrounds, sports areas, road traffic noises, and rain noise particularly on iron roofing materials. This limitation was unavoidable.
Equipment

The equipment used in all classrooms was exclusively the Phonic Ear Easy Listener Sound field distribution systems with four speakers and Madonna or boom microphones for improved signal to noise ratios. The improved S/N ratio delivered by this equipment and available teacher support were critical variables in this selection process. A single installation team followed the manufacturer's instructions for installation in all classrooms in the study. Variation existed in the design of different classrooms which may have resulted in variations in classroom acoustical conditions. This was an unavoidable limitation in the current study's design.

Future researchers will benefit from knowledge of the significant differences in sound field amplification and PA systems. Sound field distribution systems do not just amplify sound in the sense that a PA system does, but rather they evenly distribute sound. A recent study in Hong Kong found that by achieving a higher S/N ratio, a sound field amplification system was considered a more effective amplification system in classrooms than a PA system (Leung Wai Ho, 2004).

Use of Equipment

A responsibility for participation in the study included using the equipment consistently. The teachers were asked to record their frequency of use of the equipment. The accuracy of data on teacher use may be questioned with a resulting variation in length of time students were in the
enhanced listening environment. Observations and checks on teacher use were made during unannounced “drop-in” visits. Most teachers fully accepted and became familiar with the equipment from the outset, using it consistently following installation and the start of the study. Other teachers took some weeks to remember to use it consistently. The researcher’s observations were in agreement with the teacher’s self-reported use of the equipment. It is suggested that as the study continued for a full year these limitations of initial variation of use were not significant.

**Student Perceptions**

A very low return rate (15%) for student perceptions was returned despite instructions requesting teachers to obtain open-ended comments from the pupils for specific focus areas. The information was sought in the last month of the school year, which is a particularly busy time for teachers with the completion of end of year pupil assessments, report writing, class participation in school concerts, and the taking of class trips. When following up with non-responding classes, some teachers noted these pressures while others felt that the teacher questionnaire, for which there was a very good response rate (100%), had replaced the need for student feedback. Less reliance on teacher cooperation for this aspect of data collection, such as using an independent recorder may have yielded more student responses. Increased significance could have been achieved in this study with greater recording of measurements perceived by the children and young people.
Teacher Absenteeism and Teacher Well Being

The leave form was one unobtrusive piece of data collected by all schools. It was thought that it may have revealed different trends in teacher absenteeism for teachers who do or do not have the support of classroom sound field distribution equipment. The use of this form of absenteeism data as a measurement of well being of teachers is a design aspect that was limiting. The qualitative data collected may give a more accurate perception from the teachers regarding effects on well being.

Middle Ear Dysfunction

While a strength of the study was that all parents were requested to complete the questionnaire on middle ear dysfunction, a limitation was that parental interpretation relied on memories about details of past incidents for the particular child in their family over a period of up to nine years. The incidence of treated middle ear dysfunction was recorded from this data at 32% of the total cohort. Local health professionals suggest that from the children they see, many local children who fail tests for middle ear function
do not receive the recommended follow-up treatment from medical practitioners.

There would appear to have been either discrepancies in completing this data or the acknowledged incidence in this population exceeds that which has been generally accepted nationally.

**Progressive Achievement Tests**

The administration and marking protocols for the standardised *Progressive Achievement Tests* are explained in the teacher's manual for each respective test. As a "group-designed" test, the tests were administered in the student's own classroom by their own teacher. An assumption is made that all teachers administered and marked the tests strictly according to the manual's instructions. With over 40 teachers being responsible for this it is possible that there was some variance from the standardization protocols thus raising reliability issues for the data collected.

**Phonologic and Phonemic Awareness Test**

This test had not been standardised to the New Zealand population of students, raising the reliability of using this tool on this population. Although the test had been used in a trial study in another New Zealand study (Allcock, 1997), it was based on tests standardised to populations in another country, Australia (Neilsen, 1995).
Mathematics Progressive Achievement Cohort

The students that took part in this study included children and young people in years five and six. Unfortunately no control group was available for year six students. The composition of the control group for mathematics (N = 58) consisted exclusively of students in year five. The composition of students in the intervention group (N = 98), consisted of students in year five (N = 64) and year six (N = 34). Many of these year six students were in whanau or family grouped classes consisting of years four, five, and six students. Had a year six control group been included it may have yielded different results and is a limiting factor in the current study.

Implications of Research Results

This is a significant study measuring the effects of sound field distribution on children and young people’s learning. Aspects of the study re-validate some areas previously studied. This study also adds unique information to the international body of knowledge on the use of this intervention. Consequently it will have implications both nationally and internationally.

Central Government

Local school principals were supportive of the research to determine if the intervention would improve educational outcomes for their students. From their own observations while the study was in progress they
determined that student outcomes were positive. These positive benefits have now been quantified through the study.

The efficacy of this intervention is being disseminated through the principal’s networks with resulting pressure being applied on Central Government to sanction and assist schools to provide sound field amplified classrooms. The resources to make this possible are considerable and Central Government is, at this stage, viewing the intervention as a local initiative.

The local principal’s network, with collective responsibility for educational outcomes for students in over 300 classrooms in the city, has recently successfully sought resources from the charitable trust that has been a stakeholder in this study. They have expanded this local initiative to provide sound field distribution for every classroom of students in the city in their first eight years of schooling.

When the research results are disseminated on a national basis it is expected that pressure will be brought on Central Government to assist with purchase of these systems to overcome specific building design problems associated with noise, distance, and reverberation to ultimately assist schools to improve educational outcomes for their children and young people.
Classroom Acoustics

In 1927, Vern Knudsen, a Professor and Chancellor of UCLA, spoke to Public School officials on building construction and stated that good acoustics are important in the school room. This present study supports these comments and should suggest to New Zealand authorities that classroom acoustics are in an even worse situation than they were some 80 years ago due to the changes in teaching practices, higher density population, and increased mechanization among other possibilities. Authorities have addressed more conscientiously other basic needs such as those of illumination and the ventilation of classrooms. The time is well overdue for authorities to acknowledge and address acoustical problems associated with noise, distance, and reverberation.

Further Research

Māori Learners

A growing body of research (Macfarlane, 2004) is identifying successful strategies used in teaching Māori learners. Macfarlane’s ideas of “cultural centredness” and personal relationships between the teacher and the child or young person are central to this. It could be speculated that Māori students improve learning outcomes faster when taken aside and have instruction explained one-to-one rather than in the class setting.

The use of sound field in this study has been a whole class
intervention where teachers have benefited by being asked to repeat instructions on fewer occasions and where students have benefited by overhearing instructions to other students’ questions. It has been suggested to the researcher that an associated shame of other Māori students overhearing a question may be a limiting factor to that student asking other questions. Further research on the use of sound field distribution and appropriateness in the Māori cultural context is suggested.

**Incidence of Middle Ear Dysfunction**

It has been suggested that the design of the instrument to record this may have been open to interpretation by either parents/caregivers or by the children and young people themselves. If the reported incidence in this study is valid, the incidence of middle ear dysfunction greatly exceeds that which has previously been accepted nationally. A re-validation of this statistic is suggested.

**Effects on Boys’ Achievement**

In an address to the Boy’s Education Conference, the Minister of Education highlighted that “two particular weaknesses identified for boys were reading literacy at primary level and internally assessed areas at secondary level” (Mallard, 2004). A Ministry of Education review of research on gender differences in compulsory education highlighted that 67% of those needing literacy help were boys and 73% of students with behaviour
problems were boys (Alton-Lee & Pratt, 2001). The current study suggests that outcomes in literacy and behaviour can be enhanced with the teacher's use of sound field distribution in the classroom. Further studies on the effect of gender difference when using this intervention are suggested.

**Teaching Reading in New Zealand Schools**

The impact on reading achievement and on phonemic and phonological skills, of instruction in a sound field amplified classroom, has been highlighted in this study. The teaching of literacy through a whole language approach has been advocated by the New Zealand Ministry of Education in recent years. This constructivist (learn-to-read-by-reading) orientation used exclusively for beginning literacy is questioned. It is suggested that an exclusive use of this approach to literacy teaching may be a contributing factor to the disparity of achievement in literacy. It is further suggested that a combination of employing effective teaching strategies, including teaching phonologic skills, as advocated by Tunmer et al. (2002b), together with using classroom sound field distribution systems, may lead to a reduction in disparity in outcomes and raise overall student achievement in literacy. Further research is suggested on successful pedagogies for literacy teaching.

**Mathematics Teaching Methods in Primary Schools**

Test statistics on the effects of this intervention on mathematics
outcomes provided an interesting variation of data between the control and intervention classes. It has been suggested that factors influencing these differences may be the teaching approach of whole class instruction versus individualised small group instruction, and single cell class versus composite class or whanau (family) grouping of students. Further study on these topics may explain the variations noted in this aspect of the current study.

**Effects in High School Settings**

The current study observed the benefits in year one-to-six schools. Studies researching the use of this intervention at the high school settings are limited and would benefit from further research.

**Conclusions**

This study provides convincing evidence to support the use of sound field distribution in classrooms when using four speakers and boom microphones. When used by an effective teacher, one who employs a wide range of teaching strategies, it can raise student achievement and remove a barrier to learning.

Significant academic achievements were observed in listening comprehension which has a flow-on effect on the overall scholastic achievement of all children and young people. Evidence of improved
outcomes in areas with a strong link to mastery of literacy were significant, in particular in the areas of phonologic skills and reading comprehension. Sound field distribution can be viewed as an effective intervention to increase literacy outcomes.

The study strongly supports the use of sound field distribution in all mainstream school settings irrespective of whether the children and young people belong to a particular ethnic group, have had a history of middle ear dysfunction, or attend schools of a particular socio-economic status. Classroom sound field distribution comprehensively benefits children and young people.

Sound field distribution is an effective tool, which, together with effective teaching strategies can enhance educational outcomes for students. In classrooms that have had basic acoustic treatments, sound field distribution can diminish the negative effects associated with classroom noise, the distance between the teacher and learner, and reverberation of classroom sound.


Sage Publications.

