# Phonak Compendium

# A review of classroom soundfield amplification systems

## Introduction

In a typical classroom, noise comes from computers, air conditioners, outside sounds, poor classroom acoustics, and the students themselves. This results in a very noisy learning environment which is significant because it is estimated that 75% of the school day is spent engaged in listening activities (Dahlquist, 1998). A noisy classroom negatively impacts a student's listening abilities, particularly impacting speech perception, reading/spelling ability, classroom behavior, attention, concentration, and educational achievement. Additionally, poor classroom acoustics may affect teacher performance and increase vocal pathologies and absenteeism.

Children listen differently compared to adults, as their brain's auditory network is not fully developed until about the age of 15 years (Flexer, 2002). Children require a quieter environment and louder auditory signals in order to learn (Cole, 2006; McCarty & Ure, 2003; Flexer, 2002; Rosenberg et al., 1999).

To combat the increased levels of noise in the classrooms, soundfield amplification systems have been used. Each system generally consists of speakers, a wireless microphone typically worn by the teacher, one or more receivers, and an amplifier. These systems are designed to provide greater auditory signals and improve speech perception. They amplify the teacher's voice above ambient noise and evenly distribute the sound throughout the room. The use of these systems enables teachers to be clearly heard, without shouting or straining their voice. It should be noted, however, that for children with hearing loss, soundfield amplification is not enough - a personal amplification system is recommended for the classroom (Wolfe et al., 2013).

This paper is intended to summarize research on the current state of acoustical conditions in the school setting, the challenges students and teachers face when in poor classroom acoustic environments, the various types of technology available and the benefits of using soundfield amplification systems for different populations of students and teachers.

## Classroom acoustics

Acoustical factors in the classroom environment can affect a student's educational achievement. These factors include: the level of background noise in the room, signal-to-noise ratio (SNR) and the reverberation characteristics of the environment. In this section, you will read key points related to the optimum classroom learning environment.

**American Speech-Language-Hearing Association. (2005). Acoustics in educational settings: [Technical report]. Retrieved from www.asha.org/policy**

As speaking and listening are the main communication modes in most educational settings, the noise levels and reverberation times (RTs) in these settings should be such that

speech produced by teachers, students, and others is intelligible. However, many learning spaces have excessive noise and RTs. All students and teachers are affected by noise and reverberation, but young students, English language learners, and students with hearing, language, or learning problems may be at a greater disadvantage.

Depending on grade level, reported SNR in classrooms range from +5 to −7 dB(A). However, for students with normal hearing to have optimal auditory comprehension, they require a +6 dB SNR. Furthermore, consonant identification performance in noise and reverberation does not reach maturity until the late teenage years, suggesting that appropriate classroom acoustics are important for young students.

Overall, the scientific literature has demonstrated that in an acoustic environment with +15 dB SNR throughout the entire classroom, students with normal hearing can hear well enough to obtain the spoken message in its entirety.

**American Speech-Language-Hearing Association. (2005). Guidelines for addressing acoustics in educational settings [Guidelines]. Retrieved from www.asha.org/policy**

Research on room acoustics and the effect of poor acoustics on listening and learning in the classroom have led to several concerns regarding classroom acoustics. These concerns include: children that either cannot hear well and/or process speech and language well; the impact of not hearing and/or processing well on listening and learning; low teacher voice level, excessive background noise level and excessive reverberation; and the solutions requiring architectural design and acoustical modifications to improve classroom acoustics.

In schools where classroom acoustics cannot be corrected and educators want to enhance the SNR of verbal instruction, soundfield is used as a solution. Even in classrooms where the acoustic criteria have been met, additional assistive technology may be required for students with hearing loss. Research indicates that the use of hearing assistive technology (e.g., FM systems, soundfield amplification) for children with normal hearing, children with hearing loss or listening problems, as well as non-native English learners is often beneficial. The use of soundfield systems must be considered on an individual and classroom-by-classroom basis.

