Effect of Sound Field Amplification on Grade 1 Reading Outcomes

Effet de l'amplification en champ libre sur les performances de lecture des élèves de première année

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Abstract

Sound field amplification provides mild amplification and even distribution of a classroom teacher's voice around the classroom as a strategy to improve listening and overcome effects of poor classroom acoustics. Research has documented improvements in attention, behaviour, speech understanding, academic outcomes and teacher vocal health, but few studies have focused on literacy outcomes. This study examined changes in reading outcomes for Canadian grade one students (N=486) in 24 classrooms, 12 with sound field amplification and 12 without, over one school year. Results indicated greater changes in the total percentage of students reading at grade level at the end of the school year in amplified classrooms vs unamplified classrooms, although results were not statistically significant. As well, positive trends were seen in improved reading outcomes for students identified at risk for reading difficulties, although again, not statistically significant.

Abrégé

L'amplification en champ libre augmente légèrement l'intensité de la voix du professeur et la répartie dans la salle de classe afin d'améliorer l'écoute et de surmonter les effets d'une mauvaise acoustique. La recherche a documenté des améliorations au niveau de l'attention, du comportement, de la compréhension de la parole et des résultats scolaires des élèves ainsi qu'au niveau de la santé vocale du professeur. Cependant, peu d'études se sont attardées aux répercussions sur l'alphabétisation. Cette étude a examiné pendant une année scolaire les changements des performances de lecture chez les élèves canadiens de première année (N=486) dans 24 classes, dont 12 avec amplification en champ libre et 12 sans. Bien qu'ils ne soient pas statistiquement significatifs, les résultats ont démontré de plus grands changements au niveau du pourcentage total d'élèves capables de lire en première année à la fin de l'année scolaire dans les classes où il y avait amplification par rapport à celles sans amplification. De plus, de meilleures performances en lecture ont été notées même chez les élèves identifiés à risque d'éprouver des difficultés en lecture. Cependant, les résultats ne sont pas statistiquement significatifs.

Key words: sound field amplification, reading, Developmental Reading Assessment

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Providing mild amplification of a teacher's voice and ensuring even distribution of the teacher's voice around the classroom to ensure better hearing, listening and attention, and to overcome the detrimental effects of poor classroom acoustics, has been a strategy used in classrooms since the early 1980s. These amplification and sound distribution systems, typically referred to as "sound field systems," are often recommended for individual students with hearing or auditory processing difficulties; however, they are increasingly being used in regular classrooms to help all children hear and listen more effectively. While the term "sound field amplification" might suggest that the teacher's voice becomes significantly louder, in fact, the primary purpose of the system is to ensure equal distribution of the teacher's voice throughout the classroom (rather than raising the volume, which would only distort the teacher's voice). This does require mild amplification of the teacher's voice but the design and placement of the speakers in the classroom ensures that the teacher's voice is heard at a clear, equal, slightly increased volume for all students, regardless of seating arrangements. The rationale for the use of sound field systems in regular classes is based on an extensive body of literature documenting a higher incidence of ear infections (and related hearing loss) in young children, greater difficulty understanding speech in the presence of noise, and immature listening skills related to neuromaturation of the auditory system well into adolescence (Bluestone, 2004; Gil-Loyzaga, 2005; Moore, 2002; Nelson & Soli, 2000; Stelmachowicz, Hoover, Lewis, Kortekaas, & Pittman, 2000).

