Benefits of Sound Field Amplification in Kindergarten through Grade 3: A New Brunswick Provincial Study

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Background

The typical elementary school classroom is an environment full of sounds in which children must distinguish speech from background noise. Teachers who need to raise their voices in order to be heard are unable to provide clear signals across the full range of speech sounds. Reducing the barriers to verbal learning within the classroom soundscape is vital since learning is highly dependent on accurately perceiving communicated messages. Sound field amplification is a system for enhancing the voice of the person speaking so that the message is clearly heard over the background noise.

This study investigated the benefits of classroom sound field amplification systems in three New Brunswick school districts. Sixty classes, with a total of 1162 students from Kindergarten to Grade 3, were involved in the study. Thirty-one of the classes had sound field systems installed, while the other 29 classes did not receive the technology. The four components of the study included:

1. Hearing Screenings

Hearing screenings were completed for 947 children who had parental permission. The results of these screenings provided baseline data on the prevalence of potential hearing problems in young New Brunswick school children. If these findings are applied to an early elementary grade class of 20 students, three to six of the students would not pass the hearing screening and would require follow-up. The results of the present study are consistent with numbers reported in the literature.

2. Measurement of the Acoustic Quality of Classrooms

The acoustic quality in the participating classes from one school district was determined by measuring and/or estimating their ambient noise level and reverberation time. A certified audiologist conducted these calculations in each of the fourteen amplified classes and 12 unamplified classes. The results from this investigation revealed the poor quality of the classroom acoustics and indicated that students in New Brunswick schools were often working in below standard classroom listening conditions.

3. Observations and Interviews

Systematic classroom observations were carried out in all of the classrooms. Observational records were made at the beginning of the study when none of the classes had sound field amplification systems and were repeated at the end of the study after the amplified classes had been using the systems for eight to ten weeks. The flow of communication within classrooms was documented through these observations. Interviews with the teachers and students in the amplified classes were also conducted at the end of the study.

The quantitative results, as well as the data from the interviews, supported the assumption that students focused and attended better and exhibited fewer distracting communicative behaviours when they could hear the teacher more clearly in the classrooms with sound field amplification being used. Results indicated that students in the unamplified classes in Grades 1 to 3 became significantly less responsive to statements directed to them from the beginning to the end of the study. This drop in student attentiveness was not found in the amplified Grade 1 to 3 classes. Also, students in the amplified classrooms initiated fewer communicative interactions while teachers were addressing the whole class, suggesting that they were giving the teacher more of their attention while classroom teaching was taking place. Similarly, students in the amplified classes did not communicate as much while teachers were talking to the peers of the observed child, especially in Grades 1 and 2.

Another aspect of the communication flow within classrooms involved the number of statements teachers made to individuals and to the whole class. Teachers who were amplified did not need to address students individually as much as unamplified teachers did. This suggests that the amplified teachers spent less time communicating in order to gain individuals' attention or repeating statements for those who did not hear them. Amplified teachers, therefore, spent more time talking to the class as a whole, suggesting that they were able to focus on teaching lessons or giving directions to everyone.

Several other benefits of sound field amplification were noted in the comments of students and teachers who were interviewed. First, the amplification systems helped to make classrooms more inclusive by improving the learning process for students with special needs. Next, the use of handheld microphones increased the participation of shy or quiet students and built their confidence. Also, there was a more relaxed atmosphere throughout the classroom when communication was more effective. Finally, teachers reported a decrease in voice strain and voice-related health problems. The results of the interviews also revealed that teachers still had questions remaining at the end of the study regarding the technology, indicating a need for more extensive training on the use of the sound systems.

4. Review of Reading Achievement

A number of obstacles arose related to collecting and using data on reading achievement. As a result, the provincial assessment of reading comprehension, as well as the running records, could not be analyzed and conclusions could not be made about how these measures are affected by sound field amplification.

Limitations

The following areas were considered to be limitations of this study. First, time restrictions limited follow-up on those who did not pass the hearing screenings. As well, the acoustic measures that could be taken in the classrooms were limited by time restrictions. Also, due to the complexity of the data collection instrument used in the classroom observations, it was recognized that further time should have been allotted for training the research assistants. In addition, there were variations in the way the sound field systems were installed. Also, a standard in-service training package and follow-up schedule was not given to each school district. Finally, as noted earlier, there were limitations in the collection of the reading achievement data.

Recommendations

It has been well-established in the current literature that sound field amplification is a significant benefit to young students in classroom learning environments. The results of several measures conducted for this study support the use of sound field systems in elementary classrooms in New Brunswick schools. It is recommended that this technology be considered a vital part of ongoing efforts to improve student learning. In addition to the recommendation for sound field amplification, specific recommendations are made in the following five areas.

First, the results of the hearing screenings point out the vital need to identify hearing problems in school-age children. Identification of students with hearing difficulties could lead to treatment that would reduce the negative impact on learning. Second, because many classrooms have poor acoustics and high levels of background noise, several practical recommendations were made regarding ways to improve classroom acoustics. Third, there is clearly a role for an educational audiologist to work directly with the Department of Education to address many of the problems identified in this report. Fourth, it is recommended that a sufficient budget be allotted for teacher in-servicing when sound field systems are purchased. Appendix H provides an outline of an effective teacher training program. This detailed outline is intended to be used by professionals with backgrounds in acoustics. Fifth, it is suggested that the following areas receive further study to refine and build upon the findings of this research: hearing screening follow-up, acoustic measures, use of handheld microphones, kindergarten students, second language learning, cost effectiveness and achievement measures.

Final Comments

The most common way in which children are taught in elementary classrooms is through spoken language conveyed by the teacher. Simply stated, what sound field amplification does for the learning process is to provide a way for teachers to communicate in normal, effective voices to make themselves heard without straining and thereby distorting the speech signal. Students hear the message with full clarity as if it is a one-on-one situation with the teacher. As Flexer (2004) reminds us, good clear understanding of spoken language in the classroom should not be viewed as extravagant, but as a critical component of the learning process.

1.0 BACKGROUND

The typical elementary school classroom is an environment full of sounds in which children must distinguish speech from background noise to make sense of it. Classroom listening conditions can have a significant effect on students' overall learning experience, since learning is highly dependent on clearly hearing the verbal messages being communicated. In fact, most of the information children acquire in school is communicated through speaking and listening (Flexer, 2005).

It has been well-established that successful students are able to listen to and comprehend spoken messages in the classroom (Edwards, 2005). Poor classroom acoustics can affect both teachers' and students' ability to concentrate (Garibay, 2007). In addition, being able to hear verbal communication in elementary classrooms is a fundamental factor accounting for learning the phonology of speech, which underlies learning to read and write (Nelson, Kohnert, Sabur & Shaw, 2005).

An ideal classroom will provide an environment where all words can be heard with little or no effort. However, many classrooms have speech intelligibility ratings of only 75%, which means that a quarter of all speech in the classroom cannot be discerned (Seep, Glosemeyer, Hulce, Linn & Aytar, 2000). As a result, students can be left trying to fill in the parts of instruction that are inaudible (Garibay, 2007). In such a sound-dependent environment, the impact of classroom acoustics cannot be overstated.

Teachers who must raise their voices in order to be heard are unable to provide clear signals across the full range of speech sounds. As Boothroyd (2005) explains, a raised voice increases the volume of all sounds (i.e., audibility), but not the clarity of each sound (i.e., intelligibility) equally. Some sounds, such as vowels, are more clearly understood when the teacher speaks loudly, while consonants become less intelligible. This is especially important in the English language because high frequency consonants carry a great deal of meaning. Without good clarity of all of the speech sounds, words will sound mumbled. With sound field amplification, all sounds are amplified equally and teachers do not need to raise their voices.

A number of internal features within classrooms, as well as external noise sources, influence classroom acoustics. These include background noise from heating, ventilation and air conditioning (HVAC) systems or electronic equipment in the room; noise in the hallways or outside the windows; collaborative groups working side by side in the classroom; reverberation of sound off hard surfaces; and the natural loss of the teacher's speech signal as it travels over distances within the room (Nelson & Soli, 2000; Smaldino & Crandell, 2000; Smaldino, Doggett & Thunder, 2004).

In order to receive verbal communication in the classroom, students must be able to focus on relevant sounds and filter out the ambient noise. Seep et al. (2000) describe the signal-to-noise ratio (S/N) as a measure of the teacher's voice minus the measure of the background noise in the room. A higher S/N results in speech that is easier to understand, while a low or negative S/N means that the speech is much less intelligible or unintelligible to the listener. It has been recommended that voices be at least +15 decibels (+15 dB S/N) higher than the background noise for optimal listening conditions (Kay, 2006).

Bradley and Sato (2004) studied speech recognition in children at three grade levels. Their results revealed that Grade 6 students achieved scores of 95% correct in a speech recognition task with a signal-to-noise ratio of +8.5 decibels (dB). Students in Grade 3 required +12.5 dB S/N for these same results, while those in Grade 1 required +15.5 dB S/N. With a higher S/N of +25 to +30 dB, the students in Grade 1 and Grade 3 scored 98%, while those in Grade 6 scored almost 100% on this speech recognition task.

It has long been recognized that the typical signal-to-noise ratio in most classrooms does not meet the recommended guidelines (American Speech-Language-Hearing Association, 1994) and may adversely affect educational performance (Boothroyd, 2004; Crandell, Kreisman, Smaldino & Kreisman, 2004). Nelson et al. (2005) estimated that many occupied classrooms have noise levels of 70 dB or higher. An American task force (commonly referred to as ANSI) introduced a standard for school design (Acoustical Society of America, 2002). ANSI recommended 30 to 35 dB for an acceptable classroom noise level. This would allow young children to have a S/N of at least +15 dB which is the optimum listening level. The task force also made recommendations about reverberation time within classrooms. They recommended no more than 0.6 seconds as an acceptable time for the sound to fully decay after bouncing off surfaces in the room (Acoustical Society of America, 2002).

The complex listening environment of the typical classroom most strongly affects the young inexperienced listener. Children younger than 13 to15 years of age do not have mature auditory systems and therefore they require better conditions for listening (Anderson, 2004; Boothroyd, 2004). Their ability to focus in noisy surroundings is less well developed than that of adults (Crandell & Smaldino, 2000; Flexer, 2005). Furthermore, young children do not yet have an extensive vocabulary or the life experiences to be able to fill in the gaps of missed information (Flexer, 2005; Kay, 2006; Seep et al., 2000).

Children learning a second language also need optimal listening conditions in order to understand the spoken language (Nelson & Soli, 2000). Since they cannot rely on previous linguistic experience, they must depend more heavily on the acoustic signal (Nelson et al., 2005). These children would be less familiar with the distinctions at the sound and word level that indicate changes in the meaning of words in the second language. Younger children learning a second language would not only have linguistic, but also developmental issues from having less mature auditory systems. Nelson et al. (2005) describe second language learners as experiencing double jeopardy with the additional negative impact of classroom noise on their learning.

Other factors which further compound children's ability to listen in the classroom include deficits in attention, speech, language, or auditory processing; learning disabilities; and developmental delays. Eriks-Brophy and Ayukawa (2000) cited research showing positive effects of sound field amplification with children presenting with these problems. These include greater academic gains, increased attentiveness and less distractibility.

Flexer, Richards, Buie and Brandy (1994) found that up to one third of the students in Kindergarten and Grade 1 classes had reduced hearing. Temporary hearing impairment, caused by factors such as ear infections, is more prevalent in young children than in older children and adults. As previously outlined, young children are at a greater disadvantage for learning in the typical classroom since they require the speaker's voice to be louder and clearer than the background noise (i.e., a higher signal-to-noise ratio) compared to older children (Crandell, Smaldino & Flexer, 2005; DiSarno, Schowalter & Grassa, 2002).

Often, school personnel attribute problems such as noncompliance, inattention, and off-task behaviour to a need for better classroom management without considering the degree to which hearing deficits may be contributing to the problem (Flexer, 2004). As mentioned earlier, young children need at least +15 dB in order to fully understand spoken messages. Research has shown that adults can understand familiar spoken material at a lower S/N of 0 dB (Nelson & Soli, 2000). Therefore, adults may not fully appreciate the negative effects of a moderately noisy classroom since they are able to understand speech in noise much better than young children (Bradley and Sato, 2004).

Reducing the barriers to verbal learning within the classroom soundscape is the goal of many audiologists and speech-language pathologists who work with children. Nelson & Soli (2000) state that "all children need good, clear signals and low background noise for full understanding" (p. 356). Acoustic accessibility is not a luxury – it is a necessity" (Flexer, 2004, p.139).

2.0 HISTORICAL PERSPECTIVE

In the 1980s, audiologists, speech-language pathologists, and teachers of students with hearing impairments in New Brunswick were advocating for better classroom listening conditions for children with hearing loss. Initially, personal FM systems were provided for children with hearing impairments in the classroom setting. A personal FM system involves the teacher wearing a microphone to amplify his or her voice, while students wear receivers connected to their hearing aids in order to hear the teacher directly. These systems provide a great benefit to individual students with hearing impairments by improving their ability to filter out the teacher's voice from the background noise and reduce the negative impact of reverberation and distance from the teacher.

About 15 years ago, speakers were set up in some New Brunswick classrooms creating a "surround sound" so that teachers' amplified voices were heard by all of the students. The benefits of classroom sound field amplification for all children became immediately apparent. The improvement in sound clarity was acknowledged in the educational community as a vital factor for enhancing all children's learning in the classroom environment.

Since then, audiologists and speech-language pathologists around the province have provided numerous educational sessions on the benefits of classroom amplification, while continuing their efforts to lobby the government for acquiring sound field systems. In 1997, a CBC television news report brought New Brunswick's use of classroom sound field amplification technology into the public eye. This report won a national media award and was broadcast across the country to promote the technology. Since 1997, four other television interviews on classroom amplification were also conducted in New Brunswick, three in English and one in French.

In 2005, The New Brunswick Association of Speech-Language Pathologists and Audiologists (NBASLPA) responded to the call for recommendations to the Department of Education's commissioned review of inclusive education. In their submissions, the importance of good classroom acoustics for all children was emphasized. In the final report, *Inclusive Education: A Review of Programming and Services in New Brunswick* (MacKay, 2006), the effectiveness of sound field technology was recognized. MacKay (2006) noted "The value of these systems in improving communications and reducing stress is hard to refute" (p. 226).