Leung Wai Ho, S. (2004). *Special school classrooms in Hong Kong: Sound field and public address amplification systems compared.* Unpublished Bachelors Thesis, Department of Speech and Sciences, Hong Kong University.


Oakhill Park, Liverpool, UK: M. G. McLoughlin.


http://www.rotoruatrust.org.nz/


Appendix A

Information Letter and Consent Form for Parents/Caregivers
Information Letter and Consent Form for Parents/Caregivers

Term 1, 2002

Supervisor: Dr Rod Beattie, Renwick College, NSW, Australia
Research Student: Michael Heeney, Westbrook School, 362 Malfroy Road, Rotorua

Project Title: Effects of Classroom Amplification on Learning

Dear Parent/Caregiver,

Last year the Rotorua Energy Charitable Trust donated funds to trial amplification equipment, similar to a public address system, in some Rotorua primary schools. A research project is planned for the current school year and your child’s class is one of the rooms selected to participate.

The research project is under the supervision of Dr Rod Beattie as chief investigator from Renwick College, which is associated with the University of Newcastle in Australia. The doctoral study will be conducted by Michael Heeney as a study to meet higher degree requirements from that University. Michael is the Waikato/Bay of Plenty regional coordinator for deaf education and is based at Westbrook School in Rotorua.

The purposes of the study are to find out the value of classroom amplification systems on children’s learning, if they are of particular benefit to children who have had repeated ear problems, and if they have an effect on the well being of teachers. The report to the Minister of Health, Whakarongo Mai, indicated a higher incidence of “glue ear” among Maori, and so the benefits for this group will be studied. Data will be collected from classrooms with the systems installed and from control classes without the systems.
Your child’s school administers the Progressive Achievement Tests at the start of each year to help in planning teaching materials, methods and programmes most suitable for children in the class. With your consent I wish to collect and use this data at the start of this and next year. Consent forms will be retained by your school principal. I also wish to collect information from spelling tests at the start and conclusion. As such, I would ask you to discuss the project with your child, where appropriate, so that they understand the purpose of the study and that the final decision as to whether they participate in the project rests with them.

Your privacy is assured in accordance with the New Zealand Government Privacy Act (1993). All information gathered as part of this project will be anonymous. No child, teacher, or parent will be identified by name in any report or publication arising from the study. To ensure confidentiality and anonymity each participant will be identified by number code only. You have the right to withdraw from this project at any time and do not have to give a reason for withdrawing.

The following statement is pertinent to any complaints you may experience:

The University requires that all participants are informed that if they have any complaint concerning the manner in which a research project is conducted it may be given to the researcher, or, if an independent person is preferred, to the University’s Human Research Ethics Officer, Research Branch, The Chancellery, University of Newcastle, Callaghan NSW E-mail: Human-Ethics@newcastle.edu.au

Progress on the research will be made available to your school. Final copies of the research report will be forwarded to the Ministry of Education and to your school for your information.

Please contact me if your have questions or return the attached consent form to your child’s teacher if you are willing for him/her to participate in this research.

Yours faithfully,

Michael Heeney

Dr Rod Beattie
Please remove this consent statement from the previous information and return to Michael Heeney

I agree to ________________'s participation in the Effects of Classroom Amplification on Learning study and give my consent freely. Where appropriate, I have discussed this project with my child and gained their consent to participate. I understand that the project will be carried out as described in the information letter that I have retained. I realise that whether or not I or my child participates, the decision will not affect his/her studies at school. I also realise that my child and I can withdraw from this study at any time and do not have to give any reason for withdrawing. I have had all questions answered to my satisfaction.

Signature: __________________________ Date: __________________

Questionnaire:
1. Please tick box your child identifies as:
   - New Zealand Maori
   - Pakeha/European
   - Other

2. Has your child been treated for middle ear dysfunction (otitis media with effusion, or “glue ear”)?
   - Yes
   - No

Please return to your child’s teacher or mail to:

Michael Heeney
Effects of Classroom Amplification on Learning Project
c/- Westbrook School, 362 Malfroy Road, Rotorua
Appendix B

Information Letter and Consent Form for Teachers
Term 1, 2002

Supervisor: Dr Rod Beattie, Renwick College, NSW, Australia
Research: Michael Heeney, Westbrook School, 362 Malfroy Road, Rotorua

Project Title: Effects of Classroom Amplification on Learning

Dear Teacher,

Last year the Rotorua Energy Charitable Trust donated funds to trial amplification equipment, similar to a public address system, in some Rotorua primary schools. As you are aware, a research project is planned for the current school year and you have been selected to participate.

The research project is under the supervision of Dr Rod Beattie as chief investigator from Renwick College, which is associated with the University of Newcastle in Australia. The project will be conducted by Michael Heeney as doctoral research to meet the degree requirements from that University. Michael is the Waikato/Bay of Plenty regional coordinator for deaf education and is based at Westbrook School in Rotorua.

The purposes of the study are to find out the value of classroom amplification systems on children’s learning, if they are of particular benefit to children who have had repeated ear problems, and if they have an effect on the well being of teachers. The report to the Minister of Health, Whakarongo Mai, indicated a higher incidence of “glue ear” among Maori, and so the benefits for this group will be studied. Data will be collected from classrooms with the systems installed and from control classes without the systems.
With your consent, I propose measuring teacher absenteeism through the analysis of the Weekly Schedule of Leave forms that your school provides to MultiServe as one aspect of measuring teacher well being. Consent forms will be retained by your school principal.

Your privacy is assured in accordance with the New Zealand Government Privacy Act (1993). All information gathered as part of this project will be anonymous. No child, teacher, or parent will be identified by name in any report or publication arising from the study. To ensure confidentiality and anonymity each participant will be identified by number code only. You have the right to withdraw from this project at any time and do not have to give a reason for withdrawing.

The following statement is pertinent to any complaints you may experience:

The University requires that all participants are informed that if they have any complaint concerning the manner in which a research project is conducted it may be given to the researcher, or, if an independent person is preferred, to the University’s Human Research Ethics Officer, Research Branch, The Chancellery, University of Newcastle, Callaghan NSW.
Email address: Human-Ethics@newcastle.edu.au

Progress on the research will be made available to your school. Final copies of the research report will be forwarded to the Ministry of Education and to your school for your information.

Please contact me if your have questions or return the attached consent form to me if you are willing to participate in this research.

Yours faithfully,

Michael Heeney

Dr Rod Beattie
Consent Statement

I agree to participate in the Effects of Classroom Amplification on Learning study and give my consent freely. I understand that the project will be carried out as described in the information letter which I have retained. I realise that whether or not I participate my decision will not affect my standing in the school community. I also realise that I can withdraw from this study at any time and do not have to give any reason for withdrawing. I have had all questions answered to my satisfaction.

Signature: __________________________ Date: __________________

Please detach consent form and return to:
Michael Heeney
Effects of Classroom Amplification on Learning Project
c/- Westbrook School, 362 Malfroy Road, Rotorua
Appendix C

Proposal to Rotorua Energy Charitable Trust
Proposal to Rotorua Energy Charitable Trust

WESTBROOK SCHOOL

Easy Listener Soundfield System

Proposal to Rotorua Energy Charitable Trust

Coordinated by Westbrook School
Westbrook School has trialed Soundfield Systems over the last twelve months.

With the support of the Rotorua Energy Charitable Trust we would like to propose that these units are used as part of a Rotorua Incentive Pilot School to support Children’s Listening programmes in selected Rotorua Schools.

The basis of selection would be across Decile 1, 2, 5, and 10 schools to show the advantage across the full educational spectrum.

It is proposed that the project would be researched in part by Mr. Michael Heeney.

If this application is successful it would be our intention to actively seek support from the Ministry of Education to endorse the extension of this project.
PROPOSAL COSTINGS TO
ROTORUA ENERGY CHARITABLE TRUST

Selected Schools:

Westbrook Primary, Sunset Primary, Western Heights Primary, Otonga Primary, & St Marys

30 Units required.

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SOUNDFIELD PROPOSAL

Schedule of Cost per Unit: $xxxxxx

1      xxxxxxxxx
23     xxxxxxxxx
30     xxxxxxxxx
148    xxxxxxxxx
198    xxxxxxxxx
302    xxxxxxxxx

Does not include relocating power points or shelving if required.
Appendix D

Ongoing Communication with Participants

4.1 - Research Update #2
4.2 - Research Update #3
4.3 - Research Update #4
4.4 - Research Update #5
4.5 – End 2002 Checklist for Teachers
4.6 – Classroom Sound Distribution Research Project
Ongoing Communication with Participants

D.1 - Research Update #2

Research Update #2     27 February 2002

Classroom Sound Field Amplification, Listening and Learning
A research project made possible with funding from the Rotorua Energy Charitable Trust

To all participating schools and teachers : Westbrook Primary ( Barry Roberts)
Sunset Primary ( Neils Rasmussen)
Otonga Primary ( Reg Nimmo)
St Mary’s Primary ( Sister Julian)
Western Heights Primary ( Ric Merrington)

Kia ora e hoa mā

I trust the start of the year has been a good one for your staff and students.

The Progressive Achievement Tests which form the basis of the benchmark assessments for the research project will be no doubt be completed soon. This forms phase two of the research. The ethics committee at the University of Newcastle met this week and clearance to distribute the consent forms is anticipated any day. As soon as this happens I will distribute them to you.

Enclosed please find copies of Using the F.M. Sound Field Amplification System. I have prepared this brief summary to assist the teachers in trouble shooting and to ensure the equipment is used effectively. I would imagine that from previous experience that your teachers are already noticing the benefits of the system. From the experience of other teachers it has been found that as teachers get more familiar with the equipment, the use of the system will increase. In fact they tend to rely on it. The “golden rule” is: **choose when to turn the system off, not when to turn it on.**

I would like to meet briefly with the teachers in your school who are participating in the research project to answer their questions and to find out if there are any issues that I can assist with. I suggest that we meet sometime after completion of the P.A.T.s as this is the time when all systems should be in full operation. I am available to meet either before school, at a lunch meeting, or after school. I would appreciate it if you would canvas your staff to find the best time on any of the following days; March 6,7,8,13,14 or 18.

At the completion of phase two, the benchmark data collection stage, I will be forwarding a first progress report to the sponsors of the equipment, the Rotorua Energy Charitable Trust.