As well, studies have found that recommended acoustical standards for noise levels and reverberation times are not achieved in the majority of classrooms, and that classrooms represent poor listening environments for young children (Bess, Sinclair & Riggs, 1984; Crandell & Smaldino, 1994; Crandell & Smaldino, 2000; Pekkarinen & Viljanen, 1991). Researchers have argued that the intersection of poor classroom acoustics, the inherent high demands on listening and auditory processing in classrooms, and the immature listening skills of children due to neuromaturation, create barriers to learning that place all children at educational risk (Anderson, 2004; Flexer, 2004). A possible strategy to address these barriers to learning is the use of sound field amplification. By improving signal to noise ratios (ie. the level of the teacher's voice compared to the level of the background noise), clearer speech signals can be attained (Larsen & Blair, 2008). By raising the level of the speaker's voice slightly above the background noise, his/her voice becomes easier to hear clearly. While the purpose of the system is to improve signal to noise ratio by increasing the signal (the teacher's voice), there are reasons to suggest that there might also be an additional effect of decreasing background noise. While there are no research studies measuring decreased background noise levels in classrooms with sound field amplification, Flexer (2009) reported that in fact, the majority of background noise in classrooms is created by students themselves (although certainly there can be other internal sources of noise such as fans). Classroom noise levels can therefore be expected to rise when students are inattentive, talking to each other or otherwise unengaged in classroom instruction. If sound field systems can increase student attention, behaviour and engagement, classroom noise would be expected to decrease. This was seen in a recent Canadian study by Rubin, Aquino-Russell, & Flagg-Williams (2007), who conducted a study of 60 New Brunswick classrooms, grades 1 through 3, half of which used sound field amplification. Using the Revised Environmental Communication Profile (as described in Massie, Theodoros, McPherson, & Smaldino, 2004), they found statistically significant increases in student responses to teacher statements, decreases in the number of teacher repetitions, and fewer student initiated communications with peers during instruction in the amplified classrooms. Anecdotally, teachers and students reported a perceptual decrease in background noise levels.

Sound field amplification has been shown to have positive effects on speech discrimination, attention, behaviour, listening and academic outcomes (see Millett, 2008 for review). Studies have found improved scores in speech discrimination tasks and dictated spelling tests (Arnold & Canning, 1999; Burgener & Deichmann, 1982; Zabel & Taylor, 1993). Massie & Dillon (2006) reported statistically significant improvement in ratings of attention, communication and classroom behaviour with sound field amplification, and noted that teachers considered that "sound-field amplification facilitated peer interaction, increased verbal involvement in classroom discussion, and promoted a more proactive and confident role in classroom discussion" (p. 89). Wilson (1989) studied language skills for children enrolled in Head Start programs, and found that while neither sound field amplification nor teacher training in language development alone resulted in measurable changes in language scores for these children, the combination of amplification and training did.

Studies investigating changes in academic outcome measures, such as standardized reading tests, are fewer but suggest a potential positive impact. Given that the strongest predictor of reading skills are early phonological awareness skills (a skill heavily reliant on hearing), and given that improved speech perception might be expected to result in greater potential to benefit from classroom instruction, an argument can be made for a positive relationship between sound field amplification and reading outcomes. Flexer, Biley, Hinkley, Harkema, & Holcomb (2002) studied changes in phonological awareness skills in three groups of kindergarten children; one group taught with the standard curriculum, a second group taught with the standard curriculum plus targeted phonological awareness instruction, and a third group taught with the standard curriculum plus phonological awareness instruction in an amplified classroom. While both the second and third groups showed higher post-test scores on a standardized test of phonological awareness, the third group from the amplified classroom showed the highest scores. At the end of the first semester of kindergarten, 57% of children in the control group and 43% of the children in the direct instruction group scored in the "at risk" category, compared to 7% of the group receiving direct instruction and sound field amplification.

Allcock (1999) also reported improvement in scores on standardized tests of phonological processing, with 74% of children in amplified classrooms achieving an improvement of 1 stanine or more, versus 46% in unamplified classrooms. Chelius (2004) reported that students in grades 1, 3, 4 and 5 in amplified classrooms achieved better standardized test scores in early literacy, on the Developmental Reading Assessment and in reading fluency. Similarly, a longitu dinal study by Gertel, McCarty, & Schoff (2004) found that students in amplified classrooms scored 10% higher on a standardized achievement test than students in unamplified classrooms. Dairi (2000) found first grade students in amplified classrooms to show greater literacy gains as measured by a reading inventory. Long-term outcome measures from the Mainstream Amplification Resource Room Study Project (MARRS) indicated better scores on standardized tests of listening and language skills for kindergarten students, and better scores in the areas of math concepts, math computation and reading for grade 2 and 3 students (Ray, 1992).

Although studies reporting benefits of sound field amplification for students in regular classrooms are numerous, very few of them are Canadian and few focus specifically on literacy outcomes. The present study was undertaken as a pilot project in a Canadian school board to investigate changes in reading performance for grade 1 students related to provision of sound field amplification in the classroom over the course of one school year.