The use of technology to enhance student learning was advocated in the current New Brunswick Department of Education plan for the future of education in this province. The intent of this five year plan, *When Kids Come First* (New Brunswick Department of Education, 2007), is to build the best education system in Canada. A specific action in Commitment #4, To Give Educators the Tools to Innovate and Lead, is to "develop a multi-year plan to create technology-enriched classrooms that house such technologies as …FM [sound field amplification] systems…" (New Brunswick Department of Education, 2007, p. 20).

Given the professional support for improving classroom listening conditions and New Brunswick's growing interest in sound field amplification systems, a need was identified for a provincial study of the benefits of these systems. The New Brunswick Department of Education reviewed the more recent advancements in sound field technology. They chose infrared technology for this study, the second generation of sound field amplification systems, over FM systems.

Initial sharing of information about this study included a presentation at the annual conference of the Canadian Home Care Association (Aquino-Russell, Rubin, & Flagg-Williams, 2006) and two presentations at the annual conference of the Canadian Association of Speech-Language Pathologists and Audiologists (Rubin, Aquino-Russell, & Flagg-Williams, 2007; Rubin & Lushington, 2007). Portions of the present study were included in a presentation for the International Association of Logopedics and Phoniatrics Conference (Rammage & Stefanishyn, 2007).

3.0 PROCEDURES

This study involved 60 classes, from Kindergarten to Grade 3 (K-3), in three New Brunswick school districts. Thirty-one classes received sound field amplification systems after the initial classroom observations were conducted. Twenty-nine classes did not have amplification systems installed during the time period of the study. The amplified classes made up the experimental group and the unamplified classes comprised the control group. The amplified and unamplified classes were divided evenly within the three school districts. They were matched as closely as possible on student enrollment and were balanced between English and French Immersion (French Im.) classes. The amplified classrooms included 610 students and two were split grade levels. The unamplified classrooms included 552 students and three were split grade levels. The distribution of the classes is outlined in Table 1 below.

Table 1
Number of Students and Classes in Participating School Districts

	District A		District B		District C		TOTALS	
Grade	Amplified students (classes)	Unamplified students (classes)	Amplified students (classes)	Unamplified students (classes)	Amplified students (classes)	Unamplified students (classes)	Amplified students (classes)	Unamplified students (classes)
Kindergarten	66 (3)	67 (3)	41 (2)	40 (2)	41 (2)	36 (2)	148 (7)	143 (7)
1 English	30 (2)	12 (1)	39 (2)	38 (2)	14 (1)	10 (1)	83 (5)	60 (4)
1 French Im.	42 (2)	43 (2)	0 (0)	0 (0)	17 (1)	16 (1)	59 (3)	59 (3)
2 English	30 (2)	29 (2)	38 (2)	38 (2)	22 (1)	15 (1)	90 (5)	82 (5)
2 French Im.	40 (2)	33 (2)	0 (0)	0 (0)	20 (1)	17 (1)	60 (3)	50 (3)
3 English	39 (2)	31 (1)	43 (2)	43 (2)	27 (1)	26 (1)	109 (5)	100 (4)
3 French Im.	36 (2)	38 (2)	0 (0)	0 (0)	25 (1)	20 (1)	61 (3)	58 (3)
TOTALS	283 (15)	253 (13)	161 (8)	159 (8)	166 (8)	140 (8)	610 (31)	552 (29)
English	165 (9)	139 (7)	161 (8)	159 (8)	104 (5)	87 (5)	430 (22)	385 (20)
French Im.	118 (6)	114 (6)	0 (0)	0 (0)	62 (3)	53 (3)	180 (9)	167 (9)

None of the classrooms had sound field technology at the beginning of the study. Each classroom in the amplified group was provided with a Phonic Ear frontrow™ pro infrared sound field system, four mounted speakers, a wireless pendant microphone and one hand held wireless microphone. Teachers in these classes received basic instruction on the technology from either an audiologist and/or the Phonic Ear sales representative. The classes began to use their systems immediately after the initial observation visit was made for the pre-intervention data collection.

This study involved the following four components: hearing screenings; measurement of acoustic quality of classrooms; observations and interviews; and review of reading achievement. The procedures involved for each of these components are discussed in the sections that follow.

3.1 Hearing Screenings

Hearing screenings were completed for all of the students involved in the study who had parental permission (see Appendices C and D). This facet of the study provided the added element of establishing an auditory profile of early elementary school students across New Brunswick. Information on children's hearing status at the elementary level is not systematically obtained at present in New Brunswick.

Hearing screenings were conducted in the various schools by the speech-language pathologist (SLP) involved in this study using a GSI 17 Grason-Stadler 17 portable screening audiometer. Assistance in three schools was provided by a certified audiologist using a Model MD-IP M.D. Systems portable audiometer. The audiometers were calibrated and daily checks were made to ensure appropriate functioning. Although the rooms used for screening varied by location, the SLP or audiologist ensured that acoustical conditions were appropriate for conducting the screenings. On occasion, the ambient noise level was judged to be high enough to interfere with the testing and an alternate location had to be found in the building.

Initial instruction was provided by the SLP or the audiologist to an individual or small group of up to six children as the room size and attention span of the children permitted. Instruction included placement of the headphones and practice responding by raising a hand to tones presented by the examiner without using the headphones. For a small number of children, who could not reliably raise their hand when hearing the tone, an alternate procedure was utilized. This involved teaching the student to respond to the sound by releasing an item into a container each time they heard a sound.

Students were given pure tone threshold hearing screening tests at 20 dB for 1000, 2000, and 4000 Hz and 25 dB at 500 Hz for each ear. If the child failed to respond to one or more of the frequencies tested, the child was identified as needing to be rechecked or referred for follow-up. These screening guidelines are those suggested by the New Brunswick Association of Speech-Language Pathologists and Audiologists (1988).

As illustrated in Table 2 below, participation rate by grade level ranged from 73% to 89%. A total of 947 students representing the four grade levels in this study were screened. The total number of students tested represented 82% of the study participants.

Table 2
Number of Students Who Had Hearing Screenings by Grade Level

	Grade Level				Total
	Kindergarten	Grade 1	Grade 2	Grade 3	
Students Screened	241	215	251	240	947
Total Participants	291	261	282	328	1162
Percent Screened	82	82	89	73	82

3.2 Acoustic Quality of Classrooms

An additional component of this study involved measuring and/or estimating the acoustic quality of all of the classes in two schools in one school district in order to form a profile of the soundscape of these classrooms (Lushington, 2007). A certified audiologist determined the acoustic quality of the classrooms by measuring and/or estimating ambient noise level and reverberation time. The schools were arbitrarily named School X and School Y to protect their identity.

Classroom size was measured and recorded prior to taking the sound level measurements. Reverberation was estimated based on classroom size as per the ANSI standard (Acoustical Society of America, 2002). School X had measurements taken in 14 classrooms prior to the activation of the sound field systems. School Y, the control school for the study, did not receive sound field amplification. Twelve classes were measured in School Y.

Noise level measures were recorded in each room. The area in each room with the highest noise level was determined to be the key location. This is where the initial measures were taken. A Quest 2900 Integrating Average/Data Logging sound level meter was used. It was connected to a tripod set at .8 meters, which is consistent with a typical seated position of a child in Kindergarten through Grade 6. The seated position was as per the ANSI standard (Acoustical Society of America, 2002).

As indicated previously, the ANSI standard is 35 dBA or less for a typical size classroom. A is a weighted scale that simulates the way a normal ear hearing the sound would process it. ANSI further allows for a conformance standard not exceeding 2 dB of this value. For the purposes of this study, the acceptable level of ambient room noise was defined as 37 dBA or less. Background noise levels were calculated by taking several measurements over one-minute intervals and averaging them. When the difference between the highest and the lowest of five

averages was 3 dBA or less, the noise level was defined as steady. If the difference was greater than 3 dBA, then the noise level was unsteady.
In the classrooms that were measured, when the noise level was steady and conformed to the acceptable ambient room noise of 37 dB or less, then sound levels were measured at five other locations within the classroom. The average of these five measurements, combined with the measurement at the key location was determined to be the overall background noise level of the classroom. If the levels were found to be unsteady, no further measurements were taken. This is because ANSI recommends a continuous one hour average of noise levels when background noise is found to be unsteady, and time constraints did not allow the additional measures to be taken.

3.3 Classroom Observations and Interviews

Four Research Assistants (RAs) observed the students in the 60 classes that took part in this study. Each RA was assigned to particular schools and observed the same classrooms at the beginning and at the end of the study. All initial observations were completed in February or March of 2006. Final observations took place during the last two months of the 2006 school year.

The four Research Assistants observed classrooms using a systematic observation protocol, Revised Environmental Communication Profile (RECP), which measured the flow of communication (See Appendix A). This instrument is described by Massie, Theodoros, Byrne, McPherson, and Smaldino (1999). In order to learn this protocol, the RAs were trained by the researchers and participated in classroom practice. Reliability checks for each of the RAs were conducted at the beginning and the end of the study by two of the researchers to ensure consistency of the data collection procedure.

The RECP provided a means to quantify the flow of communication during the normal course of events in classrooms. This comprehensive observation tool was used to gather data on various types of communication, including verbal and nonverbal communication made by teachers and students. Given that the present study involved amplification of the teachers' voices, the analysis focused on the data collected when the teachers were communicating using spoken language. By analyzing the data, it was possible to determine how often and in what direction teachers and students communicated.

Because the data was gathered by observing what happens naturally in classrooms, the number of communicative initiations that were collected varied among groups. Therefore, proportions were used in the analysis. Results in the amplified and unamplified groups were tested for significance of the difference between two independent proportions.

In order to maintain consistency and to focus on literacy, observations were made only during dedicated Language Arts time periods. Measurements of the flow of communication were taken using a time sampling procedure in which each child was observed for 30 seconds with a 10-second recording period between each observation. Students were observed in turn until all had been observed four times. Neither the teachers nor the students were aware of who was being observed.

At the end of the study, one researcher interviewed all of the teachers and students in the amplified classrooms. A copy of the interview guide is contained in Appendix B. The data obtained from this semi-structured interview process was analyzed using content analysis. Themes were generated in order to help understand the teachers' and students' views about their experiences while using the sound field amplification systems. An experienced educator, independent of the research, was engaged to review the plausibility of the proposed themes.

3.4 Reading Achievement

A number of complicating factors prevented the collection and analysis of reading achievement data in this study. An explanation of these obstacles is presented in the Results section of this report. To address these problems, a suggestion for gathering reading achievement data is made in the Recommendations section. Although results were not obtained, the following sections discuss the intended procedures for examining the provincial Grade 2 reading comprehension assessment data and Kindergarten to Grade 3 running records.

3.4.1 Provincial Assessment of Reading Comprehension

Various province-wide assessments, including reading comprehension at the end of Grade 2, are conducted in New Brunswick. For this study, the intent was to combine the Grade 2 reading comprehension results from all of the schools in the study which had sound field systems installed in 2006. It was also intended that the same procedure would be carried out with those schools which did not have the systems installed that year. The 2005 test results were to be collected from the same groups to form a profile of typical achievement for Grade 2.

3.4.2 Running Records

In addition to the Grade 2 provincial reading comprehension tests, teachers in New Brunswick schools administer running records to children during the early stages of literacy development to assess their reading proficiency. Running records involve students reading unfamiliar books orally. The teacher determines the students' overall accuracy, error rate and self correction rate, in addition to text comprehension. Students must achieve a set criterion to progress to the next reading level.

Grade level performance criteria differ for English and French Immersion classes. In English classes, students may achieve a running record level of A to P+, while levels are from A to M+ in French Immersion classes. A set containing both fiction and nonfiction books from the Atlantic Canada Reading Assessment Resource (Pearson Education Canada, 2001) are used for testing students in the English classes. A similar set of French leveled books compiled from various publishers are used for testing students in the French Immersion classes.

In most schools, running records assessments are given in January and June for students in Grades 1 through 3 and in June for Kindergarten students. School districts across the province have varying criteria for performance standards on these measures. In order to aggregate the data, it would be necessary to apply a single standard to all the results of the running records. Table 3 below outlines the performance criteria that were to be used in this study.

Table 3
Grade Level Performance Criteria for Running Records

Program	Grade Level							
	Kindergarten		Grade 1		Grade 2		Grade 3	
	Jan	June	Jan	June	Jan	June	Jan	June
English	A	B	EF	H	JK	L	N	P
French Immersion	NA	NA	D	E	GH	I	KL	M

4.0 ETHICAL CONSIDERATIONS

Prior to commencing the investigation, this study was approved by the Ethical Review Committee at the University of New Brunswick. Consent for the children's participation (see Appendices C and D) and for the teachers' participation (see Appendices E and F) was obtained.

5.0 RESULTS

The results of the four components of the study are presented in the following sections:

1. Hearing Screenings
2. Acoustic Quality of the Classrooms
3. Classroom Observations and Interviews
4. Reading Achievement

Each section begins with a statement of the key question or questions that were addressed in that component of the study.

5.1 Hearing Screenings

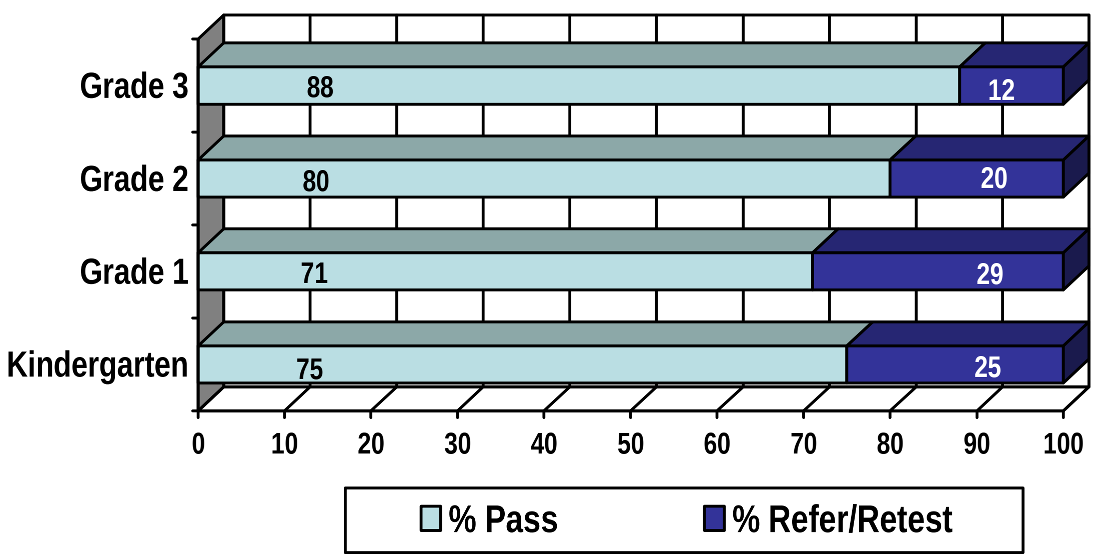
One key question was addressed in the first component of the study.

