Evaluating Sound Field Amplification Technology in New Brunswick Schools[1]

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Background

The typical elementary school classroom is an environment full of sounds. 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). 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. Thus, it has been well-established that successful students are able to listen to and comprehend spoken messages in the classroom (Edwards, 2005).

In such a sound-dependent environment, the impact of classroom acoustics cannot be overstated. Many features within classrooms influence their acoustics. They include background noise from ventilation systems or equipment in the room, noise in the hallways or outside the windows, collaborative groups working side by side, 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 noise.

"All children need good, clear signals and low background noise for full understanding" (Nelson & Soli, 2000, p. 356). It has long been recognized that the typical signal to noise ratio in most classrooms does not meet the recommended guidelines (ASHA, 1994) and may adversely affect educational performance (Crandell, Kreisman, Smaldino, & Kreisman, 2004). "Acoustic accessibility is not a luxury – it is a necessity" (Flexer, 2004, p.139). Reducing the barriers to verbal learning within the classroom soundscape is the goal of many speech-language pathologists and audiologists who work with children.

The complex listening environment of the typical classroom most strongly affects the young or inexperienced listener. Children younger than 13-15 years of age do not yet have mature auditory systems (Anderson, 2004; Boothroyd, 2004). They require better conditions for listening because they are not able to focus as well as adults in noise and also do not have the experience with language to fill in the gaps of missed information (Crandell & Smaldino, 2000; Flexer, 2005).

Other factors which further compound children's ability to listen in the classroom include deficits in attention, language, or auditory processing. Children learning a second language also need optimal listening conditions in order to recognize unfamiliar words (Boothroyd, 2004; Nelson & Soli, 2000). Children with otitis media or hearing loss are

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also compromised (Crandell, Smaldino & Flexer, 2005; DiSarno, Schowalter & Grassa, 2002). Flexer, Richards, Buie and Brandy (1994) found that up to one third of the students in Kindergarten and Grade 1 classes had reduced hearing. Often school personnel attribute problems such as noncompliance, inattention, and off-task behaviour as being due to a need for better classroom management without considering the degree to which hearing deficits may be contributing to the problem (Flexer, 2005).

Given these reasons for an emphasis on sound clarity for children's learning, sound field amplification technology has become increasingly recognized as an effective method for enhancing teachers' speech signals in the classroom. In this study, we explored the use of sound-field amplification technology in Kindergarten through grade 3 (K-3) classrooms in New Brunswick. We investigated the effects of amplification on communication during Language Arts classes. In addition, we sought feedback on the perceptions of the teachers and students whose classrooms were amplified.

Procedures

This pilot study involved 60 classrooms in three New Brunswick school districts. The classrooms were matched as closely as possible on student enrollment and were balanced between French Immersion and English classes. The procedures included both quantitative and qualitative design. The intervention was Phonic Ear frontrow ™ pro infrared sound field systems with four mounted speakers. Half of the classrooms in the study were provided with a wireless pendant microphone and one hand held wireless microphone. None of the classrooms had sound field technology at the beginning of the study.

Flow of communication within classrooms was measured using the Revised Environmental Communication Profile (RECP), an approach described by Massie, Theodoros, Byrne, McPherson, and Smaldino (1999). Research assistants were trained and had classroom practice in order to learn the recording protocol. Reliability checks for data collection accuracy were conducted with all of the research assistants. Classrooms were observed during language arts classes pre- and post-intervention. Observations 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.

The qualitative component of the study involved semi-structured interviews and open-ended questions with teachers and students in all of the experimental classrooms. The data were analyzed using content analysis. Through this process, themes were generated to help understand the perspectives of teachers and students in the study.

In addition, acoustic measures were recorded by the audiologist using a sound level meter in all of the experimental and control classrooms in one school district in order to form a profile of the soundscape of these classrooms. Also, hearing screenings of all of the students were completed by the speech-language pathologist or audiologist in all of the classrooms in order to establish an auditory profile of the population.

Analysis of Classroom Communication Flow

The RECP provided a means to quantify the flow of communication during the normal course of events when classrooms were engaged in Language Arts activities. These records indicated how often and in what direction teachers and students communicated.