Research questions

The research questions for this study addressed the impact of sound field amplification on reading scores for grade 1 students, specifically:

(a) Do students in amplified classrooms demonstrate a greater gain in number of reading levels attained than students in unamplified classrooms over the course of a school year? In other words, are students in amplified classrooms able to read materials at a higher level of difficulty than students in unamplified classroom after one school year?

(b) Do students in amplified classrooms demonstrate a greater change in the percentage of students reading at grade level than students in unamplified classrooms? An alternate outcome measure to be investigated concerned changes in the numbers of students reading at or above grade level. It could be argued that ensuring that students are meeting the benchmark and reading at grade level is the more important outcome measure for the purposes of school boards and ministries of education.

(c) Is there an interaction between gender and amplification – that is, is there a difference in percentage of males reading at grade level in the amplified classrooms compared to unamplified classrooms? This research question was included as purely exploratory in nature, based on research which links reading proficiency and gender. Research continues to debate differences in reading performance between girls and boys (Martino, 2008), and in fact, initiatives by the Ontario Ministry of Education addressing boys' literacy were recently launched based on the three-year Boys' Literacy Teacher Inquiry Project (Ministry of Education, 2009). Boys' literacy is an important topic in education in Canada, and therefore, findings that an intervention such as sound field amplification provided particular benefits to boys would be interesting.

(d) Is there an interaction between at-risk readers and amplification – that is, do students identified as at risk (as defined by provision of Early Reading Intervention in grade 1) show a greater change in reading scores or percentage of students reading at grade level in amplified classrooms? The research on the benefits of sound field amplification for students at risk for learning discussed earlier suggests that sound field amplification may be of particular benefit for children who are struggling academically, perhaps by providing an extra "boost" in focus, attention and speech discrimination. The same rationale may also hold true for students identified as being at risk for reading difficulties (although not identified formally with a reading disability)

Method

Participants

This study took place in the Hastings and Prince Edwards District School Board in eastern Ontario over the 2002-2003 school year; with the exception of two small cities (total population 45,000 people), communities within this board are largely rural. This board has a total of 53 grade 1 classes, of which 24 were selected to participate in the sound field amplification study. Demographic information collected for each student included gender, existence of an Individual Education Plan (IEP), and participation in an Early Reading Intervention (ERI) program in senior kindergarten or grade 1. Parental and teacher consent was obtained prior to the study.

Initially, a total of 514 students were included in the study, in 12 schools. At the time of final testing in May 2003, 28 students had moved to other schools and therefore, complete data was available for 486 students. Of these 28 students, 12 were from amplified classrooms and 16 were from unamplified classrooms. Data for these students was removed prior to analysis. Of the participating schools, 6 had a single grade 1 classroom, 4 had two classrooms, 2 schools had three classrooms and 1 school had four classrooms, for a total of 24.

This study implemented a quasi-experimental, non-equivalent groups (based on lack of random assignment of students to classrooms) design which measured pre-test and post-test reading scores for an experimental group (amplified classrooms) and control group (non-amplified classrooms). Where possible, schools with more than one

Table 1
Demographic information

	Total # students	Gender M	F	Students with IEPs	Hearing screening completed	Refer results on hearing screening	Students receiving ERI in grade 1
Amplified classrooms (N=12)	247 (50.8%)	123 (49.8%)	124 (50.2%)	22	174 (67.2%)	27 (15.5%)	94 (38.1%)
Unamplified classrooms (N= 12)	239 (49.2%)	132 (55.2%)	107 (44.8%)	16	147 (57.7%)	16 (10.9%)	90 (37.7%)
Total (N=24)	486	255 (52.5%)	231 (47.5%)	38 (7.8%)	321 (62.5%)	43 (13.4%)	184 (37.9%)

grade 1 class were selected, to account for potential differences in school size, design or classroom acoustics, and to enable one grade 1 class in the school to be equipped with sound field amplification, and one to remain unamplified. Schools were selected that had similar sizes and geographical locations, and no split grade 1 classes were included.

Sound field amplification systems

Phonic Ear VocaLight infrared sound field amplification systems were installed in 12 grade 1 classrooms. The systems consist of a teacher-worn transmitter, an infrared sensor and receiver, and four wall-mounted speakers. All systems were installed by a professional company contracted by Phonic Ear. All teachers using the systems were inserviced on use, care and maintenance at the beginning of the study.