Key Question 1:

What is the prevalence of potential hearing problems in students in Kindergarten to Grade 3 classes (K-3)?

The hearing screenings provided baseline data on the prevalence of potential hearing problems in young New Brunswick school children. Figure 1 shows the percentage of students by grade level who met the criteria for adequate hearing, as well as those who did not meet the criteria and needed to be referred or reassessed. As illustrated, a much lower percentage of children in Grade 3 did not meet the criteria for adequate hearing levels as compared to the younger students. The results of these screenings provided baseline data on the prevalence of potential hearing problems in young New Brunswick school children. If these results are applied to a classroom of 20 students, three to six of the students would require follow-up. These results are consistent with the findings of Flexer et al. (1994).

Figure 1
Results of Hearing Screening by Grade Level

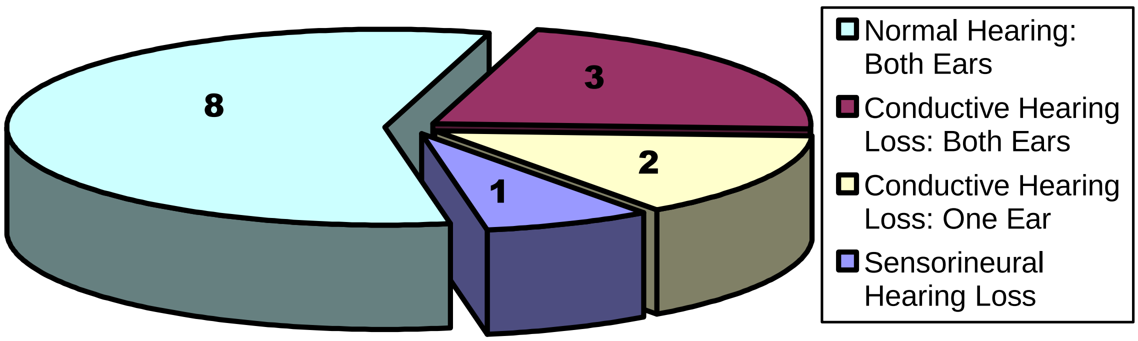


Results of the hearing screenings were given to the schools and the parents in written form (see Appendix G). For those students who did not meet the criteria (New Brunswick Association of Speech-Language Pathologists and Audiologists, 1988), recommendations were made for follow-up. Further comments were occasionally added on the form by the speech-language pathologist or audiologist conducting the screening.

Some parents followed up on recommendations for further evaluation. This information was not formally tracked in this study. In some cases that were brought to the attention of the researchers, audiological evaluations detected previously unrecognized permanent (i.e., sensorineural) hearing loss and numerous children with otologic problems, requiring medical intervention, such as temporary conductive hearing loss from middle ear problems.

Although the follow-up results are unknown for most of the students in the study, 14 children who had not passed the hearing screening were seen at one hearing clinic and the results were shared with the researchers. See Figure 2 below. Eight of the children had normal hearing in both ears and were discharged. Five children were referred for medical treatment for conductive hearing loss. Three of these children were referred for hearing loss in both ears while two of the children were referred for hearing loss in one ear. One child was determined to have previously undetected permanent sensorineural hearing loss in both ears.

Figure 2
Results of Hearing Screening Follow-Ups from One Audiology Clinic



5.2 Acoustic Quality of the Classrooms

Two key questions were addressed in the second component of the study. The responses to both questions will be integrated in this section:

Key Question 2:

What is the ambient noise level of Kindergarten to Grade 3 (K-3) classes?

Key Question 3:

What factors affect the listening conditions in K-3 classes?

The ambient noise level of the classrooms tested ranged from a low of 35.4 dBA to a high of 52.3 dBA. As outlined in the Procedures section, a level of 37 decibels was accepted as the standard for the noise level of the classrooms in this study, using the guidelines of the Acoustical Society of America (2002). It is important to note that when the classroom noise level is 52 dB, it is in fact 32 times more than the expected standard of 37 dB (A. Lafargue, personal communication, July 18, 2007). This is due to a doubling in the sound pressure level for every 3 dB increase in the noise level.

Table 4
Effect of Increase in Classroom Noise Level

Classroom Noise Level	Sound Pressure Level
37 decibels or less	acceptable ambient noise level
40 decibels	unacceptable noise level 2 times more powerful than 37 dB
43 decibels	unacceptable noise level 4 times more powerful than 37 dB
46 decibels	unacceptable noise level 8 times more powerful than 37 dB
49 decibels	unacceptable noise level 16 times more powerful than 37 dB
52 decibels	unacceptable noise level 32 times more powerful than 37 dB

In order to maintain acceptable classroom listening conditions, the teacher's voice (i.e., the signal) needs to be heard over the classroom noise. The accepted standard signal-to-noise ratio (S/N) must be +15 dB in order to allow for 100% speech intelligibility. It has been recognized that most classrooms do not meet this guideline (American Speech-Language-Hearing Association, 1994). The results of the acoustic measurements taken in this study demonstrated that students were often working in classroom listening conditions that were below the recommended standard.

The following sections present the results of the acoustic measures taken for School X and School Y.

5.2.1 School X

All classrooms in School X failed to meet ANSI standards for listening conditions (Acoustical Society of America, 2002). The heating and ventilation (HV) system was a major contributor to the noise levels in School X. Two classrooms were retested at a key location after regular school hours following HV system noise reduction. As shown in Table 5 on the next page, these two classrooms (X2 and X8) showed a significant reduction in dBA. Class X2 had a 14.2 dBA reduction and class X8 had a 12.5 dBA reduction. All measures above the accepted standard of 37 dB are highlighted. When the heating and ventilation systems were turned off or minimized, as illustrated, these classrooms then had noise levels below 37 dB. Therefore, they met the ANSI recommended standard for adequate classroom listening conditions.

5.2.2 School Y

In School Y, eight of the 12 classes met the ANSI standard for adequate classroom listening conditions of 37 dB. All but one of the classrooms (Y11) had steady noise. Results for measurements taken in the key locations for School Y are illustrated in Table 6 on the following page. Measures above the accepted standard of 37 dB are highlighted.

Table 5
Sound Level Readings in Key Locations for School X

Room	Key Location Measurements in dBA 1 min average					Average	Noise	HV Reduction in dBA 1 min average
X1	**45.4**	**44.8**	**45.5**	**46.2**	**45.8**	**45.5**	Steady	--
X2	**53.0**	**53.1**	**52.8**	**48.2**	**42.6**	**49.9**	Unsteady	35.7
X3	**49.9**	**49.0**	**48.9**	**48.9**	**48.9**	**49.1**	Steady	--
X4	**46.6**	**46.6**	**46.6**	**46.7**	**46.8**	**46.7**	Steady	--
X5	**45.3**	**45.2**	**44.8**	**45.1**	**45.4**	**45.2**	Steady	--
X6	**52.3**	**51.5**	**49.6**	**49.7**	**49.8**	**50.6**	Steady	--
X7	**40.8**	**41.7**	**41.4**	**41.2**	**41.1**	**41.2**	Steady	--
X8	**51.0**	**47.1**	**46.6**	**46.7**	**43.8**	**47.0**	Unsteady	34.5
X9	**46.8**	**47.1**	**50.9**	**46.9**	**45.9**	**47.5**	Unsteady	--
X10	**47.9**	**48.0**	**48.3**	**48.0**	**48.2**	**48.1**	Steady	--
X11	**55.5**	**51.6**	**51.6**	**51.3**	**51.3**	**52.3**	Unsteady	--
X12	**50.7**	**49.2**	**49.1**	**49.0**	**49.0**	**49.4**	Steady	--
X13	**47.4**	**47.3**	**47.4**	**47.5**	**47.5**	**47.4**	Steady	--
X14	**43.5**	**43.4**	**44.2**	**43.1**	**43.4**	**43.5**	Steady	--

Table 6
Sound Level Readings in Key Locations for School Y

Room	Key Location Measurements in dBA 1 min average					Average	Noise
Y1	34.7	34.0	34.3	33.9	34.2	34.2	Steady
Y2	36.0	36.3	35.1	35.5	35.6	35.7	Steady
Y3	36.6	35.4	35.1	35.0	35.0	35.4	Steady
Y4	**39.2**	**37.1**	**38.3**	36.8	36.7	**37.6**	Steady
Y5	**38.5**	**38.7**	**38.7**	**38.5**	**38.9**	**38.7**	Steady
Y6	36.4	36.5	36.6	36.2	36.7	36.5	Steady
Y7	**38.8**	**39.2**	**39.2**	**38.7**	**39.2**	**39.0**	Steady
Y8	36.4	35.8	35.4	35.2	35.4	35.6	Steady
Y9	34.8	33.2	33.7	33.0	33.3	33.6	Steady
Y10	**38.7**	36.4	**37.4**	37.0	37.0	36.3	Steady
Y11	**41.3**	**44.3**	**45.3**	**46.1**	**46.1**	**46.1**	Unsteady
Y12	36.7	36.7	37.0	36.8	36.8	36.8	Steady

Since most of the classrooms in School Y were at or near the recommended standard and had steady noise, five additional measures were taken at various locations and the classroom average was calculated. Intermittent noise from the kitchen vent affected the adjoining classroom (Y11). Therefore, further measurement in that classroom was discontinued. Results are shown in Table 7.

Table 7
Sound Level Readings in Various Locations for School Y

Room	Average (Key Locations)	Various Location Measurements in dBA 1 min average					Classroom Average In dBA
Y1	34.2	34.7	35.0	35.6	**37.4**	35.5	35.4
Y2	35.7	35.5	35.4	35.6	35.4	35.6	35.5
Y3	35.4	36.4	33.4	**37.1**	34.0	**37.2**	35.6
Y4	**37.6**	35.9	36.4	36.1	34.9	35.2	36.0
Y5	**38.7**	**39.2**	36.8	**37.8**	35.4	**38.7**	**37.8**
Y6	36.5	33.5	34.8	33.2	34.2	36.1	34.7
Y7	**39.0**	36.0	**38.0**	**39.7**	**38.7**	**38.5**	**38.3**
Y8	35.6	**38.3**	34.0	34.0	33.7	36.1	35.3
Y9	33.6	34.2	33.8	35.4	35.5	34.3	34.5
Y10	36.3	**34.3**	34.9	36.6	**37.6**	34.5	35.8
Y11	**46.1**	---	---	---	---	---	---
Y12	36.8	36.7	35.5	34.7	36.9	**37.6**	36.4

5.3 Classroom Observations and Interviews

The third component of the study addressed both Key Question 4 and Key Question 5.

Key Question 4:
What are the effects of sound field amplification intervention on the flow of communication in Kindergarten to Grade 3 (K-3)?

Key Question 5:
What are the teachers' and students' views on using a sound field amplification system in their classroom?

The flow of communication within the classroom setting was defined by the following three types of interactions: the teacher directly addressing the observed student, the teacher speaking to the class, and the teacher speaking to a peer of the observed student. Each of these sections is subdivided between student communicative interactions and teacher statements.

5.3.1 The Teacher Directly Addressing the Observed Student

5.3.1.1 Student Communicative Interactions

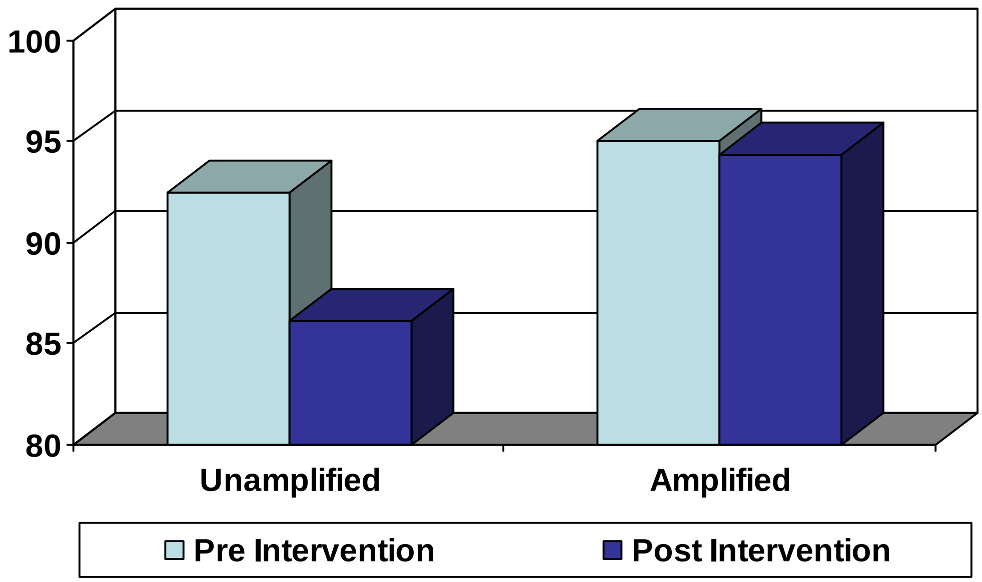
Quantitative data was collected by observing individual students. The focus of the first category of data was occurrences of the observed student responding to the teacher directing a verbal statement to that student. Students' communicative interactions might include gesturing, touching others, talking, or making eye contact. As shown in the RECP protocol in Appendix A, the observed student's communication could be directed in one of four ways (i.e., to the teacher, to another student (peer), to the class as a whole, or to him/herself). Those communications initiated toward the child him/herself were not included in the analyses since it was not possible to interpret the meaning of self-talk.

The data on teachers' statements directed to the child was combined for Grades 1 through 3 since they had a similar response pattern. In Kindergarten, the pattern of the results differed from Grades 1 to 3. The reason for this difference could not be determined from the data collected.