I look forward to your confirmation of a suitable time for me to meet with your staff. Please contact me at any time, ph/fax 07-348 8832 or mobile 021-827.485.

Kind Regards

Michael Heeney
D.2 - Research Update #3

Classroom Sound Field Amplification, Listening and Learning
A research project made possible with funding from the Rotorua Energy Charitable Trust and the Oticon Foundation

To all participating schools: Westbrook Primary (Barry Roberts), Sunset Primary (Neils Rasmussen), Otonga Primary (Reg Nimmo), St Mary’s Primary (Sister Julian), Western Heights Primary (Ric Merrington)
& participating classes: Sound Field room #: control room #:____

Kia ora e hoa mā,

I trust the sound field equipment is now an integral part of your day and you are choosing when to turn it off rather than when to turn it on. If you had or are experiencing any difficulties at any time with the equipment working, I hope I am correct in assuming that you resolve these by using the troubleshooting guide and contacts given out at my meeting with you last term. If you still experience difficulty, please contact me directly. With over thirty Rotorua classes participating in this research project it is not possible for me to meet individually that frequently but please contact me if you have a need.

The permission slips to participate in the research are still coming in. Return rates for each of the identified classes-those with sound field equipment and the control classes in those schools vary from 0% return rate to 100% return rate. Up until yesterday I had ___ from your class. While some very few families are choosing not to participate, I suspect that many forms have been left in school bags or “lost in transit”. I ask for your support to target these students. As the PAT testing is complete for all students from year two up, I would like to have a further drive to get more permissions to use the data. I suggest that at the next parents’ report evening you put out more of the forms and draw attention to the research and offer another opportunity to participate. Attached is the Listener article which I distributed last year and complements the description on the ethics clearance form itself. A larger cohort of students from your class will increase validity of conclusions from the research. Your help is appreciated. Please note that your school is invited to invoice me for any additional photocopying done on my behalf. The Oticon Foundation has generously made funds available to support this research project.

The return rate for teacher permission slips to access data on your sick leave during the project is very low. With the similarity of forms to the parental form I suspect many may have overlooked this. I am happy to receive a signed approval by yourself if you are willing for me to access this via your school through the Datacom returns. You then do not need to do anything else on this.

You are participating in research that I am confident will benefit thousands of young New Zealanders. Your school benefits by keeping this equipment which was purchased by the Rotorua Energy Charitable Trust. Some schools have already extended their use by purchasing more sound field equipment systems. I would suggest that prior to further purchases that the principals liaise with each other as Oticon have not only reduced their prices but are offering generous discounts for purchases above 2, 5 and 10 systems.

Kind Regards

Michael

Michael Heeney
07-34 888 32 or 021-827 485 or heeney@wave.co.nz
D.3 - Research Update #4

Research Update #4  22 July 2002

Classroom Sound Field Amplification, Listening and Learning
A research project made possible with funding from the Rotorua Energy Charitable Trust
and the Oticon Foundation

To all participating schools: Westbrook Primary (Barry Roberts), Sunset Primary (Neils
Rasmussen), Otonga Primary (Reg Nimmo), St Mary’s Primary
(Sister Julian), Western Heights Primary (Ric Merrington)

& participating classes: Sound Field room #: ___ control room #: ___

Kia ora e hoa mā,

I trust the equipment is all recharged and operational again after the holiday break and that you are
reaping the benefits of its use. With the winter colds and flu going around I am confident you will
notice even more positive benefits of amplification of your voice through the system. Please
remember to contact me if you have tried the trouble-shooting page and something still isn’t
working as you think it should. Alternatively, if you know a repair is needed, contact or send
directly to Oticon.

We are now half way through the research project. My main task at this stage is to keep all units
fully operational and in use. I am preparing a short questionnaire to distribute during the term
which will give some qualitative data on how you are finding the sound field system and on the
frequency that you use the system. The data collection of the Progressive Achievement Tests
occurs again at the start of next year. The phonological testing of the junior students not covered by
the PATs occurs in term four.

A major piece of research on New Zealand classroom acoustics by Oriole Wilson was recently
released. You may have seen the coverage on TV. It endorsed and encouraged the use of sound
field systems in the New Zealand setting along with the use of acoustic tiles in our noisy
classrooms. If you would like a copy of this research or of the summary of this research please
contact Oticon, on freephone; 0800 OTICON.

Please contact me at any time if you have questions that I can assist with.

Kind Regards

Michael Heeney
Michael Heeney
07-3488832 or 021-827 485 or heeney@wave.co.nz
Please share with your teachers:

Research Update #5  7 October 2002

Classroom Sound Field Amplification, Listening and Learning

A research project made possible with funding from the Rotorua Energy Charitable Trust and the Oticon Foundation

To all participating schools: Westbrook Primary (Barry Roberts), Sunset Primary (Neils Rasmussen), Otonga Primary (Reg Nimmo), St Mary’s Primary (Sister Julian), Western Heights Primary (Brett Griffin)

Kia ora e hoa mā,

I trust the equipment is all recharged and operational again after the holiday break and that you are reaping the benefits of its use. Please remember to contact me if you have tried the trouble-shooting page and something still isn’t working as you think it should. Alternatively, if you know a repair is needed, contact or send directly to Oticon.

A poster summary of the research project is attached. When parents and teachers agreed to be involved I said I would make available progress
updates. I would appreciate it if you would put the poster up and draw it to the attention of staff, board members and parents. You may like to invite participating parents to read the poster through an announcement in your newsletter.

**What happens in term four?**

All teachers will also be given a questionnaire to complete later this term. A focus will be on students behavioural aspects observed while using the equipment. Those teachers in the year one/two groups who administered the phonological testing earlier this year will be repeating this in November. Data on teacher absenteeism will also be collected at the end of the year. I will contact schools individually to find the best process for collecting this from the Multi Serve returns information. The PAT data collection occurs again at the start of 2003. The identification of the intermediate school for 2003 for your senior students will be helpful to a smooth collection of data next year.

Please contact me at any time if you have questions that I can assist with.

Kind Regards

Michael Heeney

07-34 888 32 or 021-827 485 or heeney@wave.co.nz
D.5 - End 2002 Checklist for Teachers

Classroom Sound Distribution Project

School End of Year
CHECKLIST

1. Teacher Questionnaires
   - Majority have been received. Attached duplicates.

2. Teacher Absentees
   - Collation of returns to Datacom to Michael at end of year

3. Phonological Testing
   - Attached materials, only for those junior classes that were tested earlier. Michael has funding for reliever where necessary.

4. PATs
   - Benchmark testing again in 2003

5. Transfers to intermediate schools 2003/Withdrawals 2002
   - Suggestion: Front page roll photo copied (name/dob) and new intermediate school 2003 or withdrawn from current noted beside name.

6. Pupil Comment
   - Open ended comments eg. benefits to listening to directions, noise levels in this years class, effort to listen to teacher, things that would have made it better/easier for students, any comments parents have made to students about changes due to the system etc.

After end of term contact/mailing address:
Michael Heeney  13 Waitawa Place  Rotorua  ph 021 -827485
Greetings «FirstName»

We are in the final data collection stages with the collection of the current round PAT test results. This will give us data to correlate with from 2002. The tests to be collected are all areas that were tested in 2002. Additional tests are included as the next class moves up a level—these additional will not be needed.

The population to be collected from remains the same group that had permission given to participate in the project last year. These students have now moved up a class level. While I can provide a list of these students it has been suggested to me by two principals that it would be easier for schools to provide data from the entire level and let me fathom out who I can and cannot use. Students from your school tested will now be in years «Years». I would like to make this data collection process as smooth and easy as possible and undertake, should you agree to this method of collection, to give the assurance that only those with the permission to participate will be used.

I will be contacting intermediate schools for those students who have moved to an intermediate school.

I am hopeful that during the Easter holiday period I will be able to complete the second data entry and have the end of the term as my target for collection of PAT results. Please contact me if you feel this is not going to be possible. Following the data entry will follow a lengthy analysis and the writing up of this research. It has indeed
been wonderful knowing that at least three of the five participating schools have observed the benefits themselves to the extent that they are not waiting for the final report. Instead they have opted to purchase additional units for the commencement of the current school year.

I thank you in advance for your continued cooperation with the data collection phase. On a more sombre note: If you have teachers new to the equipment this year- please make sure they understand they do not put disposable batteries in a recharging unit as the bill to replace is in the order of $700.00. If you want me to discuss the operation of the sound field units with your teachers at any time please feel free to contact me.

Michael Heeney
Research student
University of Newcastle
Appendix E

School Newsletter Article and Permission Slips

E.1 – School Newsletter Article

E.2 – School Newsletter Notes Re Oticon Brochure
Dear Principal and staff,

The classroom amplification research appears to be progressing well in all six schools. I am now at the data collection stage as the benchmark assessments should all be completed. I am aiming for as large a population as possible for this project. I do need to have written parental permission to use the data and am writing to request your support in obtaining this. I have prepared the following to include in your next Newsletter to support the ethics clearance /letters that are being distributed from Monday 22nd. I am asking teachers to encourage students to aim to return these by Wednesday prior to ANZAC Day. I know this will not be possible for all returns but I find the shorter return time, generally the better return rate. I am planning on a pick-up from your school of these forms on Tuesday 30th April.

I would also appreciate if you and your staff could also target the control group within your school with permission letters. I have discussed this with the teachers in the project but not with your other staff members. The only obligation is to collect the return letters and provide me with PAT data or phonological /spelling data for the year two students.

Both groups also have a teacher letter permission slip to enable me to access data on teacher absenteeism. Anecdotal evidence suggests teachers value the equipment with such comments as “I wouldn’t have gone in today if I didn’t have the FM.”

I thank you in advance for your cooperation. This is a significant piece of local research which I trust will ultimately have implications throughout New Zealand.

Regards

Michael
Newsletter Article  *(I have prepared this as a draft for you to work from- feel free to edit)*

Classroom Sound Field Research Project Permission Slips

Our school is participating in a project that is studying the effects of listening and learning. Rooms______________ have been installed with systems similar to a small public address system. These rooms and a similar control group (Rooms______________) recently had permission letters sent home. I encourage you to read the letters and support this research. Essentially it involves giving out information recorded by the school when we did the Progressive Achievement Tests or for junior students, spelling/phonological tests. This forms benchmark data that will be compared in a years time.