Hearing screening

In September, hearing screenings were completed using otoacoustic emissions testing by a graduate student in audiology from the School of Human Communication Disorders at the University of Western Ontario. Parental consent was obtained prior to screening. A Maico Ero-Scan (screener model) was used for all screening. A "pass" result on this screening required the presence of otoacoustic emissions at 2000, 3000 and 4000 Hz in both ears; absence of an otoacoustic emission at any frequency in either ear was recorded as a "refer." Parents were notified of hearing screening results, and provided with information on follow-up for students receiving a refer result. Due to time and financial constraints, not all students in the study were screened (only 321 of 484 students received hearing screenings).

Reading Assessment

The first edition of the Developmental Reading Assessment (DRA) was used in this study, and was administered and scored by each student's classroom teacher (Beaver, 1999). The DRA is used routinely as the standard reading assessment across the school board, so that all teachers in the study had used the DRA before and were familiar with its use. To further ensure consistency, all teachers received a short inservice on the DRA at the beginning of the study. School board policy required administration of the DRA in September, January and May. Only data from September and May was used for this study, because of the very short time span between the September to January, and January to May administrations.

Because DRA book levels are not numbered entirely consecutively (e.g., levels are coded as 0, 1, 2, 3, 4, 8, ….), the book level achieved by an individual student represents data which has characteristics of both nominal and ordinal data and cannot be analyzed as raw data. Therefore, data was analyzed in two different ways. First, data was recoded to indicate number of levels changed between September and May (e.g., a student who achieved a level of 3 in September, and 8 in May showed a gain of 2 levels, not 5). This recoded data was then used to compare mean number of levels increased over the school year between groups. Second, the DRA Benchmarks for first and third terms were used to code each student as reading below grade level or at/above grade level in both terms. Using this data, percentage of students reading at grade level could be calculated for different groups.

Teacher questionnaires

Of the 12 teachers using sound field amplification, 11 completed the Teacher Opinion and Observation List, Voice Subsection, of the Listening Inventory for Education (Anderson & Smaldino, 1998). This instrument is a teacher questionnaire which asks teachers about their experiences with sound field amplification using a 5 item Likert scale ("strongly agree" to "strongly disagree"). Examples of items on the Teacher Opinion and Observation List include "your voice shows less sign of strain at the end of the day" and "you have to repeat yourself less often."

Results

Demographic information is provided in Table 1, and indicates that the amplified and unamplified classrooms were very similar with respect to number of students, distribution of gender, number of students with IEPs, number of students whose hearing was screened, and number of students receiving Early Reading Intervention (ERI). Overall, 7.8% of students had educational programs which included an IEP, and more than one third (37.9%) of students had been identified by their teachers as being