As illustrated in Figure 3 on the next page, the percentage of time students responded to direct teacher statements was high overall. Student response rates in every group were above 85%. The labels "Pre" and "Post" are used throughout this study to identify measures taken at the beginning and at the end of the study.

In the unamplified condition, there was a drop in student response rate to teacher statements directed to them. This difference was significant ($z=1.684$, $p<.05$). However, this drop in student response was not observed in the classrooms that had amplification systems. In those classrooms, the response rate did not significantly change over time. This result demonstrated that in the classrooms equipped with sound field amplification, students maintained a higher level of response to direct communication from their teachers.

Figure 3
Percent of Student Responses to Direct Teacher Statements
Grades 1 to 3



In the interviews, the students commented on their own increased attention levels. They felt that they were more focused because they could hear better. For example, a Grade 3 student in District A stated, "It makes a big difference in my math and my reading and everything…I listen better when she has the speaking thing on." As noted by a Grade 1 teacher in District A, "Children are more attentive whenever I turn the system on. They tend to look at me more."

This improvement in concentration was viewed by teachers to have a direct impact on the enhancement of student learning. A Grade 2 teacher in District B remarked, "I think a lot of children will benefit with the system. I think there are kids who need that little extra to help them focus. In that sense, it's definitely worthwhile, for sure." Another teacher said, "I think they're getting the directions where they weren't getting them before" (Grade 3 teacher, District A).

Teachers and students in the amplified classrooms also mentioned noticing a reduction in distracting background noise. Although the background noise was probably still present, the perception that the noise level was reduced may be because the amplified teachers' voices became more prevalent. "I think I lost [the attention of] a lot of the kids because they couldn't hear, especially with this fan system in here; it's noisy" (Grade 3 teacher, District C). "They hear you better. The noise level in the class really goes down when I use it...I don't have to repeat as much" (Grade 1 teacher, District A).

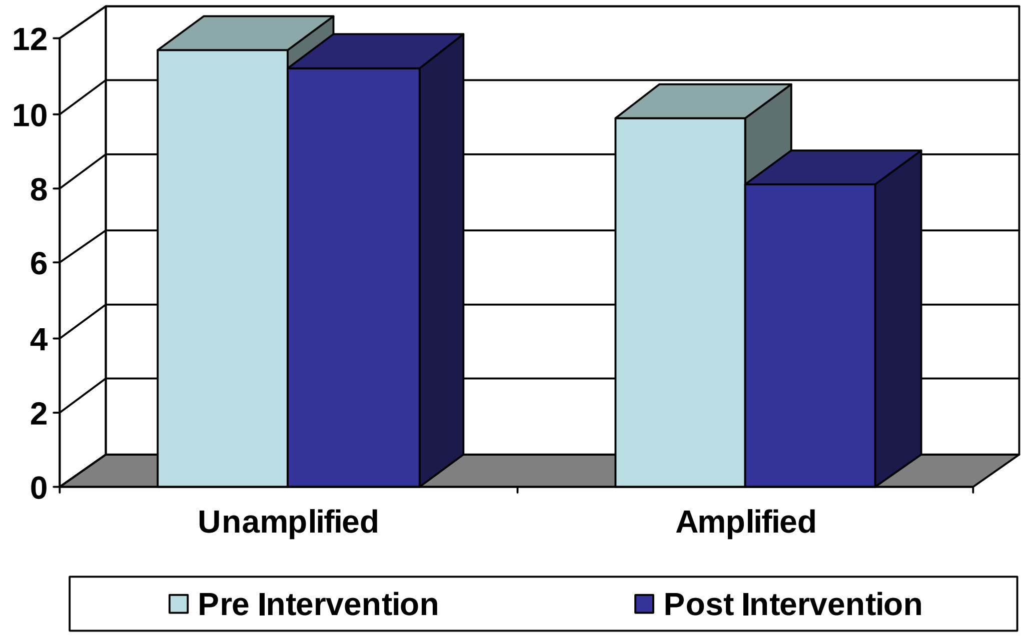
5.3.1.2 Teacher Statements

The number of statements made by teachers in this first category of data (i.e., statements directed to the observed child) was also examined. It is important to note that the data collection procedure involved observing each student in turn for 30 seconds. This procedure was repeated four times during each classroom observation. Only the teacher's statements made to the child while the selected child was being observed were recorded. Data analysis at each grade level involved determining the percentage of the recorded teacher statements out of the total number of 30-second observations made.

Teachers who were amplified were more audible and intelligible to all students in the classroom. Thus, it was expected that these teachers would not need to spend as much time directing their verbal statements to individuals in attempts to gain their attention or repeat statements for those who did not hear them. As a result, teachers would be able to spend more time talking to the class as a whole, including teaching lessons or giving directions.

The expected result was demonstrated in Grades 1 to 3 as illustrated in Figure 4 on the next page. This graph shows the percentage of child-directed teacher statements out of the set of total statements made. As can be seen, teachers who were amplified made fewer statements directly to individual children. This difference was significant ($z=1.73$, $p<.05$).

Figure 4
Percent of Teacher Statements Directed to the Observed Child
Grades 1 to 3



In regard to the Kindergarten data, the analysis revealed that teachers continued to increase the number of direct statements they made over time in both amplified and unamplified classrooms. However, Kindergarten teachers who were amplified did not increase their percentage of direct statements as much as the unamplified teachers. The direction of this trend is consistent with the expected results.

5.3.2 The Teacher Speaking to the Class

5.3.2.1 Student Communicative Interactions

The second category of data was occurrences of the observed student initiating communication while the teacher was speaking to the class as a whole. The teacher's communications might include teaching a lesson, giving directions, or asking a question.

It was expected that students in the amplified classrooms would spend less time engaging in communicative interactions while the teacher was speaking to the whole class. For example, they would do less gesturing, less talking to a peer, or make less eye contact with a peer. In contrast, it was expected that students in the unamplified classes would be likely to engage in more communicative interactions when they could not as clearly hear the teacher.

The quantitative data showed that when amplification was used by the teacher, students initiated fewer communicative interactions while the teacher was speaking to the class. As illustrated in Figures 5 to 8 that follow, students in both groups showed decreases in the number of communicative interactions, but the effect was stronger for the amplified groups at each grade level. These effects reached statistical significance in the amplified groups in Grade 1 ($z=2.298$, $p<.05$), Grade 2 ($z=1.709$, $p<.05$) and Grade 3 ($z=2.375$, $p<.01$). The decrease in communicative interactions made by students in Kindergarten, although not significant, was in the expected direction. In Grade 3, the unamplified group also showed a significant decrease, but the effect was not as strong ($z=1.963$, $p<.05$) as that of the amplified group.

In their interviews, teachers stated that they felt they could move around the room more freely and still be heard clearly by all students. One teacher commented, “It’s easier to get their focus back again. Sometimes I would have to take time to come way over to get to them, touch them because they wouldn’t hear me. But at least with this system I can get their attention from where I am. It’s quicker, it’s faster, it’s easier that way” (Grade 3 teacher, District A).

Some students commented that teachers could be heard more clearly when they were speaking to the whole class. “And sometimes we read stories and it’s easier to hear what she’s saying instead of somebody always saying, ‘What? What? What?’ It’s way easier” (Grade 3 student, District A). Another student noted, “Now that we have the microphone, we’re learning a lot more and we’re actually listening and not fooling around” (Grade 3 student, District A).

Figure 5
Percent of Student Communicative Interactions When the Teacher Speaks to the Class Kindergarten

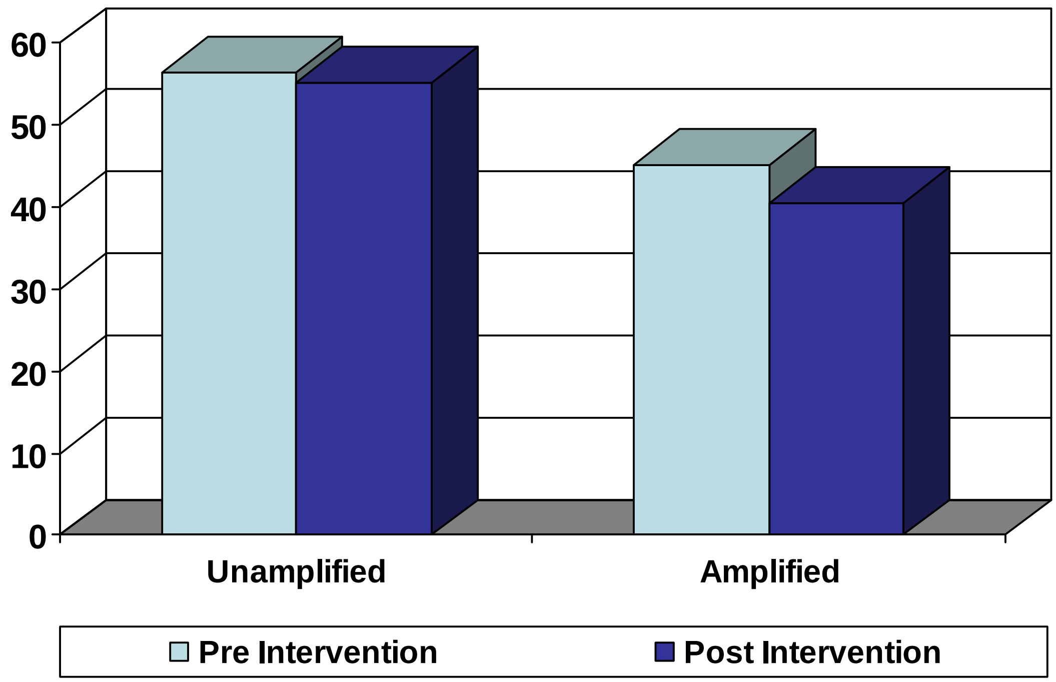


Figure 6
Percent of Student Communicative Interactions When the Teacher Speaks to the Class Grade 1

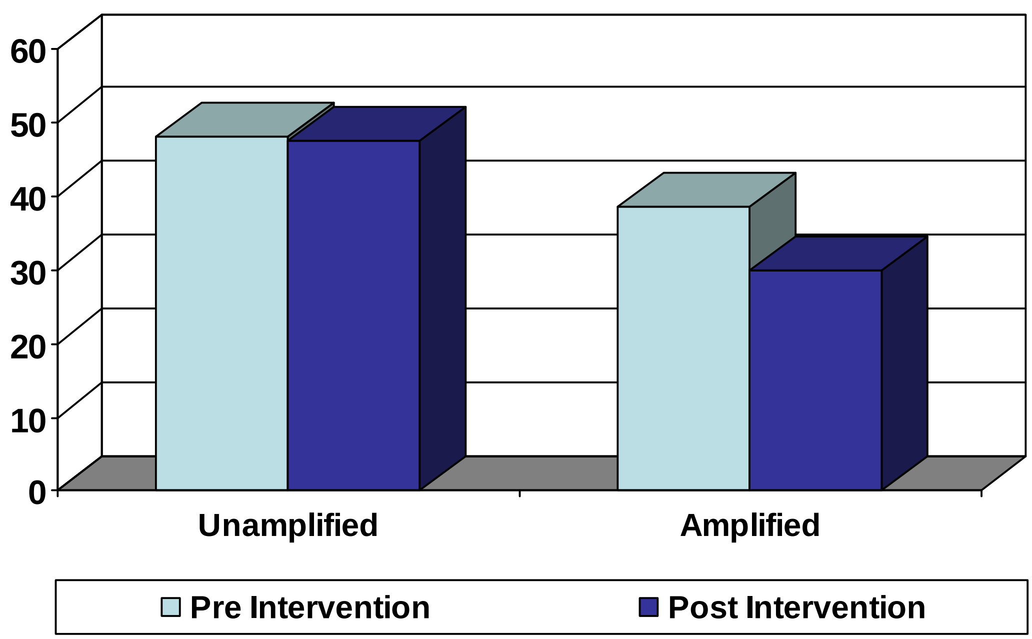


Figure 7
Percent of Student Communicative Interactions When the Teacher Speaks to the Class Grade 2

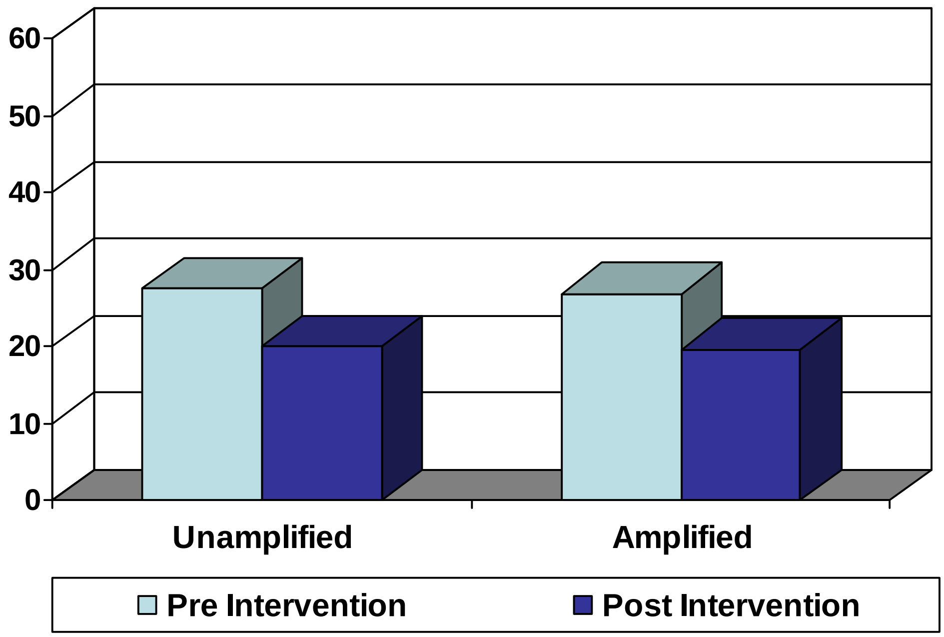
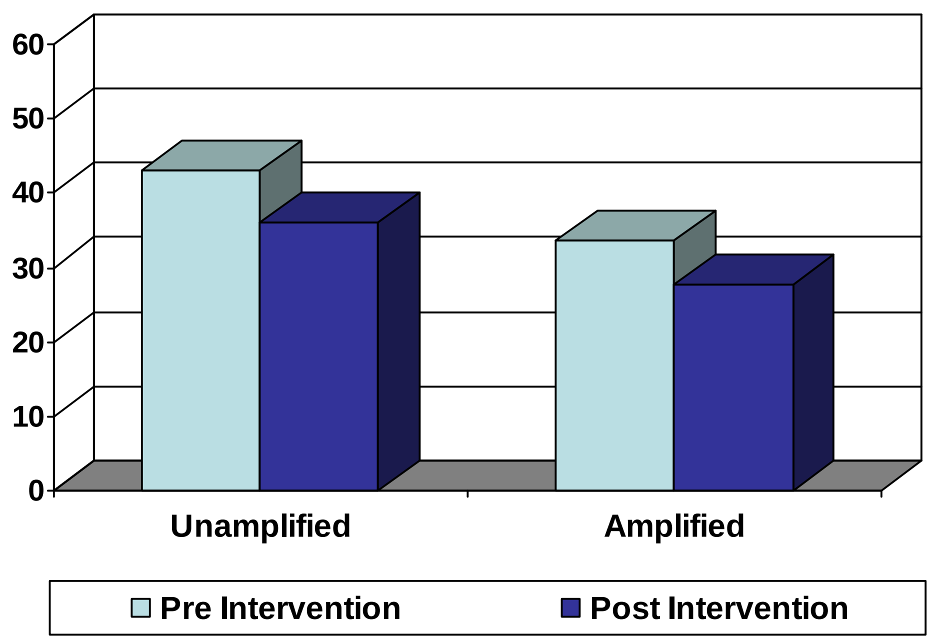