Three categories of information were analyzed. They were: 1) Cues to child (teachers' statements directed to the child being observed), 2) Cues to peers (teachers' statements directed to peers of the child being observed); and 3) Cues to class (teachers' statements directed to the whole class).

Because the data was gathered by observing what happens naturally in classrooms, the number of observations varied among groups. Therefore, proportions were used in the analysis (i.e., the percentage of time each type of teacher cue elicited a response from the student being observed). Our expectation was that students would respond by communicating more often when they were directly addressed by teachers whose voices were amplified. On the other hand, when cues were indirect, it was expected that students would respond less often when teachers' voices were amplified because they would be listening more and communicating less. Of course, there are reasons why this would not hold true in every case, such as group work where peer interaction is encouraged or raising one's hand to answer a question. Therefore, we expected to find trends, rather than extreme changes.

Second, the analysis compared teachers to themselves on how often the three types of cues were given. We expected that teachers with amplification would be able to spend more time talking to the class as a whole, providing class-wide instruction and less time directing their verbal statements to individual students to gain their attention or repeat statements to those who did not hear them. Here again, there are caveats to consider. For example, there may be valid reasons for directing statements to individuals which would have nothing to do with whether or not students' heard the communication clearly.

The following are the results for each of the three types of cues:

1) Cues to Child (statements directed to the child being observed)
The results varied across the grade levels in the following ways. In grades 1-3, students in the non-amplified (control) group responded over time less often to cues directed to them. The same trend was also found in the amplified (experimental) group, but it was a slight change, indicating results that were closer to the expected direction. **This trend supports the positive effect of amplification in these classes. The positive result was strongest in grade 1.**

On the other hand, among kindergarteners, the result was opposite to what was expected. The kindergarteners responded less often to direct cues in the experimental classes and more often in the control classes. This may be related to differences in teaching style for Kindergarten classes. For these very young children, teachers may naturally need to spend more time talking directly to individuals as opposed to directing their statements to the whole class. Amplifying teachers' voices at this grade level did not increase children's responses to direct cues. As noted later, however, when students' responses to whole-class cues were examined, the Kindergarten children obtained the same positive results as those in grades 1-3.

In regard to how often the teacher cues were given, we expected **teachers to need less time directing their instruction to individuals in order to maintain their attention or repeat instructions. The expected result was clearly found in the grades 1-3. Grade 1 had the strongest trend in the expected direction. In Kindergarten, the number of direct cues decreased similarly in both the control and experimental groups.**

2) Cues to Peers (statements directed to peers of the child being observed)
The results were mixed across the grade levels. In Kindergarten, there were very few data points recorded in the pre-intervention condition for the experimental group. Therefore, that grade level could not be analyzed. **Grades 1 and 2, demonstrated the expected results, in which students responded a lot less often to cues directed to their peers.** The same trend was also seen in the group which did not receive amplification, but the effect was much weaker. **These results support the positive effect of amplification on individual students by reducing their communication (thus, we assume, listening more) when their peers are being addressed.**

In grade 3, the expected trend was not strongly supported. While the amplified group (experimental) did show a decrease in response rate as expected, the non-amplified (control) group showed a much larger decrease at that grade level.

In regard to the number of cues that were given, **we expected teachers to need less time directing their instruction to peers** for the same reasons that they would spend less time directing cues to the individual child (see previous section). The expected result was not found in any of the groups at any grade level. Given that Kindergarten had a very small number of occurrences as noted above, we considered grades 1-3 together. In that analysis, the amount of increase over time was considerably smaller in the amplified group than in the non-amplified group. This would support **a trend more toward the expected direction (a decrease) when sound field amplification was introduced.**

3) Cues to Class (statements directed to the whole class)
We expected children to respond to 'cues to class' less often when the teachers' voices were amplified. It was expected that students would spend more time listening and less time communicating because they would hear the lessons more clearly (see above for caveats).