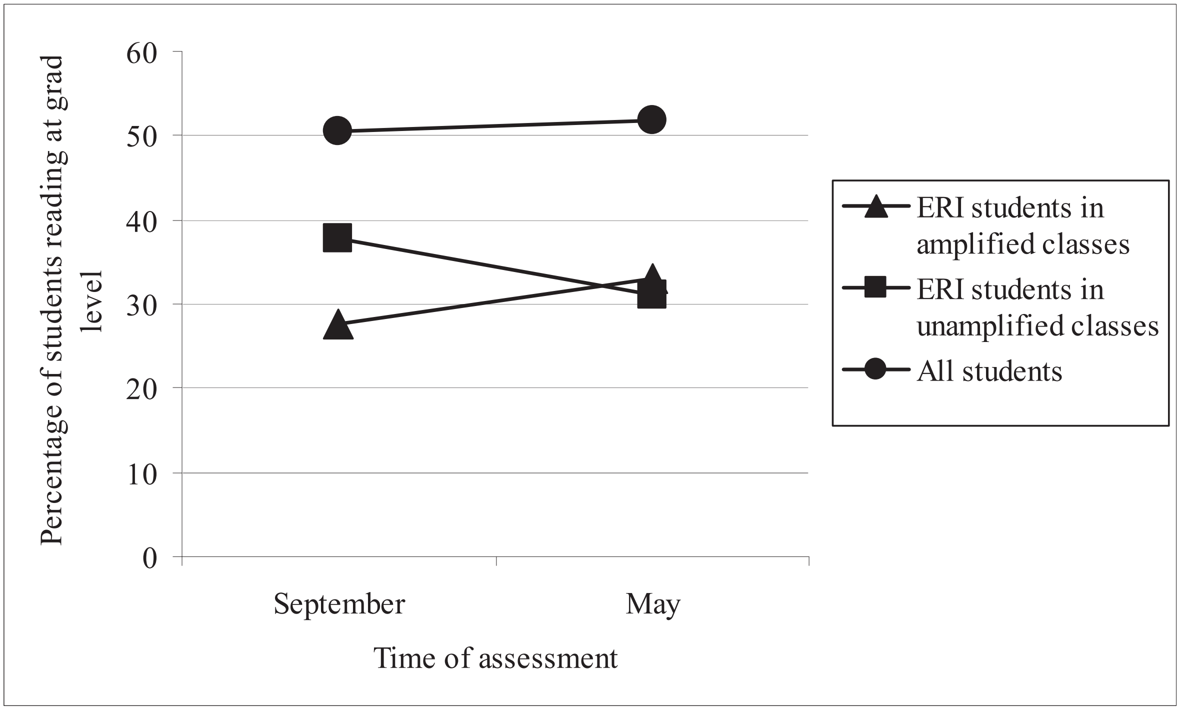

Figure 1: Change in percentage of students at risk at grade level

at risk for reading in kindergarten, and therefore received Early Reading Intervention in grade one.

The first research question addressed changes in mean increase in reading levels between September and May for the experimental vs. control groups. As described previously, data was recoded to reflect total number of levels increased for each student. A one-way analysis of variance (ANOVA) using "number of levels increased from September to May" as the dependent variable indicated a mean change of 5.80 levels (standard deviation=3.02) for the amplified classrooms, and a mean change of 5.89 levels (standard deviation = 2.81) for the control classrooms, a difference which was not statistically significant ($F_{1,471}$=.12, p>.05). However, while potentially a useful analysis, comparing changes in number of reading levels increased is complicated by the fact that differences between levels do not represent equal intervals. That is, the level at which a student starts is important. The lower levels (e.g., moving from a Level 1 book to a Level 3 book) does not represent, either quantitatively or qualitatively, the same change in reading competency and skill as does moving from a Level 18 to a Level 20 book. A more useful way of looking at the data is to compare percentage of students reading at grade level, which is, after all, potentially the statistic of most interest to teachers and administrators.

The second research question asked "do students in amplified classrooms demonstrate a greater change in the percentage of students reading at grade level in May than students in unamplified classrooms?" Using the benchmark data from the DRA for first term and third term, each student was identified using his/her September and May scores as reading at/above grade level or reading below grade level. Table 2 illustrates these results for amplified and unamplified classrooms. A Chi-square test was used to investigate differences between the two groups, and was not found to be statistically significant $\chi^2(2, N = 486) = .48$ $p > .05$. However, a trend showing a greater percentage of students reading at grade level in the amplified classrooms was seen, with an increase of 2.8% in amplified classrooms compared to a decrease of 0.4% in the unamplified classrooms. A post hoc power analysis indicated that this sample size (N=486) with alpha = .05 yielded a statistical power of .11, indicating that this study did not have sufficient power to detect an intervention effect size. Since the sample size in this study was relatively large, it may be that the instrumentation used (the DRA) was not sensitive to effects of sound field amplification or that the study duration was not long enough to see such effects.

The third research question, "is there an interaction between gender and amplification?" was included strictly as an investigational question, as no previous sound field research studies have examined questions of gender differences and, as discussed previously, there is at least a theoretical rationale for investigation of this question. A numerical value of 0 was assigned to scores below the benchmark in September and May, and a value of 1 to scores above the benchmark, again for September and May. A two-way analysis of variance demonstrated a significant main effect for gender, ($F_{1,482}$=1.97, p<.01), with a greater percentage of girls than boys reading at grade level, but no significant main effect for amplification nor an interaction effect between the two.