Figure 8
Percent of Student Communicative Interactions When the Teacher Speaks to the Class Grade 3



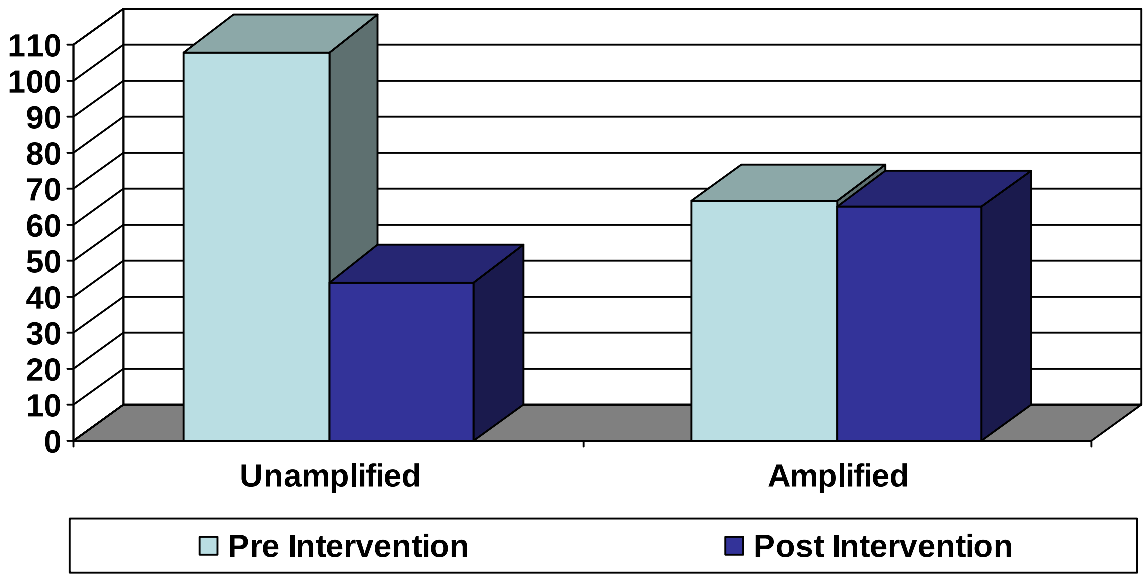
5.3.2.2 Teacher Statements

The number of statements made by teachers in this second category of data (i.e., teacher statements directed to the whole class) was also examined. As previously noted, the data collection procedure involved observing each student in turn for 30 seconds. This procedure was repeated four times for each classroom observation. Only the teacher's statements made to the class while the selected child was being observed were recorded. Data analysis at each grade level involved determining the percentage of the recorded teacher statements out of the total number of 30-second observations made.

More than one student-initiated communication could occur within the same 30-second period. For example, a student might initiate a statement to a teacher and might also communicate with a peer a few seconds later. This sometimes resulted in recording more than one communicative initiation for the same child within one observation period. Thus, the number of teacher statements recorded was sometimes greater than the number of 30-second observations, resulting in a percentage greater than 100 percent for some groups. This occurred in the control group in Kindergarten, Grade 1 and Grade 2 at the beginning of the study.

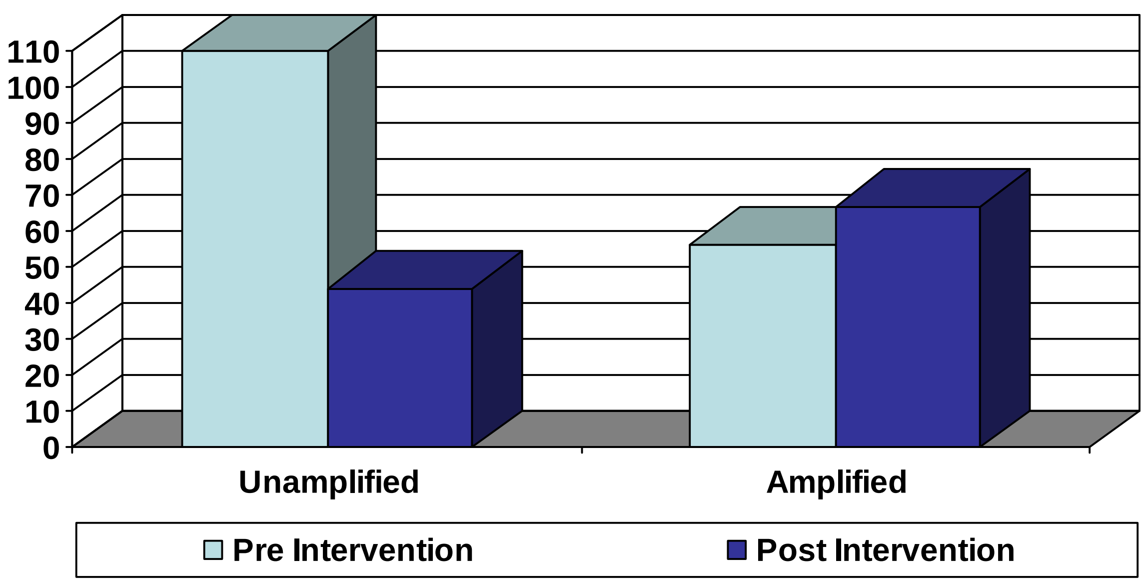
It was expected that teachers who were amplified would spend more time talking to the class as a whole (e.g., giving lessons, instructions, etc.) rather than frequently directing their communication to individual students. As Figure 9 on the next page illustrates, when the data was aggregated across grade levels, the percentage of teacher statements in the amplified classrooms showed no significant change. In contrast, in the unamplified classes, there was a very large drop in the percentage of teacher statements that were class-directed. This indicates that without sound field amplification, teachers decreased the amount of time they spent speaking to the whole class.

Figure 9
Percent of Teacher Statements Directed to the Class
Kindergarten to Grade 3



The large decrease noted in cumulative data for unamplified classes (see Figure 9) was evident at every grade level. In the amplified classes, very small decreases were noted at each grade level, with the exception of Grade 1. At this grade level, the expected increase was seen. This is illustrated in Figure 10.

Figure 10
Percent of Teacher Statements Directed to the Class
Grade 1



The teachers who were amplified mentioned that they did not need to spend as much time keeping students focused. The following are some examples of their statements. “[The] number one [benefit of the system for me is] not having to repeat things about 50 times” (Grade 1 teacher, District A). “For children with short focus, during group sessions, I find they get lost. It’s just so much clearer, even if their eyes aren’t on me, they can tell me what I said. My voice doesn’t blend in anymore” (Kindergarten teacher, District A). “It takes less energy to speak. Also you don’t repeat yourself as much. If the children are working at their tables, and there are some children in the reading corner and you want everyone to get back in a focused spot, you just have to say it once” (Grade 2 teacher, District A).

5.3.3 The Teacher Speaking to a Peer of the Observed Student

The focus of the third category of data was occurrences of the observed student initiating communication while the teacher was directing a verbal statement to another student in the class. As mentioned in the other sections, the observed student’s communication could be directed to the teacher, to another student or to the class. The students’ communicative interactions may include gesturing, touching, talking, or making eye contact.

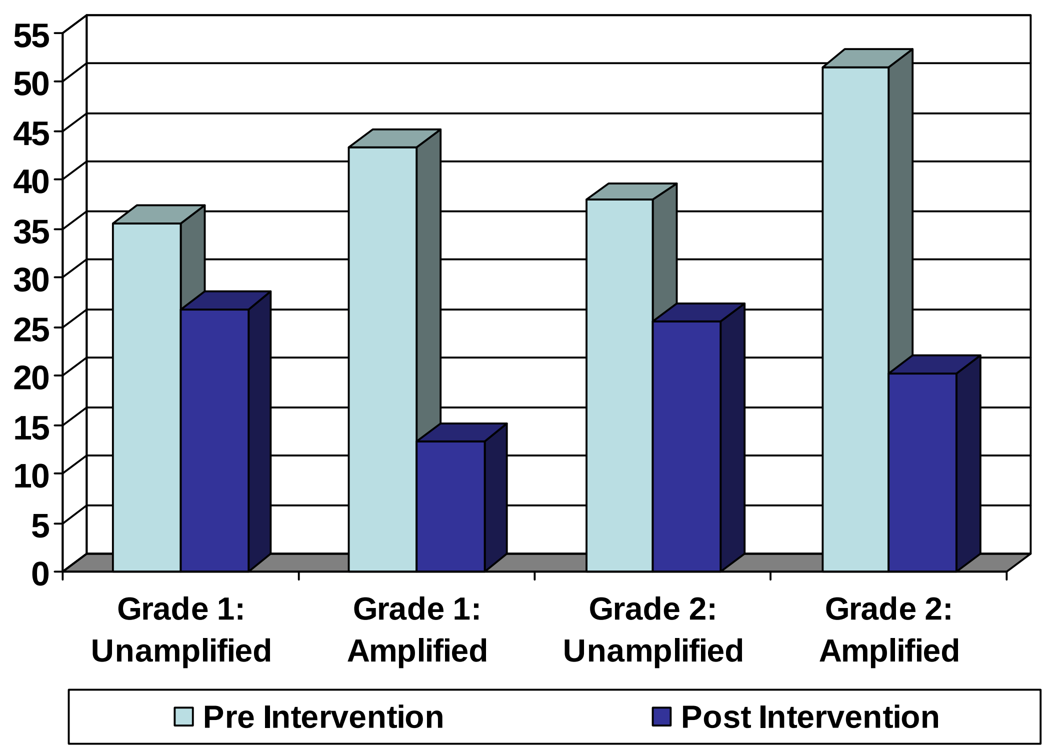
5.3.3.1 Student Communicative Interactions

There was an expectation that the number of times students would initiate communicative interactions when teachers spoke to peers would decrease in the amplified classrooms. It was assumed that students would be listening more attentively when the teacher’s voice was amplified and, therefore, more audible to the students.

When the data was combined for all grade levels, the percentage of student communicative interactions decreased in both the amplified and the unamplified classes. These results were significant in both the amplified group ($z=3.153$, $p<.01$) and the unamplified group ($z=3.534$, $p<.01$).

As shown in Figure 11 below, when the data was separated by grade level, there were clear differences between the amplified and unamplified classes in Grades 1 and 2. While students in both the amplified and unamplified Grade 1 and 2 classes did not exhibit as many communicative interactions, this result was significant only for the amplified groups (Grade 1, z=3.452, p<.01; Grade 2, z=3.191, p<.01). The decrease in communicative interactions was not significant in either of the unamplified groups. It was assumed that the reduction in communicative interactions when teachers were speaking to peers was due to students being able to focus and attend better when they could hear the teacher more clearly.

Figure 11
Percent of Student Communicative Interactions When the Teacher Speaks to a Peer Grades 1 and 2



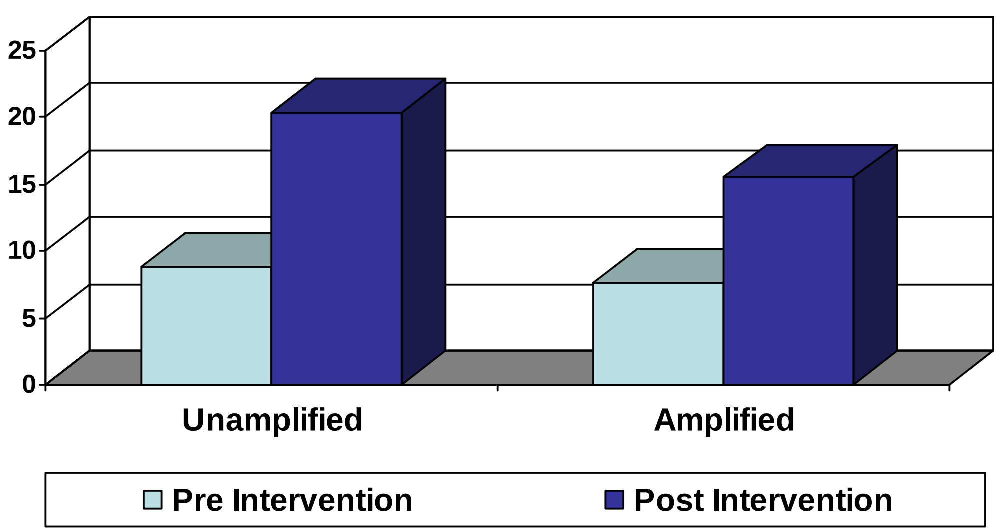
5.3.3.2 Teacher Statements

The number of statements made by teachers in the third category of data (i.e., statements directed to peers) was also examined. As previously noted, the data collection procedure involved observing each student in turn for 30 seconds. This procedure was repeated four times in each classroom observation. Only the teacher's statements made to a peer while the selected child was being observed were recorded. Data analysis at each grade level involved determining the percentage of the recorded teacher statements out of the total number of 30-second observations made.

It was assumed that with amplification, the flow of teachers' communication to individual students would decrease and more time would be spent communicating to the whole class. Thus, teachers who were amplified were expected to make fewer statements to the peers of the observed student than teachers who were not amplified.