The research is being conducted by a Rotorua educator, Michael Heeney, as part of his PhD work through the University of Newcastle. The project is sponsored by the Rotorua Energy Charitable Trust and at the conclusion of the research, our school along with the other four local schools, keeps the equipment which amounts to a donation of $15,000 to our school. You are invited to contact Michael on 021-827 485 with any further questions. Conclusions from this research will be presented to our Board, the Ministry of Education and to other stakeholders.
E.2 - School Newsletter Notes Re Oticon Brochure

ST MARYS SCHOOL – Article for School Newsletter.

SOUND FIELD SYSTEMS

Children in rooms 10, 9, 8, 7, Totara, Rimu will be taking home a brochure which explains more about the sound field systems being used in their classrooms as part of a year long research project. The control room Rata will also bring a brochure home.

If you have not yet sent in your child's consent form please return it to class teacher as soon as possible.

Thank you. Michael Heeney

WESTERN HEIGHTS PRIMARY SCHOOL – Article for School Newsletter.

SOUND FIELD SYSTEMS

Children in rooms 6, 16, 1, 8, 4, 20, will be taking home a brochure which explains more about the sound field systems being used in their classrooms as part of a year long research project. The control rooms 2, 10, 18, 17, will also bring a brochure home.

If you have not yet sent in your child's consent form please return it to class teacher as soon as possible.

Thank you. Michael Heeney
CREATING ENHANCED LEARNING ENVIRONMENTS
The benefits of sound-field amplification systems

Michael Heeney, MA, Adv Dip Tch, AODC, Dip EHI,
PhD student at University of Newcastle, Australia
Regional Co-ordinator, Kelston Deaf Education Centre
CREATING ENHANCED LEARNING ENVIRONMENTS

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.

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

Sound-field classroom amplification systems 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 Rototuna, 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 Phonak Ear Easy Listener sound-field systems. The Easy Listener's high frequency emphasis ensures best speech intelligibility in noisy conditions. The four loud speakers were mounted around the room to create even distribution of sound. The teachers used wireless transmission with "Madonna style" microphones to maximize the signal to noise ratio. Their speech was transmitted via FM radio waves to an amplifier/preamplifier. The units were set up as suggested by the manufacturer. Tone and volume controls were individually adjusted for maximum clarity in accordance with each teacher's voice and each classroom's acoustical characteristics. All teachers received training in how to use the Easy Listener 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.
CREATING ENHANCED LEARNING ENVIRONMENTS

FINDINGS

Sound-field dramatically improves listening and reading

PST percentile rankings are normally stable for each child from year to year. Significant improvements were noted in the intervention group’s scores in the PST 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.

Sound-field dramatically improves phonological skills

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

Quicker classrooms

Sixty-six per cent 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 in the room as much."

Increased on-task behaviour

Seventy-three per cent of teachers noted increased on-task behaviour, with learners remaining on-task for longer periods. Off-task behaviour was reported as easier to address when 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 redirect when they went off-task."

"I have noticed some learners make exceptional progress – they are auxiliary 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 children 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.

Table 1: Progressive Achievement Tests Results

<table>
<thead>
<tr>
<th>Subject</th>
<th>Intervention</th>
<th>Control</th>
<th>Mean Change</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listening</td>
<td>22.3</td>
<td>10.2</td>
<td>11.3</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Comprehension</td>
<td>30.7</td>
<td>30.6</td>
<td>0.10</td>
<td>p=0.051</td>
</tr>
<tr>
<td>Reading</td>
<td>106</td>
<td>83</td>
<td>23.7</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Comprehension</td>
<td>60</td>
<td>40</td>
<td>20.4</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Reading Vocabulary</td>
<td>107</td>
<td>82</td>
<td>24.1</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Mathematics</td>
<td>206</td>
<td>162</td>
<td>44.2</td>
<td>p=0.004</td>
</tr>
<tr>
<td>Control</td>
<td>45</td>
<td>32</td>
<td>13.0</td>
<td>p=0.017</td>
</tr>
</tbody>
</table>

Figure 4: Progressive Achievement Tests
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 sense of 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.

"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 read she doesn't have to shout!"

Reduced vocal strain

In a previous study of classroom settings, 85 percent of teachers claimed that the level they need to speak at to be heard strained their voices. 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 finding less tired and being able to maintain energy reserves.

"Vocal strain is completely minimized."

"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 90 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-saving 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
CREATING ENHANCED LEARNING ENVIRONMENTS

intervention period. The benefits of low 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 PRT for listening comprehension was analysed for 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 significant difference between the improvements in those who had previously been treated for middle ear dysfunction and those that had not.

SUMMARY

- Sound-field improves learning and literacy outcomes, creates enhanced classroom harmony and improved student behaviour, and reduces vocal 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 practice needs 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.
- Teachers should be 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.
CREATING ENHANCED LEARNING ENVIRONMENTS

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. 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 Allan for New Zealand children based on the Sutherland Phonological Awareness Test. The tests measure achievement in ten specific phonetic areas from letter-sound relationships to counting phonemes and the ability to substitute phonemes in blends 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.

References

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- Dr Rod Battie, University of Newcastle for supervising the study.
- The principals, teachers and students at Western Heights Primary School, Western School, Sunset Primary School, Otonga School, St Mary's School for participating in the study.

FURTHER INFORMATION
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Email info@otsman.org.nz
Published in February 2004 © Otsman Foundation in New Zealand Limited
Appendix F

Equipment User Guides

F.1 - Users Guide for the Easy Listener PE 210 Sound Field System
by Phonic Ear®

F.2 - Brief Guide and Trouble Shooting
EASY LISTENER™

PE 210 sound field system

user guide
PE 210R receiver
PE 210FSR receiver
AT0578 mini speakers
AT0664 ceiling speaker
AT0806 distributed ceiling speaker
PE 300T transmitter

other resources on line at www.phonicear.com
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Distributed ceiling speaker: AT0806 ............................................. 4
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base station receiver: PE 210R/PE 210FSR

1. FM volume
   Controls the volume of the presenter's voice through the FM transmitter

2. auxiliary volume control
   Controls the volume of auxiliary sound equipment — such as TVs and CD players — plugged into AUX INPUT jack on back of receiver (see 9)

3. tone
   Controls bass-to-treble emphasis

4. ON indicator
   Lights when unit is powered and functioning

5. NO FM indicator
   Lights when unit is not receiving an FM signal

6. power switch
   Powers the unit
**base station receiver: PE 210R/PE 210FSR (cont’d)**

7. **power jack**
   Connect AT0577 wall transformer here

8. **speaker output terminals**
   Connect to speaker(s) via speaker cables; match red to red
   and black to black; depress and release lever to secure

9. **auxiliary input jack**
   Connect a TV, CD player or other secondary sound source here

10. **antenna jack**
    Connect antenna here

11. **channel number**
    Make sure the channel matches your transmitter

12. **frequency selector switch (PE 210FSR only)**
    Switch to the channel that matches your transmitter

13. **indicates FSR model (PE 210FSR only)**
**transmitter: PE 300T**

14. on/off switch

15. charging indicator
   - Glows red when charging NiCad or NiMH batteries
   - (Never recharge alkaline batteries!)

16. channel number
   - Make sure the channel matches your receiver

17. battery compartment
   - Use AA rechargeable NiCad or disposable alkaline batteries
   - (never recharge alkaline batteries!)

18. belt clip

19. microphone jack
   - Plug in a directional microphone (AT8291-L lapel mic or, preferably, the AT855M microphone behind-the-neck mic)

20. auxiliary charge jack
   - Connect to a CD player or other device through the AT9532 cord to transmit a second sound source; connect to personal charger (see 21) to recharge NiCad or NiMH batteries (never recharge alkaline batteries!)
cluster ceiling speaker: AT0664

21 safety wires
Loop through speaker and attach to stable beam

22 speaker cable crimp connectors
Connect to receiver via speaker cables; match red to red and black to black and crimp with pliers to secure

distributed ceiling speaker: AT0806

23 mounting tabs
Allow quick and easy installation
mini speakers: AT0578S

24 speaker input terminals
Connect to receiver via speaker cables; match red to red and black to black; depress and release lever to secure.

25 speaker cable strain relief
Feed speaker cable through eyehole to reduce strain.

26 speaker stand adapter (optional)
Use to mount speaker on AT0579 floor stand or AT0579-T tabletop stand.

27 wall mount harness

28 wall mount bracket
sound field system setup and operation

1 understanding sound field

but

• distance
• noise
• echo
• vocal fatigue

2 charging

charging 300T

1 Plug charger into unit
2 Plug charger into wall socket

• Charge every night for 12 hours
• Charge only rechargeable NiCad or NiMH batteries
• Never recharge alkaline batteries

replacing batteries

1 Push off battery compartment door
2 Insert batteries into compartment and replace door
sound field system setup and operation (cont’d)

### 3a where to mount mini speakers (AT05785)

- Use as many speakers as is practical (4 are recommended).
- Mount on walls, ceiling beams, columns, or other structure to bring speakers close to listener.
- Mount speakers as high up as possible and angled down.
- Aim speakers down toward listeners’ faces.
- The farthest listener each speaker can serve should be less than twice as far away as the closest listener. (D2 > 2D1 in diagram)

### 3b mini speaker mounting

1. Screw wall bracket into wall
2. Screw harness into round hole in wall bracket
3. Screw speaker onto wall bracket
4. Attach harness to top of speaker
5. Attach speaker wires to back of speaker
6. Aim the speaker to desired position*
7. Secure speaker by tightening the ball joint using a 4mm Hex Key

* Consult Sound Wizard program for best speaker placement.
3c daisy chaining

- Daisy chaining allows setup with shorter cable lengths
- For optimum performance, daisy chain speakers in pairs: e.g. speakers 1-2 plus 3-4 rather than 1-2-3-4

3d where to mount ceiling speakers (A06664)