The fourth research question, "do students identified as at risk (as defined by provision of Early Reading Intervention in grade 1) show a greater change in reading scores or percentage of students reading at grade level in amplified classrooms?" was investigated using the same analysis method as question 3. A two-way analysis of variance again showed a main effect for ERI (students

Table 2
Changes in percentage of total students reading at grade level

	% of students reading at grade level in September	% of students reading at grade level in May	Change from September to May
Amplified classrooms (N=247)	50.9%	53.7%	+2.8%
Unamplified classrooms (N=239)	50.2%	49.8%	-0.4%

receiving ERI scored lower than other students), but no significant main effect for amplification and no interaction effect. Not surprisingly, students identified at risk showed a mean increase in reading levels of only 4.22 levels, compared to students not receiving ERI, whose reading levels increased on average by 6.81 levels. In September, for the total group of students, 55% of students were reading at grade level. By May, this number had not increased, with only 52.9% reading at grade level. When considered overall, students receiving ERI also showed a slight decrease in percentage of students reading at grade level. These results are discouraging in terms of the efficacy of the Early Reading Intervention program, since no apparent changes in numbers of children reading at grade level were seen overall. However, when at-risk students in amplified and unamplified classrooms are examined more closely, some interesting trends were seen.

In September, a smaller percentage of students reading at grade level was found in the amplified classrooms (27.7% versus 37.8%). In May, results indicated that the percentage of students reading at grade level in amplified classrooms had increased by 5.3%, while for the unamplified classrooms, the percentage of students reading at grade level had decreased by 6.7%. Figure 3 summarizes this trend, in comparison to the performance of all students. A post hoc power analysis was performed and yielded a statistical power of .05, again indicating that this study did not have sufficient power to detect an intervention effect size. As described previously, it may be that the instrumentation used (the DRA) was not sensitive to effects of sound field amplification or that the study duration was not long enough to see such effects.

During the study design phase, it was intended that results for students with hearing loss would be analyzed. However, this proved not to be feasible given the large number of students who could not be screened, the small number of students with refer results, the very unequal sample sizes between students with "pass" and "refer" results, and the fact that the small number of students with refer results were spread over 12 classrooms. Hearing screenings were conducted for 321 of 486 students (62.5%), with 43 students receiving a "refer" result (13.4%). Refer results were obtained for 27 students in amplified classrooms, and 16 students in unamplified classrooms. Comparing reading outcomes for sample sizes of 27 and 16 was not felt to be statistically valid.

Teacher experiences with the sound field systems were extremely positive. The LIFE uses a 5 point Likert scale from "strongly agree" to "strongly disagree." With respect to vocal strain, 100% of teachers strongly agreed that they showed less vocal strain during the day, and all teachers strongly agreed with the statement "overall you like the impact on your teaching voice and presentation." Ten of 11 teachers strongly agreed that noise interfered less with teaching. Responses were averaged for each item, and results showed teachers reporting the strongest agreement for statements concerning need for less repetition (average rating = 4.45), less need for clarification (3.91) and less need for time spent in classroom management (3.91). Table 3 indicates the percentage of teachers reporting agreement or strong agreement with each statement.

Discussion

This study indicated positive changes in the percentage of students reading at grade level for students in amplified classrooms, compared to students in unamplified classrooms. Students in unamplified classrooms showed no overall change in the percentage of students reading at grade level between September and May, while amplified classroom results showed an increase of 2.8%, although differences between the two groups were not statistically significant. Two factors can be identified which may explain positive trends but lack of statistical significance, particularly in view of findings of very low statistical power for both the overall group of students and for the students at risk for reading difficulties.

This study represented almost half of all grade 1 classrooms in this school board, and all classrooms consistently showed a very high percentage of students reading below grade level. The fact that many students in this school board appear to be at risk for reading difficulties, even at grade 1, suggests that interventions with this population might be expected to show smaller, or slower effects. The relatively short time span of the study may have also been a factor. Although the study was conducted over the entire time span of grade 1, a single school year seems a relatively short time span to show large changes in reading proficiency, regardless of the nature of the intervention.