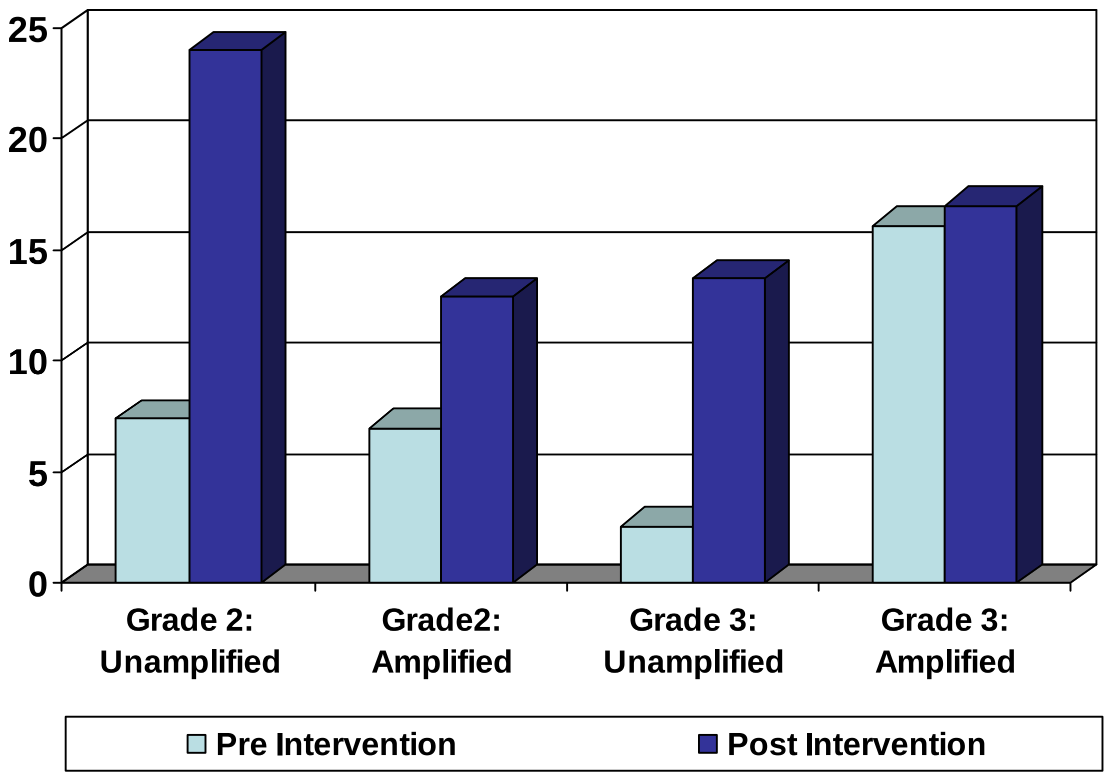
Figure 12 below illustrates that when the data was combined for all grades, both the unamplified and the amplified groups showed increases in teacher statements to peers. The results were significant in both the unamplified group ($z = -9.064$, $p < .0001$) and the amplified group ($z = -8.018$, $p < .0001$). However, the results were not in the expected direction.

Figure 12
Percent of Teacher Statements Directed to Peers
Kindergarten to Grade 3



The data in this area was also analyzed by grade level. In Grades 2 and 3, the increase in teacher statements in the amplified classes was much less than in the unamplified classes. The results of this analysis are presented in Figure 13 below.

Figure 13
Percent of Teacher Statements Directed to Peers
Grades 2 and 3



In Grade 3, the increase in the amplified group did not reach statistical significance, while in the unamplified group the increase was significant ($z = -5.843$, $p < .0001$). This indicates that teachers who were amplified, compared to those who were not, spent less time speaking to individual students and more time communicating to the class.

The second key question addressed in this component of the study is outlined again on the next page:

Key Question 5:

What are the teachers' and students' views on using a sound field amplification system in their classroom?

The sound field systems were accepted well by both the teachers and the students in this study. Teachers' and students' views on using the sound field amplification systems were revealed in the semi-structured interviews. Some of the findings have already been integrated with the quantitative data in the previous sections. Other themes that were generated included the following:

1. Inclusion of Students with Special Needs
2. Educational Benefits of Handheld Microphones
3. More Efficacious Communication
4. Decreased Teacher Voice Strain
5. Learning to Use the Technology

5.3.4 Inclusion of Students with Special Needs

Teachers commented that the amplification technology helped to make their classrooms more inclusive. They stated that the sound field systems improved the learning process for students with various special needs. A Kindergarten teacher in District C noted, "I think it draws in children with problems. I have a girl with speech problems. It gives them the will to take the risk, the chance, and they'll speak in the mic." Another teacher stated, "We have a little boy who's…legally blind…he really relies on his hearing. To me, [the sound system] has probably been most beneficial" (Grade 1 teacher, District B). A Grade 1 teacher in District C said, "I have noticed one particular child, the one we thought might have a central auditory processing problem. Since I've had this [sound system], he's wakened up. He wasn't participating…He's really started to speak and participate."

5.3.5 Educational Benefits of Handheld Microphones

The teachers noted that using the handheld microphones increased the participation of all students. It was felt that students' confidence could be built through greater participation. When students used the microphone, they offered to speak more often since they were no longer being told to repeat themselves. One teacher commented, "Now that they know that they can be heard by everyone, those that would never volunteer to answer are" (Grade 3 teacher, District C). A Grade 3 teacher from District A said, "They would mumble. You couldn't hear them…[now with the handheld microphone] it's beautiful seeing these kids wanting to participate." Another comment by a Kindergarten student in District C also illustrates this point, "When I tell a story I like when I'm using it."

The enhancement of students' voices was also a benefit for students who spoke softly and those who were shy. Teachers noted that students risked participating more often when they held the microphone. A Grade 2, District C teacher noted, "It seems to give the kids a sense of empowerment. Like the kids in the class said, even if you're shy, that way everybody gets to hear your voice because often it was painful to hear some kids do an oral presentation. You have to make them do it, but some kids never heard what they were saying." Another teacher noted "They want to read. They want that microphone in their hand so it makes those shy kids come out" (Grade 3 teacher, District A).

5.3.6 More Efficacious Communication

Participants made a number of statements referring to ways in which the communication within classrooms was more efficient and effective. As a result, there was a more relaxed atmosphere. One student said, "Madame can speak higher and everybody hears her…It's more relaxing…It's better so they don't have to yell" (Grade 2 student, District C). A Grade 3 teacher in District B reflected, "It's allowed me to be leveled all day long...Now I'm able to just be on an even keel for the whole day…I find they're all a little more relaxed."

Teachers and students spoke of saving time, which contributed to more effective communication. For example, they mentioned that they did not need to repeat themselves as often. Also, teachers found they were more efficient because they did not lose time when moving around the class since their voices could be heard well in all parts of the room.

5.3.7 Decreased Teacher Voice Strain

Excessive use of the voice in the teaching profession places many teachers at risk for laryngitis, sore throats, and other health problems related to vocal strain. In fact, compared to other professions, teachers are 32 times more likely to report health concerns related to their voices (*What do teachers' voice problems cost?* n.d.). These problems contribute to lost time at work, and the need for substitute teachers, resulting in inconsistency in teaching the students. Teachers felt that there was a decrease in voice strain when they used the amplification systems. Their statements about the reduced strain on their voices highlight this important additional benefit of the sound field systems.

A Grade 1 teacher in District C remarked, "I do have different allergies so that makes my throat more vulnerable. In September, it's really difficult when there's so much singing, repeating, and chanting." She added, "I'm noticing the wear and tear on my voice after all these years of forcing and talking when you have laryngitis…I'm croaky a lot. [Using the sound system] makes a big difference. I'm one of those teachers with the tendency to lose their voice frequently." A Grade 1 teacher in District A said, "I don't find it as tiring on my voice. I think there is a difference." Another Grade 1 teacher in District A commented, "[When I use the system] I find I'm not as tired at night as I was before." A Kindergarten teacher in District A stated, "I do find that my throat and voice don't seem as dry at the end of the day. And I'm not as tired, probably because there's more effort going into speaking without it."

Some teachers remarked that they had a reduction in voice problems since the sound system was implemented. As noted by a Grade 3 teacher in District A, “I wasn’t straining anymore. I wasn’t having to talk loud anymore. My throat finally got better and I’m not as tired at the end of the day from trying to strain my voice. What a difference for me not having to project my voice over the constant movement in this room.”

Others noted that they had naturally soft voices and amplification prevented vocal straining. A Kindergarten teacher in District C commented, “I don’t have to strain so much for the kids to hear me…I’m not having to force [my voice]… Usually, by this time of the year…I lose my voice…Now I just have to speak clearly into [the microphone].”

5.3.8 Learning to Use the Technology

A few participants noted that some amplified sounds were unnecessary or not related to spoken messages. For example, at times, teachers’ microphones touched clothing or jewelry, making sounds which could be distracting. A Kindergarten student in District A mentioned, “When something touches her buttons, noise goes through both speakers up there.” Also, others mentioned that teachers’ sneezes or coughs were amplified if they did not mute the microphone.

In addition, teachers sometimes found that standing too close to a speaker could cause feedback. One teacher said, “The central box that you turn it on, it’s right behind my story corner. When the children are sitting on the mat, if I go too close to it, it’ll whistle” (Grade 2 teacher, District A). It was also noted that, at times, teachers would forget to turn on or recharge the equipment. As well, others indicated that substitute teachers needed to be oriented to the use of the technology.

At the beginning of the study, the sound field systems were professionally installed and the teachers received instruction on the proper care and use of the systems. In general, teachers needed time to familiarize themselves with the technology and learn the best ways to manage these issues efficiently. Most teachers felt they had already found ways to deal with them. For example, one teacher tried putting a desk under the speaker so that she would not stand too close to it, while another teacher moved her own desk chair away from the speaker for the same reason.

5.4 Reading Achievement

One key question was formulated for the final component of the study.

Key Question 6:
What are the effects of sound field amplification intervention on reading achievement of students in the Kindergarten to Grade 3 classes?

In answering this question, it was intended that available data from the following two sources would be examined:
1. provincial assessment of reading comprehension in Grade 2
2. running records for Kindergarten to Grade 3 students

Since a full set of data could not be obtained, results are not available. The two sections that follow describe the problems that were encountered.

5.4.1 Provincial Assessment of Reading Comprehension

A number of obstacles arose related to collecting and using reading achievement data. Due to the longer than anticipated time required for the tendering process for the sound field systems, the study was postponed from the middle to the later part of the school year. Therefore, there was a limited period of time in which the systems were in use during the 2005-2006 school year. Thus, the provincial assessment results of 2007 would be needed in order to make a meaningful comparison between those that had the technology and those that did not.

Next, some classrooms which did not have sound field systems during the 2005-2006 school year, acquired the systems the following year. Thus, their status changed from unamplified to amplified, making comparisons across time inappropriate.

Also, some schools in this study had both unamplified and amplified classrooms within the same school. In other schools, only some of the classes were part of the study. Assessment results for each school are sorted by program (i.e., English and French Immersion) and not by individual classrooms. Therefore, the data combined some classes at each grade level that were in this study with others that were not. The data could not be separated into unamplified and amplified groups.

A significant limitation was the incomplete set of reading comprehension data submitted for analysis. A full set of data was not provided by all of the school districts. For these reasons, the Grade 2 provincial reading achievement data could not be analyzed. Conclusions could not be made about how these measures may have been affected by the use of sound field amplification.

5.4.2 Running Records

Using the data for running records was also problematic. The running record results from all of the districts involved in the study were not available. School districts vary in how they maintain these records and some records were not kept in a way that would be usable for this research.

This study took place in the final months of the 2005-2006 school year. In order to establish a profile of typical changes over time, running records were requested from the three school districts for both January and June of that school year, as well as for the previous year and the following year. The results of the running records were provided for only a small number of students in this study. Therefore, an analysis could not be completed.

6.0 LIMITATIONS

The following limitations are discussed in the sections that follow: hearing screenings, acoustic measures, timing of the study, training of the Research Assistants, installation of the sound systems, teacher in-servicing and reading achievement data.

6.1 Hearing Screenings

The results of the hearing screenings were shared with parents and school personnel. Time restrictions did not allow return visits to a school to test those children who were absent or unavailable on the scheduled screening day. Also due to time limitations, the researchers were unable to follow-up on the children who did not pass the screenings. Further, there was no provision made in the parental consent to allow the information from the various audiology and Ears, Nose and Throat clinics to be shared with the researchers. A compilation of this information would have provided an accurate profile of the types of hearing deficits in young children in New Brunswick schools. Since hearing problems can interfere with the ability to learn and communicate effectively, earlier detection should help ensure that the child gets the needed services and support.

6.2 Acoustic Measures

There were time and equipment restrictions that limited the acoustic measures that could be taken in the classrooms. Sound level readings were conducted only in classrooms when they were unoccupied. Time limitations did not allow for testing in classrooms with teachers and students present. Testing in occupied classrooms would provide additional information about other interfering sounds from the presence of people in these rooms.

In this study, an A-weighted scale was used to measure the sound levels in classrooms. This scale measures sound pressure level in a way that most closely resembles human hearing. Another acoustical measure is the C-weighted scale. This scale measures more sounds in the low frequency range than does the A-weighted scale. Use of the C-weighted scale can be beneficial when low frequency noise is excessive in a classroom. Time limitations did not allow for measurements with a C-weighted scale.

Reverberation time, an estimate of how quickly sounds fade away in a room, affects the level of background noise as the noise is not absorbed and bounces off hard surfaces. High reverberation time makes speech less easily understood. In this study, reverberation time was not measured due to time and equipment limitations.

6.3 Training of the Research Assistants

The design of this study required the involvement of several Research Assistants (RAs). It was necessary to make classroom observations during certain times of the day (i.e., literacy block) and there was a short length of time within which to carry out all of the observations. In order to conduct the study in several locations concurrently, four RAs were involved. To ensure consistency in the data collection process among the four RAs, a training session was given by the researchers. The RAs also followed this session with their own practice in their respective schools. Due to the complexity of the data collection instrument, it was recognized that further time should have been allotted for training, including on-site visits for the individual practice sessions.