- Center speaker over listening area
- >3.5m/12ft ceiling recommended
- >30cm/1ft distance from fluorescent lighting transformer is recommended
**sound field system setup and operation (cont’d)**

3e  ceiling speaker mounting  
(AT0664)

1. Remove 60 x 60 cm/2 x 2 ft ceiling tile
2. Lower speaker into space
3. Secure safety wires
4. Connect and crimp speaker cable (run cable along wall)

3f  where to mount ceiling distributed speakers  
(AT0806)

- Space speakers evenly over listening area
- >3.5m/12ft ceiling recommended
- >30cm/1ft distance from fluorescent lighting transformer is recommended
sound field system setup and operation (cont’d)

3g distributed speaker mounting
(AT0806)

1. Cut and remove round hole in ceiling tile
2. Slide speaker into hole in tile
3. Tighten screw in mounting tab

NOTE: Speakers should be evenly spaced over the listening area

4a installing the receiver

1. Plug transformer into receiver
2. Plug transformer into wall socket
3. Connect speakers (red to red, black to black)
4. Connect antenna
5. Connect secondary sound source (optional)
6. Set dials as shown
sound field system setup and operation (cont’d)

5 using the transmitter and mics

1. Clip to belt or wear around neck
2. Put on microphone
3. Plug in microphone
4. Turn transmitter power on

- AT0712
- AT0512
- AT0291-L directional mic
- AT0816 collar mic
- AT0814M earhook mic
- optional
- recommended
- AT0655M (two wearing options)

Keep antenna cord as straight as possible. Do not coil

then

4. Power
sound field system setup and operation (cont’d)

6 activate the base-station receiver

1. Turn power on
2. Confirm “On” light is lit
3. Adjust FM VOL as necessary
4. Adjust AUX VOL if team teaching or using TVs, CD players, etc.

7 walk, talk, and listen to quality (Initial setup only; reposition speakers if necessary. See 3)

- Ask another person to assess volume levels from front and back of room while you speak
sound field system setup and operation (cont’d)

8 team teaching: option 1

with a handheld mic

first teacher
second teacher

team teaching: option 2

with another 300T & 300R

1 Adjust FM VOL, AUX VOL as necessary

2 Adjust VOL as necessary
optimal channel pairs for team-teaching

When setting up a team teaching system using personal FM transmitters (see [8]) it is a good idea to select channels that are as far apart as possible. Here are some recommended channel pairs.
**specifications**

**base station receiver: PE 210R/ PE 210FSR**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving frequency</td>
<td>72MHz to 76MHz (U.S./Canada)</td>
</tr>
<tr>
<td></td>
<td>37, 72, or 173 MHz (outside U.S./Canada)</td>
</tr>
<tr>
<td>Frequency stability</td>
<td>±200Hz 0° to 50°C</td>
</tr>
<tr>
<td>Modulation</td>
<td>FM narrow-band</td>
</tr>
<tr>
<td>S Frequency response</td>
<td>100Hz to 1kHz ±3dB</td>
</tr>
<tr>
<td>Speakers</td>
<td>Four 8-ohm</td>
</tr>
<tr>
<td>Maximum acoustic output</td>
<td>90dB SPL @ 1m</td>
</tr>
<tr>
<td>Auxiliary input level</td>
<td>100 mV</td>
</tr>
<tr>
<td>Aux input impedance</td>
<td>&gt;10k ohm</td>
</tr>
<tr>
<td>Signal-to-noise</td>
<td>&gt;60dB</td>
</tr>
<tr>
<td>THD</td>
<td>&lt; 2%</td>
</tr>
<tr>
<td>Nominal deviation</td>
<td>±3.6kHz</td>
</tr>
<tr>
<td>Maximum deviation</td>
<td>±10kHz</td>
</tr>
<tr>
<td>Squelch</td>
<td>RSSI Type</td>
</tr>
<tr>
<td>Squelch level</td>
<td>1µV at 20dB SINAD</td>
</tr>
<tr>
<td>Power supply</td>
<td>16.5VDC at 1.2A (AT577)</td>
</tr>
<tr>
<td>User controls</td>
<td>ON/OFF/VOL</td>
</tr>
<tr>
<td></td>
<td>FM VOL</td>
</tr>
<tr>
<td></td>
<td>AUX VOL</td>
</tr>
<tr>
<td></td>
<td>TONE</td>
</tr>
<tr>
<td></td>
<td>Channel selector (PE 210FSR)</td>
</tr>
<tr>
<td>Displays</td>
<td>LEDs for “On” and “No FM”</td>
</tr>
<tr>
<td>Color</td>
<td>Black with purple/white lettering</td>
</tr>
<tr>
<td>Size</td>
<td>21.6 x 12 x 6.4 cm/8.5 x 6 x 2.5 in</td>
</tr>
<tr>
<td>Weight</td>
<td>635g/1.4 lbs</td>
</tr>
<tr>
<td>Case</td>
<td>Aluminum, baked enamel finish</td>
</tr>
</tbody>
</table>

**transmitter: PE 300T**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitting frequency</td>
<td>72MHz to 76MHz (U.S./Canada)</td>
</tr>
<tr>
<td></td>
<td>37, 72, or 173 MHz (outside U.S./Canada)</td>
</tr>
<tr>
<td>Modulation</td>
<td>FM narrow-band</td>
</tr>
<tr>
<td>Operating range</td>
<td>30m/100ft</td>
</tr>
<tr>
<td>User controls</td>
<td>Off/on</td>
</tr>
<tr>
<td>Inputs / Outputs</td>
<td>3.5mm auxiliary input jack</td>
</tr>
<tr>
<td></td>
<td>2.5mm microphone input jack</td>
</tr>
<tr>
<td>Battery life</td>
<td>40Hr (AA alkaline)</td>
</tr>
<tr>
<td></td>
<td>10Hr (AA NiCad)</td>
</tr>
<tr>
<td>Size</td>
<td>2.5 x 9.4 x 5.6 cm/1 x 3.7 x 2.2 in</td>
</tr>
<tr>
<td>Weight</td>
<td>80g/2.8oz</td>
</tr>
<tr>
<td>Case</td>
<td>ABS Cycloc plastic</td>
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## Specifications (cont’d)

### Mini-speakers: AT05785

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Speaker Type</td>
<td>Bass reflex</td>
</tr>
<tr>
<td></td>
<td>8.9cm/3.5in woofer</td>
</tr>
<tr>
<td></td>
<td>2.5cm/1in soft-dome tweeter</td>
</tr>
<tr>
<td>Impedance</td>
<td>8 Ohms</td>
</tr>
<tr>
<td>Capacity</td>
<td>40W continuous power</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>100Hz to 10kHz</td>
</tr>
<tr>
<td>User Control</td>
<td>On/off switch</td>
</tr>
<tr>
<td>Size</td>
<td>17.8 (H) x 11.4 (W) x 12.7 (D) cm/7 (H) x 4.5 (W) x 5 (D) in</td>
</tr>
<tr>
<td>Weight</td>
<td>1.13kg/2.5lbs</td>
</tr>
<tr>
<td>Mounting</td>
<td>Wall mounting brackets provided</td>
</tr>
<tr>
<td></td>
<td>(tabletop/floor stands also available)</td>
</tr>
<tr>
<td>Cable</td>
<td>AT0581 7.3m/24ft, 14.6m/48ft, and 18.3m/60ft lengths available</td>
</tr>
<tr>
<td>Strain Relief</td>
<td>Spring-loaded pull-out cable retainer</td>
</tr>
</tbody>
</table>

### Cluster Ceiling Speaker: AT0664

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td>Speaker Type</td>
<td>4 full-range 20cm/8in speakers</td>
</tr>
<tr>
<td>Impedance</td>
<td>8 Ohms</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>96dB SPL 1W @ 1m</td>
</tr>
<tr>
<td>Capacity</td>
<td>40W, RMS</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>30Hz to 15kHz</td>
</tr>
<tr>
<td>Size</td>
<td>60.3 (H) x 60.3 (W) x 7.6 (D) cm/23.75 (H) x 23.75 (W) x 3 (D) in</td>
</tr>
<tr>
<td>Weight</td>
<td>4.53kg/10lbs</td>
</tr>
<tr>
<td>Mounting</td>
<td>Wall mounting brackets provided</td>
</tr>
<tr>
<td></td>
<td>(tabletop/floor stands also available)</td>
</tr>
<tr>
<td>Cable</td>
<td>AT0581 18.3m/60ft</td>
</tr>
<tr>
<td>Enclosure</td>
<td>Composite</td>
</tr>
</tbody>
</table>

### Distributed Ceiling Speaker: AT0806

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS Power</td>
<td>35W</td>
</tr>
<tr>
<td>Max Power</td>
<td>70W</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>63Hz to 20kHz</td>
</tr>
<tr>
<td>Impedance</td>
<td>8 Ohm</td>
</tr>
<tr>
<td>Tweeter</td>
<td>.5 in mylar dome</td>
</tr>
<tr>
<td>Dimensions (Dia x D)</td>
<td>203 x 5.7 cm/9 x 2.25 in</td>
</tr>
<tr>
<td>Weight (approx)</td>
<td>1.11kg/2.4lbs</td>
</tr>
<tr>
<td>Cable</td>
<td>AT0581 7.3m/24ft, 14.6m/48ft, and 18.3m/60ft lengths available</td>
</tr>
</tbody>
</table>
accessories

**microphones**
- Noise-canceling behind-the-neck microphone with mute (AT0655M) (recommended)
- Earhook microphone with mute switch (AT0814M)
- FM collar microphone with mute switch (AT0816)
- Directional mic with mic clip and lavalier cord (AT0291-L)
- Mic jack antenna (AT0529 A)
- AUX input patch cord 1.5m, 4.5m/5ft, 15ft (AT0532)
- PE 211 Wireless microphone system

**transmitter options**
- Wire belt clip (AT0489)
- Lavalier cord (AT0512)
- 2 rechargeable NiCad batteries (AT0665)
- Two-unit charger (AT0534)
- Waist belt (AT0712)

**receiver accessories**
- Auxiliary input cord (AT0653) 195cm/30in
- Antenna
  - 37MHz: AT0617
  - 72MHz: AT0809
  - 173MHz: AT0566
- Wall transformer (AT0577)