All of the groups demonstrated a decrease in student response, as expected in this category. Therefore, the question was whether this trend was greater for the amplified (experimental) groups. **It was a stronger effect for all grades in the amplified group, with grades 1 and 2 having the strongest results.**

In regard to the number of cues given, we expected teachers to increase the amount of time they would spend teaching to the class as a whole. The expected result was not found in any of the groups at any grade level. That is, the number of times 'cues to class' were observed always decreased over time. However, this **trend was considerably smaller at every grade level in the amplified group as compared to the non-amplified group.**

Qualitative Analysis of Teachers' and Students' Perspectives
The following themes were generated from the content analysis of the interviews conducted in the experimental classrooms:

1) Improved signal to noise ratio in classrooms
The teachers and students at all grade levels mentioned noticing a reduction in background noise, such as the fan, aquarium, etc. The teachers and students noted that they could be heard wherever they were located in the room. In addition, this was noted by several people as a special benefit for teachers and students with soft voices.

2) Enhanced learning
Teachers stated that children were more attentive. Many students said that they were more focused because they could hear better. This improvement in concentration was seen by teachers to have direct impact on the enhancement of student learning. Students described taking an active role in ensuring that they heard what the teachers were saying by noticing if the system was not in use.

Students' voices were also enhanced through the use of the handheld microphones. Most students reported that they liked using the microphone and others reported that they were still becoming accustomed to it. This was a benefit for students with soft voices and those who were shy. It was felt that their confidence could be built up through greater participation. These students offered to speak more often since they were not being told to repeat themselves, or speak up because others could not hear them. Teachers noted that some students more often risked participating orally when they held the microphone.

3) Inclusion of students with special needs
Teachers found that the amplification technology improved the learning process for students with various special needs. Teachers noted benefits for students with autism, speech-language delays, central auditory processing disorders, and sensory impairments. Their communication and, as a result, their learning was improved. For example, they increased their ability to focus and attend to the teacher and to their peers. Further, they were participating more in classroom activities.

4) 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.

Teachers and students spoke of saving time which contributed to more effective communication. 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.

Teachers felt that there was a decrease in voice strain. As their profession puts them at risk for laryngitis, sore throats, and other issues related to vocal strain, this is an added benefit. Some teachers noted that they had a reduction in voice problems since the system was implemented. Others noted that they had naturally soft voices and amplification prevented vocal straining.

5) 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. Also, teachers' sneezes or coughs would be amplified if they did not mute the microphone. Another issue was that if teachers stood too close to a speaker, there was feedback. It was also mentioned that, at times, teachers would forget to recharge the equipment. As well, it was mentioned 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 felt they had already found ways to deal with them. For example, they tried putting a desk under the speaker so that the teacher could not stand too close to it. One teacher noted that she moved her own desk chair away from the speaker. In some cases, students reminded teachers to recharge the equipment.

Analysis of Acoustic Levels and Hearing Screenings

The ambient noise levels of the classrooms tested raged from a low of 35.4 dBA to a high of 52.3 dBA. Students were often working in below standard classroom listening conditions (i.e., not the recommended +15dB signal to noise ratio that allows 100% speech audibility).

The hearing screenings provide baseline data on the prevalence of hearing problems by grade level: K - 25%, grade 1 - 29%, grade 2 - 20% and grade 3 - 12%. Referrals for audiological follow-up were made for a small portion of the students. Audiological evaluations detected cases of previously unrecognized permanent (sensorineural) hearing loss and
numerous children with otologic problems such as temporary conductive hearing loss from middle ear problems requiring medical intervention.

Summary of Key Points

Improvement in students' communicative responses to teachers' statements
- -decreased attention to statements directed to peers
- -better response to teachers' statements directed to the whole class
- -teachers stated students were more attentive
- -teachers reported that students who are shy or have communication needs participated more in class

Increased efficiency in classroom
- -better response to statements directed to individuals
- -fewer direct cues needed
- -teachers stated they used time more efficiently
- -teachers stated that less repetition was needed
- -teachers and students stated classrooms became more relaxed environments

In conclusion, participants stated wholeheartedly that they appreciated the technology. The flow of communication in classrooms improved from that of control groups in most areas studied. There were some differences across grade levels in the quantitative results, but overall improvement was generally found. Teachers felt that the amplification technology enhanced the learning process in a number of ways. Students recognized benefits as well. Teachers noted that they made adaptations to their classroom routines as needed to address problems or as new ideas to enhance their teaching strategies.

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