6.4 Installation of the Sound Systems

There were variations in the way the sound systems were installed. The three school districts independently identified who was to carry out the installation process in their schools. It is unknown whether these variations in installation had any effect on the results of the study.

6.5 Teacher In-Servicing

Each school district independently provided in-service education for teachers on the use of the sound field systems. A standard in-service training package and follow-up schedule was not given to the districts. Therefore, the content of the training for teachers may have varied. It is unknown whether variations in the educational sessions resulted in differences in how systems were used.

6.6 Reading Achievement Data

As discussed earlier, there were limitations in the results of the reading achievement analysis. First, the delay in the installation of the sound field systems resulted in a need for reading data collection to occur in the following school year. Within the following year, however, some classrooms that did not have sound systems, received them and could no longer be considered unamplified classes. Further, the provincial reading achievement data is separated by English and French Immersion program rather than by class. Finally, a full set of data was not provided by all of the school districts.

7.0 RECOMMENDATIONS

It has been well-established in the current literature that sound field amplification is a significant benefit to young students in classroom learning environments. The results of several measures conducted for this study support the use of sound field systems in elementary classrooms in New Brunswick schools. It is recommended that this technology be considered as a vital part of ongoing efforts to improve student learning.

This section highlights recommendations that emerged from the various areas of the study. Recommendations are presented for the following areas:

1. Annual Hearing Screenings
2. Classroom Acoustics
3. Educational Audiologist
4. Teacher In-Servicing
5. Areas for Further Study

7.1 Annual Hearing Screenings

Currently, regular hearing screenings are conducted with children at age 3.5 years in New Brunswick as part of a Public Health initiative. Such routine screenings of all students, however, do not occur during the school years. When the hearing screenings were conducted for this study, only 70% to 75% of the students in Kindergarten and Grade 1 met the standard for acceptable hearing. This finding is consistent with data reported in the professional literature. These hearing screening results point out the vital need to screen young children for hearing problems.

It is particularly important to identify hearing problems as early as possible, so that treatment can reduce their impact. Many conditions are treatable with follow-up care. For example, the hearing problems of those children with middle ear disorders (e.g., ear infections, wax build-up) may be educationally significant, but could be alleviated with medical intervention. Some children could present with permanent hearing loss. Early identification can lead to earlier treatment and, ultimately, better educational outcomes.

It is recommended that Public Health Nurses conduct annual hearing screenings of all children in Kindergarten. Additionally, any students in elementary school presenting with attention, speech-language and/or learning difficulties should be screened to rule out hearing deficits as a potential factor contributing to their educational concerns.

Serpanos and Jamel (2007) emphasize the need for hearing screening throughout childhood to help identify late onset or acquired hearing loss. These researchers also cite several studies which support the value of conducting a screening of middle ear function, given the high incidence of middle ear problems in early childhood. It is recommended that further discussion be held with audiologists regarding the cost-effectiveness of implementing this important additional testing.

7.2 Classroom Acoustics

Many of the classrooms in this study have poor acoustics and high levels of background noise. Lushington (2007) made a number of recommendations for improving acoustics in these classrooms. Most of these recommendations are based on the work of Whitehead (n.d.). Lushington pointed out that some of his suggestions may require room modifications and these must be made in compliance with standard fire and safety codes.

When background noise is a problem, it is important to ascertain the cause of the noise. This will help in the determination of the most appropriate solution. For example, when the problem involves noisy fluorescent light fixtures, the ballast should be replaced. When heating and ventilation (HV) systems are the cause of the noise, possible solutions might include using sound baffles, quieter fans, and insulation around ductwork. Other solutions for noisy HV systems include fixing loose or vibrating parts, cleaning the fans, and replacing worn out parts.

Another factor to consider is minimizing the distance between the students and the teachers. One measure to help reduce the physical volume of the room is to rearrange the furnishings. Also, free-standing furnishings can be positioned to break up sound reflections and isolate areas within a larger room.

Modifications can be made to help absorb unwanted classroom noise. These measures include the use of suspended acoustic ceiling tiles, sound-absorbent panels on upper walls, curtains over the windows, cork boards for the walls, and foot covers for metal chair legs. Carrying out these modifications will help to decrease the negative effects of sound bouncing off of hard surfaces. Teachers should turn off any electronic equipment not being used. Also, when electronic equipment needs to be replaced, quieter versions could be purchased. In addition, computers should be positioned as far away from the children as possible.

In the design of new schools, or the renovation of existing schools, an audiologist or a sound engineer should be consulted to ensure that the buildings are designed to provide optimal listening conditions. The ANSI (Acoustical Society of America, 2002) standard represents the best recommendation for ensuring proper acoustical design for classrooms. Seep et al. (2000) offer straightforward suggestions on creating desirable listening conditions in the construction of new schools or the renovation of older ones.

7.3 Educational Audiologist

Given the recommendations for conducting school-based annual hearing screenings and improving classroom acoustics, there is clearly a role for an audiologist to work directly with the New Brunswick Department of Education. An educational audiologist, with a specialized background for working in school settings, could address many of the problems identified in this report.

First, an educational audiologist could coordinate hearing screening programs. This role could include serving as a liaison for Public Health Nurses who would be implementing the screening program. An educational audiologist could provide guidelines for screening and training of staff on techniques to use for hearing screening.

Second, in regard to the sound field amplification systems, an educational audiologist could oversee the implementation and ongoing training of educators. To ensure that the systems continue to be used appropriately, it would be important to conduct periodic reviews and provide teachers with regular opportunities for in-service education.

Third, an educational audiologist could evaluate school environments for noise. He or she would make recommendations to improve classroom acoustics as well as overall noise and reverberation levels.

7.4 Teacher In-Servicing

It is recommended that when sound field systems are purchased, a sufficient budget should be allotted for teacher in-servicing. It appears from some teachers' comments that they still had questions remaining at the end of the study regarding the use of the technology. It is suggested that teachers receive an extensive orientation and a training package which would include information on the setup and operation of the technology, as well as the rationale for use of the equipment.

According to Flexer (2005), in-service for educators should "emphasize the brain development purpose of acoustic accessibility. The relationship of hearing to literacy needs to be targeted as does the fact that children listen differently than adults" (p. 16). In addition to providing training directly related to the technical use of the equipment, other areas should be covered. Flexer (2005) suggests that an optimal in-service education program would include background theory, as well as demonstration and practice with the technology. Instruction on incorporating the technology effectively into classroom teaching practices would also be beneficial. In-service education should be provided by individuals knowledgeable in acoustics and the use of sound field technology in the classroom.

Flexer (2005) has provided a thorough outline for an effective teacher training program. She covers both the rationale for and use of sound-field amplification systems. In addition to the technical aspects of sound field amplification, the following are some of the areas she has outlined: the importance of listening, sound and its properties, factors that limit students' ability to listen, noise and reverberation sources, and materials and strategies to manage and enhance listening. Flexer's outline is reproduced with permission in Appendix H. This detailed outline is intended to be used by professionals with backgrounds in acoustics. The outline demonstrates that there is an extensive knowledge base required to maximize the use of classroom sound field amplification.

In addition to the initial in-service training, schools should offer periodic follow-up sessions by individuals knowledgeable in acoustics and the use of sound field technology. This would help to ensure ongoing effective use of the systems. It would also be practical and cost-effective to have personnel at the school level who would be trained to troubleshoot if problems arose with the technology and to provide basic orientation on the systems for substitute teachers.

7.5 Areas for Further Study

Findings from this research lead to recommendations for areas of further study. These include: hearing screening follow-up, acoustic measures, use of handheld microphones, Kindergarten students, second language learning, cost effectiveness and achievement measures. A discussion of each of these six topics follows:

7.5.1 Hearing Screening Follow-Up

Future research could make provision for follow-up on the children who do not pass hearing screenings. A formal compilation of this information could provide an accurate profile of the prevalence and types of hearing deficits in young children in early elementary years in New Brunswick.

7.5.2 Acoustic Measures

Time constraints limited the acoustic measures that could be performed in this study. A more comprehensive assessment would provide important additional information on classroom acoustics. Assessment of reverberation, which was not conducted for this study, might aid in determining any negative effects of late reverberation on classroom listening conditions. Assessing the noise within the classrooms at various distances, with teachers and students present, might be useful. A longer assessment period, at least one hour, should also be conducted in those classrooms which show unsteady noise.

7.5.3 Use of Handheld Microphones

The use of handheld microphones in the classroom would be another area to examine. These microphones are passed from student to student allowing their voices to be amplified when they speak. This study focused on the amplification of the teachers' voices, but increasing the volume of the students' voices may have additional benefits, particularly for shy or quiet students.

While the teachers mentioned numerous educational benefits of handheld microphones, this study did not formally investigate the impact that the microphones could have on students' active engagement in the learning process. It would be expected that when students could be heard better, their participation could increase because they would be more actively engaged in orally sharing and communicating their ideas. Those who are shy and rarely speak up would no longer need to be told to talk more loudly. Children with quiet voices could be heard more clearly. With increased student involvement, classrooms would become more inclusive.

7.5.4 Kindergarten Students

A study of the use of sound field systems could specifically focus on the Kindergarten level. It is not known whether the pedagogical methods employed by Kindergarten teachers differed since these young children are just beginning to learn to pay attention and develop their listening ability in a classroom setting. Thus, it is assumed that the communicative interactions in Kindergarten would have a different emphasis than those in older grades.

7.5.5 Second Language Learning

The benefits of sound field amplification have been well documented in the literature for students learning a second language (Nelson et al., 2005). Since students in the early years of French Immersion do not have a great deal of experience with French, they must be able to clearly hear the sounds being spoken by the teacher in order to fully understand the message.

In this study, the data for the English and French Immersion classrooms were combined by grade level. A decision was made later to separate some of the data for French Immersion, even though it was not part of the research proposal. The data in which the teachers' statements were directed to the whole class was chosen to be examined. This data set was selected since it contained the largest number of cases.

In the full study, when amplification was used by the teacher, students initiated fewer distracting communicative interactions while the teacher was speaking to the class. It was assumed that this meant that students focused and attended better when they could hear the teacher more clearly with sound field amplification. In the French Immersion classes the students also initiated fewer distracting communicative behaviors with sound field amplification. These results were found in Grades 1, 2, and 3; there is no French Immersion program at the Kindergarten level. Although these results are consistent with findings in the literature, the numbers were too small to make any broad generalizations. Therefore, further investigation of the overall benefits of sound field technology in French Immersion classes should be conducted.

7.5.6 Cost Effectiveness

Another area for further study is an assessment of the benefits of sound field amplification systems on teachers' health and the potential reduction in lost work time. Teachers mentioned that their classrooms were more relaxed and that they were feeling less stressed and less tired when they used amplification. They noted that the systems allowed them greater freedom of movement since they knew that children could hear them clearly from any part of the room. Further, many teachers commented that their health was improved. For example, there was a reduction in sore throats and laryngitis. They stated that they also lost less time associated with these conditions.

Further study should evaluate the impact of sound field systems on the cost of replacing teachers with substitute teachers. Researchers in voice science have estimated that 40% of teachers experience voice problems (*What do teachers' voice problems cost?* n.d.). It is assumed that there would be a reduced rate of absenteeism when the systems are used. There is also the possible indirect benefit to students due to maintaining continuity in teaching. This is another potential are of investigation.

7.5.7 Achievement Measures

Future researchers should conduct their own achievement measures when studying the effect of classroom sound field amplification on literacy. This would help to ensure consistency in data collection and accessibility of the data needed.

A wide range of literacy measures should be considered for study to determine which areas may be affected by sound field amplification technology. This might include reading comprehension, phonological awareness, phonics, writing, and spelling. Other areas of achievement may also be worth investigating, such as numeracy and content areas like science and social studies.

8.0 FINAL COMMENTS

The most common way in which children are taught in elementary classrooms today is through spoken language conveyed by the teacher. While many teaching techniques and methods are part of the school day, the use of vocal messages is by the far the most prevalent.

There are numerous factors which impact students' ability to hear verbal communication in the classroom. For example, children's auditory systems do not fully develop until about 13 to 15 years of age. In addition, there are those children who struggle to understand oral language because of hearing loss. Many children in this study required retesting or follow-up on a hearing screening test. This finding points to the need for regular hearing screenings of young school age children to identify those who may require medical and/or audiological intervention.

Other children may experience a central auditory processing disorder or attention deficit disorder. Also, second language learners have limited experience to fill in the gaps when they don't clearly hear all of the sounds being communicated. Thus, they may have difficulty understanding unfamiliar words spoken in their classrooms.

The acoustic quality of the classroom impacts the listening environment for the child. In this study, there was a high prevalence of background noise in many classes. The need for improved classroom acoustics was evident. Anderson (2006) refers to listening as the "primary gateway to learning" and background noise as "putting bars on the gateway" (p. 23). As outlined in this report, changes can be made to school facilities to address some of the problems in their design. Although these changes will improve the learning environment, they will not be sufficient to provide optimal listening conditions for all students. The detrimental effects of poor listening conditions can be reduced by increasing the access of all students to the spoken message, thereby maximizing their learning potential.

Classroom sound field amplification provides a means for students to hear the teacher's voice clearly over the background noise. What sound field amplification does for the learning process is to provide a way for teachers to communicate in normal, effective voices without straining to make themselves heard. Simply stated, with amplification, students hear the message with full clarity as if it is a one-on-one situation with the teacher.

This report serves to inform the discussion on sound field amplification within the New Brunswick Department of Education by providing data from New Brunswick students. The first recommendation is to install sound field amplification systems in Kindergarten through Grade 3 classrooms in all New Brunswick schools. The other recommendations are to implement a school-based hearing screening program, improve classroom acoustics, consider hiring an educational audiologist, and provide in-service to educators on sound field amplification. The following are areas where further study would expand the knowledge base related to learning through spoken language in the classroom: hearing screening follow-up, additional measurement of classroom acoustics, use of handheld microphones, pedagogical methods used in Kindergarten, second language learning, teachers' vocal health, and a variety of achievement measures.

As Flexer (2004) reminds us, good clear understanding of spoken language in the classroom should not be viewed as extravagant, but as a critical component of the learning process.