**speaker accessories**
- Cluster ceiling speaker (AT0664)
- Distributed ceiling speaker (AT0806)
- Mini speaker (AT0578S)
- Tabletop speaker stand (AT0579-T)
- Speaker floor stand (AT0579)
- Speaker stand adapter (AT0582)
- Speaker cable 7m/24ft, 15m/48ft, 18m/60ft (AT0581)
- Speaker wall mount bracket (AT0578B)
caring for your system

cleaning
Clean as needed, using a soft, damp cloth.

storage
Clean with a soft damp cloth and remove the batteries from the transmitter. Place the system into an AT0580 carrying case or original packaging.

other important notes
• Protect your sound field system from excessive moisture, heat, and mechanical shocks.
• The case bottom of the PE 210R and PE 210FSR receivers, as well as the AT0757 wall transformer can get warm under normal operation.
• To protect the transmitter’s case front, position it face down on a soft surface when removing or inserting the batteries.
• Always dispose of old batteries in approved battery recycling bins. It may be illegal to dispose in the trash. If you are not sure of proper disposal method, please consult your local authority.
warranty

time period of warranty
This warranty will go into effect upon the date of purchase and will stay in effect as long as the instrument remains the property of the original owner. ONWAVE® has a 3-year warranty; VOCAPOINT™ and VOCUSMART™ have a 2-year warranty. All other products have a 1-year warranty.

what is covered by this warranty
Any electronic component, which because of workmanship, manufacturing or design defects, fails to function properly under normal use during the life of this warranty will be replaced or repaired at no charge for parts or labor, when returned to the factory service center. Transportation in and out is paid by the customer. If it is determined that repair is not feasible, the entire unit may be replaced with an equivalent unit upon mutual agreement of the manufacturer and customer.

what is not covered by this warranty
This limited warranty does not apply to:
1. Malfunctions resulting from abuse, neglect or accident
2. Instruments connected, installed, used or adjusted in any manner contrary to instructions provided by the manufacturer
3. Consequential damages and damages resulting from delay or loss of this instrument. The exclusive remedy under this warranty is strictly limited to repair or replacement as herein provided
4. Products damaged in transit unless investigated by the shipper and returned to the warrantor with the investigation report
5. Peripheral accessories as itemized within the product specification sheet as applicable, when such items are returned within 90 days from original purchase
6. Batteries if applicable

Phonic ear Inc. reserves the right to make changes in the design or construction of any of its instruments at any time without incurring any obligation to make any changes whatsoever on units previously purchased.

This warranty is in lieu of all other expressed warranties. All expressed and implied warranties will terminate upon the expiration of this written warranty. No representative or person is authorized to represent or assume for us any liability in connection with the sale or use of our products other than as set forth above.

what to do if you have questions
If you have any questions about service, call the service department at 800.227.0735, then press 7.

what to do if you need service
If you require service under the warranty terms, obtain a service order form either online at www.phonicear.com/support.asp or through our U.S. customer service department at 800.227.0735, then press 5 (or +1,707,769,1110 outside the U.S.). Fill the form out completely remembering to include:
1. Description of the problem
2. Your billing address
3. Your shipping address (if different from billing address)
4. Contact name and phone number
5. A P.O. number if the equipment is not under a warranty or service contract

Then, carefully package the equipment in the original shipping container to prevent damage and send it postpaid to the service center near you:

USA/International:
Phonic Ear Inc.
3880 Cypress Drive
Petaluma, CA 94954-7600
U.S.A.

In Canada:
Phonic Ear Ltd.
10-7475 Kimbel Street
Mississauga, Ontario
L5S 1E7 Canada

what to do if you have questions
If you have any questions about service, call the service department at 800.227.0735, then press 7.

about your batteries
To ensure that your batteries are as fresh as possible upon arrival, we have intentionally not installed them in your equipment.

install your batteries in your equipment now, then charge overnight before initial use (see user guide for charging procedure).

avoid battery corrosion
To avoid battery corrosion and damage to your equipment, do not recharge disposable or rechargeable alkaline batteries. Before charging any Phonic Ear equipment make sure only NiCd or NiMH rechargeable batteries are installed. As an added precaution, remove batteries if the equipment will not be used for several weeks.
troubleshooting

no FM reception ("NO FM" light on receiver stays on)
• Check that the transmitter is on
• Verify that the channel number of the transmitter and the receiver are the same
• Verify that the channel selector switch (PE 210FSR only) is set correctly
• Verify that the receiver antenna is attached
• Recharge or replace the transmitter’s batteries
• Verify that the microphone is working (test with another working microphone)

feedback
• Lower the FM VOL control on the receiver
• Reduce the TONE control on the receiver
• Make sure that the person wearing the 300T transmitter is not too close to the speakers
• Verify that only the AT0655M behind-the-neck mic, AT0513 over-the-head mic, AT0814M earhook mic, AT0816 collar mic or AT291 directional mic is being used with the PE 300T transmitter

weak output from speaker(s)
• Increase FM and/or AUX VOL control
• Check that none of the AT0578S speakers is blocked or covered
• Reposition the microphone closer to the speaker’s mouth
• Place the AT0578S speakers closer to the listeners
• Verify that the AT0664/AT0806 ceiling speaker has been properly installed

receiver won’t turn on (power light doesn’t turn on)
• Verify that the wall transformer is plugged into a working wall outlet
• Test with another AT0577 wall transformer

no sound from one speaker
• Verify that the speaker switch is in the ON position
• Verify that speaker cables are connected at the speaker and receiver terminals
• Disconnect speaker cable and reconnect with a new cable
• Replace speaker in question
the basics

1. **using the transmitter and mics**

   1. Clip to belt or wear around neck
   2. Put on microphone
   3. Plug in microphone
   4. Turn transmitter power on

   - AT0712
   - AT0512
   - AT0291-L directional mic
   - AT0816 collar mic
   - AT0814M earhook mic (recommended)
   - AT0655M (optional)

   - Keep antenna/cord as straight as possible.
   - Do not coil

   then

   - Power
the basics (cont’d)

2. Activate the base-station receiver

1. Turn power on
2. Confirm “On” light is lit
3. Adjust FM VOL as necessary
4. Adjust AUX VOL if team teaching or using TVs, CD players, etc.

Decreasing tone is recommended for “echoing” spaces with hard floors, bare cement walls, large windows, and other acoustically reflective items.

Increasing tone is recommended for “nullified” areas with padded furniture, carpeting, draperies, and other acoustically absorptive items.
6.2 - Brief Guide and Trouble Shooting

Using the FM Sound Field Amplification System

Once the system has been installed, it is easy to use and it is unlikely you will encounter many problems with its use.

It takes a short while to get into a routine of wearing the microphone every day and remembering to recharge it at the end of each day, but other than that there is very little for you to do.

The best way to ensure you get the most benefit from this sound system is to…

Turn it on at the start of the day, and turn it off by choice!

If you are working with a small group of children, you may wish to turn off the transmitter. You must remember to turn it on again to give the class instructions. Many children with compromised hearing miss a lot of incidental comments and instructions throughout the course of the day. If you use the sound system all the time these incidental comments and instructions will not be missed.

Choose when to turn the system off, not when it turn it on!

Setting up the System

Speakers

There are four speakers installed in each corner of the room. They should be installed so that they do not directly face each other. They should be slanted down towards the centre of the room.

Each speaker is connected to the receiver by a wire. Each wire has two connections – one red and one black, which should be connected to the appropriate space at the back of each speaker.

Each speaker has an on and off switch at the back, which should be on.
Receiver

The receiver should be on a shelf out of the reach of small fingers. Once the appropriate speech enhancement/tone and volume has been achieved, the settings do not need to be altered.

Once the correct volume has been established it is a good idea to put a mark with correction fluid at the point where the volume control button should be. This allows you to reset it should it be altered at any time.

The volume and tone buttons are the ones to use to adjust the sound. The aux. volume is not needed for normal use.
There is an antenna at the back of the receiver which should not need adjusting.

The receiver has an on and off switch. Turn this off at the end of the day when the system is not in use. If your transmitter is not on, or the batteries are flat a red light will go on which says ‘No FM’. It will go off when your transmitter is sending a signal.

The speakers are connected to this receiver at the back. They must be attached according to the correct colour – red wires to the red terminal, black wires to the black terminal.

Transmitter

This clips to your pocket or a belt. The microphone is plugged into the appropriate point.

Your microphones have a mute button to save you turning off the transmitter if you wish to speak quietly or privately to someone.

At the beginning of each day, check that the transmitter and the microphone are both on, when you wish to use the system.

The transmitter runs on two AA rechargeable batteries. There is a recharging plug, which attaches to the transmitter and plugs into the mains power. The transmitter needs to be recharged each night.

Never recharge normal batteries: They will destroy the transmitter and could cause a fire!

Microphone

You are using the “Madonna” or ear-hook “boom” microphone. Adjust the mouth-piece so that it is as close to the centre of you mouth as possible,
while being out of your line of vision. There is a little white dot that should be facing your mouth.

It will prove best to mould the wire to your skull for maximum comfort. The manufacturer’s optional “around the neck method” is not recommended for use during this study. Improving the signal-to-background noise ratio is the goal and this will be achieved more by customising the wire to your head shape.

Troubleshooting

If your system is not working, check the following:

- Is the receiver turned on? (If not there will be no red or green light showing)
- Is the transmitter working? (Is the red “No FM” light on?)
- Are the batteries charged? If it is a problem with the batteries, the “No FM” light will be on. Plug the transmitter into the mains and see if it works then – the “No FM” light will go off. The batteries may be flat or old – rechargeable batteries may need replacing after a year or so.

Use an eraser to rub the connection points of the plug into the transmitter. Sometimes it is dirty and this will clear it.

If there is a buzz in the speakers

- Are the speakers all turned on?
- Are the speakers correctly attached to the receiver?
- Is the receiver next to a computer? – Sometimes this causes interference.

If the “No FM” light goes on and off as you move

- Check that the antenna is correctly attached to the receiver.