A second factor contributing to the lack of statistical significance may be the sensitivity of the instrumentation. The reading instrument used in this study, the DRA,

Table 3
Teacher perceptions of sound field amplification use

L.I.F.E. statement	Percentage of teachers reporting agreement (score of 2) or strong agreement (score of 5) with the statement
Your voice shows less sign of strain during the day	100% - strong agreement
Your voice is more flexible	91% - agreement
Your voice sounds better than before	91% - agreement
Your voice is less vulnerable when you have a cold or allergy	64% - agreement
Noise (from whatever source) is less interfering and disruptive to your teaching	91% - strong agreement 9% - agreement
Your voice feels more like “the real you”	36% - agreement
You have to repeat yourself less often	82% - strong agreement 18% - agreement
Over the school day you speak less	64% - agreement
You feel less tired generally	36% - agreement
You do not have to clarify what you say as often with SFA	64% - strong agreement 36% - agreement
Your voice sounds more confident	82% - agreement
You are less likely to take time off because of laryngitis/ sore throat/ injury	55% - strong agreement
It is easier to get the attention of the whole class	100% - agreement
You spend less time managing behavior and more time focusing on the curriculum	64% - strong agreement 36% - agreement
You have been able to be more adventurous than before	18% - agreement
You need to raise your voice less often	91% - agreement
It is easier to think on your feet	9% - agreement
Overall you like the impact the system has on your teaching voice and presentation	100% - strong agreement

assesses overall reading competence, but does not assess phonological awareness directly, and it may be that an instrument which targets phonological awareness specifically might show different results. At the grade 1 level, the earliest assessment levels incorporate many sight words, but higher levels begin to require greater skill in decoding and greater reliance on the link between phonological awareness and print symbols. Phonological awareness refers to awareness of the sound structure of spoken words, and includes skills such as rhyming, phoneme discrimination, and segmentation, blending and manipulation of phonemes. As such, it is an auditory based skill and therefore, there may be reason to believe that an auditory-based intervention (such as sound field amplification) might have beneficial effects on its development.

Students receiving ERI as a result of identification by teachers as being at risk for reading difficulties showed more improvement in the amplified classrooms. In fact, the percentage of students reading at grade level in the unamplified classes actually decreased by 6.7%, while percentage of students reading at grade level in the amplified classes increased by 5.3% (a difference of 12% between the two groups), despite provision of the same reading intervention. These results for the unamplified classrooms do not necessarily indicate that students were performing poorer in reading compared to themselves, but that the gap between these students and students reading at grade level was widening in the unamplified classrooms. However, the gap appeared to be closing slightly in the amplified classrooms, with some students achieving age appropriate reading levels over the course of the year.

In both cases (for the group overall and for students at risk for reading difficulties), the increases in numbers of students reading at grade level in amplified classrooms were small, but contrasted with the unamplified condition, in which the number of students either showed no improvement or actually decreased. For a population of students which already demonstrated weaker reading scores than the rest of the province (as measured by provincial testing), even a small increase is a step in a positive direction. Grade 1 is an important time in the process of learning to read; it is a time when students begin to apply their phonological awareness skills to the process of decoding, and eventually, reading with comprehension. For grade 1students whose phonological awareness skills are weak, improved access to the teacher's voice as phonics programs are being taught cannot help but be beneficial.

Teacher experiences with the sound field systems were extremely positive, with teachers reporting less vocal strain, less interference from classroom noise, less need for repetition and clarification, and less time spent on classroom management. A potential weakness of this assessment instrument is that statements are often worded in such a way as to suggest a potential bias in favour of sound field benefit (e.g. "your voice sounds better than before"). As well, the possibility that teachers responded more favourably knowing that this was a board-initiated project cannot be discounted. However, certainly the large number of items for which teachers responded "strongly agree" (rather than with a more neutral rating) and indicating high satisfaction levels with the system, is consistent with other reports in the research. A number of other studies have also reported positive effects on vocal health with sound field amplification, a significant benefit in an occupation which has been demonstrated to be high risk for vocal problems (Allen, 1995; Edwards, 2005; Jonsdottir, 2002; Massie & Dillon, 2006). Teachers who experience less vocal strain and lower stress levels because of reduced noise, and more time available for teaching because of better classroom management and student listening, would be expected to have more physical and emotional resources for effective teaching.

A final piece of evidence might be considered. While statistical significance was not achieved in the data analysis, school board administrators were pleased with the results of both the reading assessment data and teacher reports of positive experiences, and subsequently purchased sound field amplification systems for 48 grade one classrooms across the school district. Further studies focusing specifically on the specific area of phonological awareness, both for typical readers and children at risk for learning to read, are recommended.

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