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Appendix A

Revised Environmental Communication Profile*

(Massie, Theodoros, Byrne, McPherson, & Smaldino, 1999)

Class: ______________ School: ________________ Date: __________ Start: ______ Finish: _____ Pg __ of __

CHILD'S COMMUNICATIVE INTERACTIONS										ENVIRONMENTAL EVENTS																
Verbal		Nonverbal				Direction of Communication				Verbal		Nonverbal				Verbal		Nonverbal				SOURCE OF STIMULI TO CHILD				
										TEACHER						PEER										
Statement	Other Vocal Behavior	Eye Contact	Tactile	Gesture	No Response	Initiations to Teacher	Initiations to Peer	Initiations to Class	Initiations to Self	Statement	Other Vocal Behavior	Eye Contact	Tactile	Gesture	No Response	Statement	Other Vocal Behavior	Eye Contact	Tactile	Gesture	No Response	Cues to child from teacher or peer	Cues to class from teacher or peer	Cues to peer from teacher	Cues Between Peers	Noise/Environment

* copied with permission

Appendix B

Interview Guide

Teachers:

- What has having the sound system here in your classroom meant to you?

- How has the system made a difference to your teaching?

- How has the system made a difference to students' learning?

- If you were told you wouldn't have the system next year, what would that mean to you?

Students:

- Take a moment to remember what your classroom was like before you had this sound system in place...Now think about your classroom today...What are the differences?

- Has having the system in your classroom helped your learning? Why?

- What are the good things?

- What are the bad things?

Appendix C

Information Letter and Consent Form for Parents of Children in Amplified Classes

Dear Parents/Guardians of Children attending X Elementary School:

Schools are putting sound systems in classrooms. The systems make the teacher's voice a little bit louder. The teacher talks into a microphone and there are speakers in the ceiling. The system makes it easier for children to hear. Sometimes, teachers give students a microphone too. Schools that have used these systems find that they help students learn better.

X Elementary School will try these sound systems in the Kindergarten, Grade 1, Grade 2, and Grade 3 classes.

Purpose of Special Project at X Elementary School

We will look at the children's learning before they start using the systems. We will also look at learning after they have used the systems.

Four Parts of the Project

1. **Hearing Screening:** We will offer a hearing screening for each student. The screener will put a set of headphones on your child. She will instruct the child to say if he or she hears the sounds. The sounds are in the speech range and will not cause any pain to hear. The screening will take less than 5 minutes. She will share the results of the hearing screening with parents.

2. **Class Reading Skills:** We will look at the reading skills from the school's records. We will look at the children's records before they had the system. We will also look at the records after the systems are used. We will not test the children. We will not use any child's name.

3. **Class Observation:** An observer will be in the class for about an hour at a time. She will look at the activities and talking during class. We will not use any child's name. She will observe two times. In January, she will observe before the teacher uses the sound system. She will come back in May or June, after the sound system has been used for a few months.

4. **Class Visit:** In June, one of us will visit your child's class. We will ask the class questions about the sound system. For example, "What was it like having the sound system in your class?" We will tape-record the answers. We will not use any child's name.

We see **no harmful effects or risks** to your child for taking part in this project. The sound system may help your child hear more and learn better.

For more information you can contact:

Rhonda Rubin, Speech-Language Pathologist, Extra Mural Program
Phone: 364-4400 E-mail: rhrubin1@serha.ca

Joan Flagg-Williams, Instructor, Atlantic Baptist University
Phone: 449-2951 E-mail: joan.flaggwilliams@abu.nb.ca

Catherine Aquino-Russell**,** Nurse, Professor, University of New Brunswick
Phone: 869-6592 E-mail: caquinor@unb.ca

A person who is not a part of this project can also answer your questions:
Dr. Cheryl Gibson, Dean, Faculty of Nursing, University of New Brunswick
Phone: (506) 458-7625 E-mail: gibs@unb.ca

Parent Permission

I understand the purpose of this special project. I understand that my child's participation is my choice. I understand that I will get a copy of this letter. I can ask questions by contacting any of the people named above.

Child's Name: __________________________ **Class:** ______________

☑**YES, my child may participate:** _______________________ _________
Parent/Guardian's signature Date

☒**NO, my child may not participate:** _______________________ _________
Parent/Guardian's signature Date

My child may not participate, but I would like my child's hearing screened:
_______________________ _________
Parent/Guardian's signature Date

NOT SURE, please call me at __________________ ____________________
Telephone Number Name

Appendix D

Information Letter and Consent Form for Parents of Children in Unamplified Classes

Dear Parents/Guardians of Children attending Y School:

Your child's school is part of a special project on student learning. We will look at the regular activities in classrooms at Y School. This project starts in January. It ends in June.

Three Parts of the Project

1. **Hearing Screening:** We will offer a hearing screening for each student. The screener will put a set of headphones on your child. She will instruct the child to say if he or she hears the sounds. The sounds are in the speech range and will not cause any pain to hear. The screening will take less than 5 minutes. She will share the results of the hearing screening with parents.

2. **Class Reading Skills:** We will look at the reading skills from the school's records. We will not test the children. We will not use any child's name.

3. **Class Observation:** An observer will be in the class for about an hour at a time. She will look at the activities and talking during class. We will not use any child's name. She will observe two times. She will come early in the new year. She will come back in May or June.

We see no harmful effects or risks to your child for taking part in this project.

For more information you can contact:

Rhonda Rubin, Speech-Language Pathologist, Extra Mural Program
Phone: 364-4400 E-mail: rhrubin1@serha.ca

Joan Flagg-Williams, Instructor, Atlantic Baptist University
Phone: 449-2951 E-mail: joan.flaggwilliams@abu.nb.ca

Catherine Aquino-Russell**,** Nurse, Professor, University of New Brunswick
Phone: 869-6592 E-mail: caquinor@unb.ca

A person who is not a part of this project can also answer your questions:

Dr. Cheryl Gibson, Dean, Faculty of Nursing, University of New Brunswick
Phone: (506) 458-7625 E-mail: gibs@unb.ca

Parent Permission

I understand the purpose of this special project. I understand that my child's participation is my choice. I understand that I will get a copy of this letter. I can ask questions by contacting any of the people named above.

Child's Name: _________________________ Class: ___________

☑ **YES, my child <u>may</u> participate:**

________________________________ ___________________
Parent/Guardian's signature Date

☒ **NO, my child <u>may not</u> participate:**

________________________________ ___________________
Parent/Guardian's signature Date

My child may not participate, but I would like my child's hearing screened:

________________________________ ___________________
Parent/Guardian's signature Date

NOT SURE, please call me at _______________ ____________________
Telephone Number Name

Appendix E

Information Letter and Consent Form for Teachers of Children in Amplified Classes

Dear Teachers at X Elementary School:

Your school has been selected as a site for evaluating the benefits of sound field amplification in grades Kindergarten through Grade 3. The selected sound field amplification involves you speaking into a wireless microphone with speakers located in the ceiling. This enables listeners to hear wherever they sit in the classroom. Students will also have a pass-around microphone to speak into which will help others to hear them. Previous research has shown that by enhancing the level of sound slightly in classrooms, students' learning is enhanced, especially because children's auditory systems are less developed than adults'.

We are looking at students' reading achievement and at the flow of communication in your class before and after the sound system has been installed. At the end of the study, one of the researchers will come into your classroom at a time convenient to you. She will ask the students questions about their views on whether or not the system made a difference to their hearing and learning. At a separate time, she will also ask you your opinion on whether or not the system has made a difference to you and your teaching. These interactions will be tape-recorded. No identifying information will be collected on who said what.

Anonymity and confidentiality are assured as your name will not appear on the qualitative data or written results of the study. We also wish to receive your consent to allow a research assistant (RA) to observe and record the communication between children and you in the classroom.

This project will commence in January 2006 and run through to June 2006. The RA will visit each class twice for approximately 1 hour each time.

We see no adverse effects or risks to you or the children in your class for participating in this research study. We see possible benefits for your students since they will be able to hear your voice better over the routine noises of the classroom (e.g., talking, moving furniture, fans).

You have the freedom to participate or withdraw from the study at any time.

We are a team of professionals who are interested in improving learning environments for children. We are all available to answer your questions. You may contact any of us and ask questions:

Dr. Rhonda Rubin, Speech-Language Pathologist, Extra Mural Program
Phone: 364-4400 E-mail: rhrubin1@serha.ca

Dr. Joan Flagg-Williams, Instructor, Atlantic Baptist University
Phone: 449-2951 E-mail: joan.flaggwilliams@abu.nb.ca

Dr. Catherine Aquino-Russell, Nurse, Professor, University of New Brunswick,
Phone: 869-6592 E-mail: caquinor@unb.ca

A contact person who is not a part of the study:
Dr. Cheryl Gibson, Dean, Faculty of Nursing, University of New Brunswick
Phone: (506) 458-7625 E-mail: gibs@unb.ca

Consent

By signing this form, I understand the purpose of the study, I understand that my participation is voluntary; I understand that a copy of the information letter/consent form will be given to me so that I can ask any further questions by contacting any of the researchers.

___________________________ Teacher's name _____ Grade level

I agree to participate in the study:

__________________________________ __________________
Signature Date

I do not agree to participate in the study:

__________________________________ __________________
Signature Date

Appendix F

Information Letter and Consent Form for Teachers of Children in Unamplified Classes

Dear Teachers at Y Elementary School:

Your school has been selected as a control group site for a research study. We are evaluating the benefits of sound field amplification in Kindergarten through Grade 3. We will be observing your regular classroom activities during two language arts classes and comparing the results with those of another school that will have amplification systems installed in the classrooms.

We are looking at students' reading achievement and at the flow of communication in your class in January or February and May or June. Anonymity and confidentiality are assured as your name will not appear on the data or written results of the study. We also wish to receive your consent to allow a research assistant (RA) to observe and record the communication between children and you in the classroom.

This study will commence in January 2006 and run through to June 2006. The RA will visit each class twice for approximately 1 hour each time.

We see no adverse effects or risks to you or the children in your class for participating in this research study.

You have the freedom to participate or withdraw from the study at any time.

We are a team of professionals who are interested in improving learning environments for children. We are all available to answer your questions. You may contact any of us and ask questions:

Dr. Rhonda Rubin, Speech-Language Pathologist, Extra Mural Services
Phone: 364-4400 E-mail: rhrubin1@serha.ca

Dr. Joan Flagg-Williams, Instructor, Atlantic Baptist University
Phone: 449-2951 E-mail: joan.flaggwilliams@abu.nb.ca

Dr. Catherine Aquino-Russell, Nurse, Professor, University of New Brunswick,
Phone: 869-6592 E-mail: caquinor@unb.ca

A contact person who is not a part of the study:
Dr. Cheryl Gibson, Dean, Faculty of Nursing, University of New Brunswick
Phone: (506) 458-7625 E-mail: gibs@unb.ca

Consent

By signing this form, I understand the purpose of the study, I understand that my participation is voluntary; I understand that a copy of the information letter/consent form will be given to me so that I can ask any further questions by contacting any of the researchers.

__________________________ Teacher's name _____ Grade level

I agree to participate in the study:

_________________________________ __________________
Signature Date

I do not agree to participate in the study:

_________________________________ __________________
Signature Date

Appendix G
Hearing Screening Report Form

______________________ was seen for a hearing screening on _____________
(Name of student) (Date)

Results indicated:

Hearing within normal limits:

___ for both ears

___ for left ear

___ for right ear

Hearing below educationally significant level:

___ for both ears

___ for left ear

___ for right ear

Recommendations: ___ parent to discuss with family doctor

___ repeat hearing screening

Screened by: ____

Appendix H

Rationale and Use of Sound Field Amplification: Outline for Teacher In-Service Training*

(Flexer, 2005)

CONTENT AREAS

I. The World Has Changed
  A. Emphasis on literacy, including current statistics of pupils' reading performance
  B. Studies show that sound field amplification improves literacy
  C. The United States has a knowledge-and information-based economy

II. The Importance of Listening
  A. Hearing versus listening: auditory brain center access, stimulation, and growth
    1. Definition and differentiation of terms
    2. Sequential levels involved in auditory skills development
  B. Variables that affect listening
    1. Acoustic signal variables
    2. Listener response task variables
    3. Listening environment variables
    4. Listener-relates variables: children do not listen like adults listen
    5. Speaker-related variables

III. Orientation to Sound and Its Properties
  A. Sound and sound waves
  B. Characteristics of sound
    1. Frequency
    2. Intensity
    3. Time
  C. Critical frequencies of speech perception
  D. Low- and high-frequency characteristics of speech sounds
  E. Activity: unfair spelling test

IV. Factors That Limit the Student's Ability to Listen
  A. Noise
  B. Reverberation
    1. Reverberation and reverberation time
    2. Effect of reverberation on speech perception
    3. Effect of age on speech perception under reverberant conditions

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* From Sound Field Amplification, Applications to Speech Perception and Classroom Acoustics 2nd edition by CRANDELL/SMALDINO/FLEXER, 2005. Reprinted with permission of Delmar Learning, a division of Thomson Learning: www.thomsonrights.com. Fax 800 730-2215.

C. Effects of noise and reverberation on speech perception
   1. Synergistic phenomenon of noise and reverberation
   2. ANSI standards for classroom noise and reverberation levels
D. Signal-to-noise (S/N) ratio, distance, and speech recognition
   1. Signal-to-noise (S/N) ratio
   2. Effects of S/N and distance on speech-recognition ability as function of listener age

V. Noise and reverberation sources
   A. External and adjacent classroom noise sources
   B. Internal classroom noise sources
   C. Common classroom noise levels
   D. Common environmental noise levels
   E. Reverberation sources

VI. Materials and Strategies to Manage and Enhance Listening
   A. Noise and reverberation absorption materials
   B. Acoustical treatments
      1. External modifications
      2. Internal modifications
   C. Instructional strategies to improve classroom listening
   D. School-based noise reduction strategies

VII. Sound Field Amplification: FM and IR
   A. Orientation to sound field amplification
      1. Description of components, and distinguishing between FM and IR systems
      2. Demonstration of sound field amplification system
      3. Benefits of sound field amplification: FM and IR
      4. Factors to consider when recommending, purchasing, installing, and using sound field FM and IR amplification systems
   B. Transmitter and microphone options
      1. Options for wearing the transmitter or microphone
      2. Tips for successful use of the transmitter or microphone
      3. How to use the pass-around microphone for children
   C. Loudspeaker options
      1. Loudspeaker placement options
      2. Loudspeaker placement variables
   D. Setting the receiver or amplifier volume control
   E. Sound field amplification system maintenance tips
   F. Sound field amplification system troubleshooting tips (wired system)