If you have any other problems, call Michael on 021 827485 or for technical faults, call Oticon: freephone on 0800 329 684.
Appendix G

Brief Paper and Poster Presentation

G.1 – Brief Paper

G.2 – Poster Presentation
Brief Paper and Poster Presentation

G.1 - Brief Paper

Classroom Sound Field Amplification, Listening, and Learning Research in Rotorua, New Zealand: An Overview

Goal
- To test the efficacy of Sound Field amplification in five New Zealand schools (decile 1a, 2, 5, 6, 10).

“Right now there is the opportunity to again bring New Zealand to the forefront of educational research by saying we will be the first country to have a sound field in every single one of our schools.” Dr Mark Flynn, 2002, Senior Lecturer in Audiology, University of Canterbury

The Research
- The research project runs from the beginning of the school year 2002 to the completion of Progressive Achievement Tests in the first six weeks of 2003.
- The Progressive Achievement Tests are the only standardised tests normed to New Zealand children commencing with the Listening test at seven years of age.

International Robust Research
- The research design project forms part of a doctoral research study being prepared by Michael Heeney under the guidance of Dr Rod Beattie at the University of Newcastle, Sydney.

New Zealand Classroom Acoustics
- Studies highlight the unsatisfactory listening environments in New Zealand schools.
- Listening is a “first order event” for cognition and learning to occur.

Barriers to Learning Environments
- (a) Noise problem, (b) Reverberation, (c) Distance

Support Throughout the Research
- (a) Teachers, (b) Schools Administration, (c) Parents
- Oticon Foundation, Oticon NZ - Easy Listener Equipment distributors
- Michael Heeney

Questions
G.2 - Poster Presentation

Testing Classroom Sound Field Amplification: Preliminary Data

Overview

- This poster outlines the procedures from an ongoing longitudinal study to determine the benefits of using sound field amplification in mainstream educational environments.
- Five selected schools with differing socioeconomic backgrounds in Victoria, New Zealand were invited to participate. Each school selected six classrooms to be amplified.
- An equal control group was invited to participate.
- The sample includes students identified as New Zealand Māori and students who have a history of unstable ear dysfunction, "glue ear".
- The study will be continuing for a full academic year from 2002 to 2003.

Subjects

- All students and teachers in the thirty amplified classrooms, and an equal control group were invited to participate.
- Participants (n=630) include European/Pakeha (n=205) and New Zealand Māori (n=425).
- Students identified as having been treated for middle ear dysfunction—acute middle ear conditions.
- Students' age range from New Zealand years 8 to 13, spanning 5 to 13 year olds.
- Socioeconomic ranking of schools include déciles 1,3,5,7,9.

Data Being Collected

- Parental input from parent-completed consent questionnaires—history, history of middle ear disease.
- Standardised screening: New Zealand norms
  Progressive Achievement Tests of Learning Competencies (year 3 up); Reading (year 4 up); Mathematics (year 4 up); Study Skills (year 5-6)
- Phonological Testing (year 2)
- Teacher assessments:
  From the academic week Ministry returns.
  Teacher comments.

Frequency of Assessment

- The assessments are administered every two months in the commencement of a new school year. Data collection occurred in 2002 and will be repeated in 2003.

Anticipated Benefits

- A greater understanding of the effects of classroom sound field amplification on learning.
- Better understanding of the effects on specific groups with disproportionately high educational needs, particularly socioeconomic groupings and at-risk populations.
- Better understanding of the effects on teachers who use sound field amplification equipment.
Appendix H

Power Point Presentation on Creating Enhanced Listening & Learning Environments
Creating Enhanced Listening & Learning Environments

- **Barrier to learning**
  - Our classrooms are too noisy
- **Reasons**
  - Very interactive teaching styles
  - movement
  - group work
- **Poor acoustic environment:**
  - limited acoustic consideration in building design
  - internal & external features
Noise can make all children and young people “hard of hearing”

- Children’s brains are not fully developed for listening until approximately 16 years of age.
- The younger the child, the more vulnerable they are with skills of sound discrimination.
- This impacts all aspects of children’s learning: key words; phrases; concepts and general understanding.
- Research links classroom listening environments and academic achievement of students.

A poor acoustic environment increases the risk of educational failure for all children, but in particular those with:

- Temporary hearing loss – middle ear dysfunction “glue ear”
- Speech/language difficulties
- Learning disabilities
- Central auditory processing difficulties
- Permanent hearing loss or sensori-neural deafness
- English as a second language (ESOL)
The three critical problems to be addressed are:

1. **Noise**
   - The noise problem (signal to noise ratio)—the difference between the teacher’s voice and the background noise level. In optimum conditions the teacher’s voice needs to be 15-20 decibels louder than background noise.

2. **Distance**
   - A frequently encountered problem for children and young people in classroom environments.
   - The greater the distance from the speaker, the more difficult it is to understand speech. *Beyond a critical distance background noise “drowns out” the speaker.*
The three critical problems to be addressed are:

3. **Reverberation** (echo effect) Rooms cause sounds to reverberate—en echo. It is perceived as annoying noise and listening attentively to a speaker becomes a problem. Curtains, carpeting, and acoustic tiles can help this problem.

A sound field amplification system

- Is essentially a sound distribution system in which speech is
  1. picked up by a wireless microphone near the speaker's mouth, and
  2. transmitted to an amplifier,
  3. which then transmits to four strategically placed speakers in the classroom.
- This effectively decreases the speaker-listener distance and minimizes the detrimental effects of distance, noise, and reverberation.
Benefits

- "It completely transforms the listening environment. The amount of energy required to listen is reduced enormously. Teachers do not have to raise their voices to be heard and it makes their jobs a lot less stressful" - Joy Allcock (Wellington)

- The teacher’s voice is distributed evenly throughout all areas of the room making it easy for all students to hear irrespective of where they sit.

- Improves listening to teachers' voice over background noise (signal to noise ratio)

- Improves:
  - Oral language
  - Literacy levels
  - Classroom harmony
  - On-task behaviour
  - Teacher voice fatigue

Expectations & Responsibilities

- Control and intervention teachers will assist with:
  - Distributing and collecting ethics permission forms and related research information, in particular,
  - the benchmark data collections, and
  - Questionnaires

- Teachers with sound field systems will ensure equipment is used and maintained
Appendix I

Classroom Sound Field Amplification Questionnaire
Classroom Sound Field Amplification Questionnaire

Thank you for your participation in the Rotorua schools’ classroom sound field amplification project. We are now nearing the completion of the data collection portion of the project.

Through this questionnaire I hope to secure some data on your perceptions on this intervention. I would appreciate it if you would complete the questionnaire and return to me in the attached envelope by 15 November 2002.

Data on students’ achievements in the form of PATs is collected at the start of 2003, and those that did the phonological testing will be repeating this in November.

1. Please indicate frequency of use of equipment:

   __ consistently for most teaching sessions

   __ consistently for selected sessions (specify type):
   ___________________________________________________________
   ___________________________________________________________
   ___________________________________________________________

   __ inconsistently due to (specify)
   ___________________________________________________________
2. Please comment on any effects on student behaviour you have noticed while using the sound field.

Noise levels:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

On task/off task behaviour:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Disruptive behaviour:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

3. Please comment on any effects you or others have noticed about your own health and well-being.

Vocal Strain:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Tiredness/energy:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Reduction in irritability levels:


Absenteeism from school:


4. Please comment on your perceptions in the learning environment that facilitate better learning.

   Better comprehension of teacher instructions:


   Improved student cooperation:


You may also wish to comment on improvements in the academic areas:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5. Please comment on any other aspects of using the sound field system relating to effective practice, improving learning outcomes, or other areas you wish to comment on that are not listed above.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

6. Coding Identification

School: ________________________________________________________________

________________________________________________________________________

Teacher/Room No: ____________________________________________________
Appendix J

Progressive Achievement Tests (Sample Pages)

J.1 - Listening Comprehension
J.2 - Reading Comprehension
J.3 - Reading Vocabulary
J.4 – Mathematics
LISTENING COMPREHENSION TEST

DIRECTIONS

This is a test of how well you listen. Listen to each story as it is read to you and then answer the questions which follow it.

For each question four or five answers are printed in your booklet, but only one of these answers is right. After you have heard each question and its answers, you are to choose the one answer you think is best.

Here is an example to show you how to do it.

Sample Exercises

S.1. (A) Climb trees. 
(B) Chase birds. 
(C) Chase butterflies. 
(D) Play with her mother.

S.2. (A) She is too clumsy. 
(B) She makes too much noise. 
(C) She is too slow. 
(D) She does not know how to catch them.

S.3. (A) Sad. 
(B) Happy. 
(C) Frightened. 
(D) Angry.

Each story and the questions which follow it will be read only once, so you should listen carefully. Try to answer every question even when you are not sure of your answer.

PLEASE DO NOT MARK THIS BOOKLET
DO NOT START UNTIL YOU ARE TOLD
J.2 - Reading Comprehension

READING COMPREHENSION TEST

DIRECTIONS

This is a test of how well you understand what you read. Read each story carefully and then answer the questions beside it. Four or five answers are given for each question. You are to choose the one answer you think is best.

Here is an example to show you how to do it.

Sample Story

Last Saturday, Steve spent all day working at home. Straight after breakfast he helped his father wash the car. After lunch he mowed the lawns, weeded the garden and swept the paths. Just as it got dark he brought in a big box of firewood.

S.1. What did Steve do straight after breakfast?
(A) Mowed the lawns.
(B) Swept the paths.
(C) Helped wash the car.
(D) Weeded the garden.
(E) Brought in some firewood.

The best answer is 'Helped wash the car'. You will see that 'Helped wash the car' has the letter (C) in front of it. Now look at your Answer Sheet. You will see that the letter C has been printed in the brackets (~) beside S.1. in the first box.

This is how you will answer the questions. In the brackets (~), just print the letter of the answer you choose.

Now try this example:

S.2. When did Steve bring in the firewood?
(A) Just as it got dark.
(B) After dinner.
(C) Straight after breakfast.
(D) After lunch.

Choose the best answer. Then, on your Answer Sheet, beside S.2., print the letter of the answer you have chosen. Do that now.

The best answer is (A), 'Just as it got dark'. If you have printed the letter A in the brackets beside S.2., you are right.

Work as quickly and carefully as you can. Answer every question even when you are not sure of your answer. Do not spend too much time on questions you find hard.

You have 45 minutes to complete the test.

PLEASE DO NOT MARK THIS BOOKLET
DO NOT START UNTIL YOU ARE TOLD
READING VOCABULARY TEST

DIRECTIONS
This is a test of words and their meanings. The test is made up of short sentences, each with a word underlined. Below each sentence are five answers. You are to choose the one answer which has the same or nearly the same meaning as the underlined word.

Here is an example to show you how to do it.

Sample Sentence 1

We named our kitten Ginger.
(A) found (B) called (C) loved (D) fed (E) remembered

The best answer is 'called'. You will see that 'called' has the letter (B) in front of it. Now look at your Answer Sheet. You will see that the letter B has been printed in the brackets ( ) beside S.1. in the first box.

This is how you will answer the questions. In the brackets ( ), just print the letter of the answer you choose.

Now try this example:

Sample Sentence 2

Watch out for the traffic.
(A) cars (B) police (C) people (D) light (E) tracks

Choose the best answer. Then, on your Answer Sheet, beside S.2., print the letter of the answer you have chosen. Do that now.

The best answer is (A), 'cars'. If you have printed the letter A in the brackets beside S.2., you are right.

Work as quickly and carefully as you can. Answer every question even when you are not sure of your answer. Do not spend too much time on questions you find hard.

You have 30 minutes to complete the test.

PLEASE DO NOT MARK THIS BOOKLET
DO NOT START UNTIL YOU ARE TOLD
MATHEMATICS TEST

DIRECTIONS
This is a test of your understanding and skill in mathematics. The questions in the test are like the samples below. Four or five answers are given for each question. You are to choose the one answer you think is best.

Here is an example to show you what to do.

Sample Exercises

S.1. The number two less than 8 is
(A) 5
(B) 6
(C) 8
(D) 9
(E) 10

The best answer is 6 since \(8 - 2 = 6\). You will see that the numeral 6 has the letter (B) in front of it. Now look at your Answer Sheet. You will see that the letter B has been printed in the brackets beside S.1. in the first box. This is how you will answer the questions. In the brackets, just print the letter of the answer you choose.

Now try this example:

<table>
<thead>
<tr>
<th>Sun</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

S.2. How many days in one week?
(A) 4
(B) 5
(C) 6
(D) None of these

Choose the best answer. Then, on your Answer Sheet, beside S.2., print the letter of the answer you have chosen. Do that now.

The best answer is (D), None of these, as none of the answers given as (A), (B) or (C) is right. There are 7 days in a week. None of the answers given says this, so (D), None of these, is the best answer. If you have printed the letter D in the brackets beside S.2., you are right.

For a few questions you may need to do some working. You can do this in the blank space at the bottom of your Answer Sheet. DO NOT MAKE ANY MARKS ON THIS BOOKLET. Do all your working on your Answer Sheet.

Work as quickly and as carefully as you can. Answer every question even when you are not sure of your answer. Do not spend too much time on questions you find hard.

You have 45 minutes to finish the test.

DO NOT START UNTIL YOU ARE TOLD
Appendix K

Phonological and Phonemic Awareness Test
Phonological and Phonemic Awareness Test

1. Sound-Letter Correspondences
Use attached test for children you think may need assessing for letter-sound correspondences.

2. Counting Syllables
Demonstrate: rainbow (rain—bow → 2)
Practice: peanut (pea—nut → 2)
   1. inside (2)
   2. television (4)
   3. luckily (3)
   4. investigation (5)

3. Sound to Word Matching
Demonstrate: What sound can you hear that is the same in these words. cat… cabbage… cup.
Practice: code… bone… over.
   1. hat… mad… Sam… (short ‘a’)
   2. feet… kneel… bean… (long ‘e’)
   3. pin… sit… give… (short ‘i’)
   4. file… tiger… guide… (long ‘i’)

4. Generating Rhyme
Demonstrate: Can you hear how these words sound the same at the end, they rhyme? Dad… had… sad.
Practice: Can you think of another word that rhymes with stone… moan… ______.
   1. tail… fail… ______.
   2. joke… soak… ______.
   3. growl… fowl… ______.
   4. press… guess… ______.

5. Counting Phonemes
Demonstrate: How many separate sounds are there in this word?
   soap → s… oa… p… →(3)
Practice: paid → p… ai….d… →(3)
   1. feed (3)
   2. hop (3)
   3. happy (4)
   4. garden (5)
6. Counting Phonemes in Blends Words
Demonstrate: How many separate sounds can you hear in “spray”
\[ s... p... r... a... \rightarrow (4) \]
Practice: How many separate sounds can you hear in “flew”
\[ f... l... e... w... \rightarrow (3) \]
1. true \( (3) \)
2. spike \( (4) \)
3. ground \( (5) \)
4. thump \( (4) \)

7. Deleting Phonemes
Demonstrate: Say “feet” without the /fl/ → “eat”
Practice: Say “bone” without the /bl/ → “own”
1. “rain” without the /lr/ \( \text{ain} \)
2. “mouse” without the /lm/ \( \text{ouse} \)
3. “hound” without the /lh/ \( \text{ound} \)
4. “soda” without the /ls/ \( \text{oda} \)

8. Deleting the Initial Phoneme in Blend Words
Demonstrate: Say “scale” without the /sl/ - cale
Practice: Say “strong” without the /sl/- trong
1. “sling” without the /sl/ \( \text{ling} \)
2. “frown” without the /fl/ \( \text{rown} \)
3. “spoke” without the /sl/ \( \text{poke} \)
4. “twink” without the /tl/ \( \text{wink} \)

9. Deleting the Second Phoneme in Blend Words
Demonstrate: Say “sting” without the /tl/ - sing
Practice: Say “break” without the /lr/ – bake
1. “frayed” without the /lr/ \( \text{fade} \)
2. “spill” without the /pl/ \( \text{sill} \)
3. “brawn” without the /lr/ \( \text{born} \)
4. “slip” without the /ll/ \( \text{sip} \)

10. Phoneme Substitution
Demonstrate: If I change the /p/ sound in “pin” to a /t/, I get tin.
Practice: What will you get if you change the /n/ sound in “happy” to a ‘/n/’? nappy.
1. The /ls/ in “seat” to a /fl/ \( \text{feat} \)
2. The /l/ sound in “pin” to an /eh/ \( \text{pen} \)
3. The /ay/ sound in “skate” to an /oo/ \( \text{scoot} \)
4. The /n/ sound in “spoon” to a /k/ \( \text{spook} \)
Appendix L

Marking Sheet for Phonological/Phonemic Awareness Test
<table>
<thead>
<tr>
<th>Test Type</th>
<th>Questions</th>
<th>Score</th>
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<td>Sound to Word matching</td>
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<tr>
<td>Production of Rhyme</td>
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<td>2. _____</td>
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<td>Total Score</td>
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Appendix M

Phonological and Phonemic Awareness Test

Bilingual Māori English Version
Phonological and Phonemic Awareness Test

Bilingual Māori English Version

Translated by Huka Mohi, Māori Resource Teacher Learning & Behaviour, Rotorua

1. **Sound-Letter Correspondences**
Use attached test for children you think may need assessing for letter-sound correspondences.

2. **Counting Syllables**
Demonstrate:  *rainbow* (rain—bow \(\rightarrow\) 2)
Practice:  *peanut* (pea—nut \(\rightarrow\) 2)
  1. roto \(\rightarrow\) inside
  2. huarahi \(\rightarrow\) road, pathway
  3. mataku \(\rightarrow\) frighten
  4. matakerepō \(\rightarrow\) blind

3. **Sound to Word Matching**
Demonstrate: What sound can you hear that is the same in these words. *cat*… *cabbage*… *cup*.
Practice:  *code*… *bone*… *over*.
  1. haka… mana… para… \(\rightarrow\) (short ‘a’)
  2. hē… mē… kē… \(\rightarrow\) (long ‘e’)
  3. kiri… piri… miri… \(\rightarrow\) (short ‘i’)
  4. kī… pī… tī… \(\rightarrow\) (long ‘i’)

4. **Generating Rhyme**
Demonstrate: Can you hear how these words sound the same at the end, they rhyme? *Dad*… *had*… *sad*.
Practice: Can you think of another word that rhymes with *stone*… *moan*… ______.
  1. miro… piro… ______ \(\rightarrow\) (tiro)
  2. mo… ko… ______ \(\rightarrow\) (to)
  3. moa… toa… ______ \(\rightarrow\) (hoa)
  4. pahu… tahu… ______ \(\rightarrow\) (kahu)
5. **Counting Phonemes**
   Demonstrate: How many separate sounds are there in this word?
   soap → s... oa... p... → (3)
   Practice: paid → p... ai... d... → (3)
   1. pakaru (3) pa/ka/ru = broken
   2. rangapu (3) re/nga/pu = partnership
   3. ngakungaku (4) nga/ku/nga/ku = squash
   4. tuamanomano (5) of many strands

6. **Counting Phonemes in Blends Words**
   Demonstrate: How many separate sounds can you hear in “kopunui”
   → ko... pu... nu... i... → (4)
   Practice: How many separate sounds can you hear in “mawehe” → ma... we... he... → (3)
   1. tuhinga (3) tu... hi... nga... = text
   2. wetewete (4) we... te... we... te... = untie
   3. hemanawatanga (5) = depression
   4. waikura (4) wai... ku... ra... = rust

7. **Deleting Phonemes**
   Demonstrate: Say “feet” without the /l/ → “eat”
   Practice: Say “bone” without the /b/ → “own”
   1. “rawe” without the /r/ (awe)
   2. “moka” without the /m/ (oka)
   3. “hau” without the /h/ (au)
   4. “koti” without the /k/ (oti)

8. **Deleting the Initial Phoneme in Blend Words**
   Demonstrate: Say “scale” without the /s/ - cale
   Practice: Say “strong” without the /s/- trong
   1. “toro” without the /t/ (oro)
   2. “kawa” without the /k/ (awa)
   3. “patu” without the /p/ (atu)
   4. “kono” without the /k/ (ono)
Appendix N

Human Research Ethics Committee—Certificate of Approval