**American Speech-Language-Hearing Association. (2005). Acoustics in educational settings: [Position statement]. Retrieved from www.asha.org/policy**

ASHA recommends an appropriate acoustical environment for all students in educational settings. ASHA endorses ANSI S12.60-2002 Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools (ANSI S12.60-2002) as the national standards for classroom acoustics. Inappropriate levels of reverberation and/or noise in an educational environment can affect students' speech perception, reading/spelling ability, classroom behavior, attention, concentration, and educational achievement. Additionally, poor classroom acoustics may affect teacher performance and increase vocal problems.

To achieve appropriate acoustical conditions in an educational setting, ASHA recommends that unoccupied classroom noise levels do not surpass 35 dB(A), the SNR should be at least +15 dB at the child's ears, and unoccupied classroom reverberation times must not exceed 0.6 seconds in smaller classrooms or 0.7 seconds in larger rooms. Factors that affect acoustical design of a classroom include size and shape, ambient noise level and sound-absorbing material.

**American Speech-Language-Hearing Association. (2002). Appropriate school facilities for students with speech-language-hearing disorders [Technical report]. Retrieved from www.asha.org/policy**

Studies have shown that 75% of the school day is spent engaged in listening activities. To perform well in academics, a student must receive and process auditory signals. When the acoustics in the classrooms are poor, children may develop self-esteem issues as they see others understanding and responding to information to which they cannot respond. As a consequence, the potential for successful academic careers and life skills are reduced.

Poor acoustics are a widespread issue of classrooms in the United States. An estimated 8–10% of the overall student population, regardless of age, may have significant learning problems affected by poor acoustical environments.

Soundfield amplification can be an addition to classrooms, with the goal of enhancing the SNR of the listening environment, especially the teacher's voice by approximately 8–10 dB. The benefits include improvement in academic achievement, speech recognition skills, listening skills, and on-task attending and learning behaviors; cost effectiveness; and reduction in teacher vocal fatigue. Additionally, soundfield amplification does not stigmatize students with a mild degree of hearing loss and/or auditory processing disorder.

**Boothroyd, A. (2002). Room acoustics and speech perception. *Seminars in Hearing*, 25(2), 155–166.**

The acoustic speech signal received by a listener depends on the source, distance, early reverberation, late reverberation, and noise. It also depends on the Speech Audibility Index which is the proportion of the useful speech signal (direct

speech plus early reverberation) that is above the level of the effective noise (actual noise plus late reverberation). The Speech Audibility Index can be used to determine various measures of speech perception, but the results depend on the complexity of the language and the characteristics of the listener.

To maintain the Speech Audibility Index at an optimal level, reverberation and environmental noise need to be low. It is important to recognize that conditions tolerable for normal hearing adults in casual conversation can be difficult for adults and children in learning situations, and intolerable for people with hearing, language, attention or processing disorders. Soundfield amplification can improve the Speech Audibility Index for all listeners in a noisy room. However, if the primary problem is reverberation, soundfield amplification can provide less benefit. Additionally, if incorrectly installed, the reverberation problem can become worse. There is no good substitute for reverberation control.

**Bradley, J.S. (2002). Acoustical design of rooms for speech. *Construction Technology Update,* 51.**

In rooms intended for speech communication, appropriate acoustical design is important. The factors that affect acoustical design include room size and shape, ambient noise level and amount and location of sound-absorbing material.

There are steps that can be taken to ensure the design of a room is appropriate for speech communication. The first step is to assess the acoustical requirements and determine the purpose of the room. The next step is to choose a maximum noise level goal and modify it to meet the needs of the intended users. Also, the maximum noise level criteria should be set for mechanical systems, and the boundaries of the room must have adequate barriers from outdoor noises, as well as adjacent spaces. Next, the reverberation time criterion must be chosen. It is also necessary to determine the required total sound absorption and amount of material to be added. Finally, consider the room shape and the location of the sound- absorbing material. For instance, in smaller rooms, the sound absorbing-material should be distributed evenly over room surfaces, while avoiding the center of the ceiling and surfaces close to talker locations, such as podiums.

**Crandell, C.C. & Smaldino, J.J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. *Language, Speech and Hearing Services in Schools*, 31, 362–370.**

This article examines acoustical variables, such as noise, reverberation, and speaker-listener distance, which can negatively affect speech perception in classrooms, as well as psychoeducational and psychosocial achievements. Noise generated within the classroom (such as children talking) produces the greatest decrease in speech perception because the spectral content of the signal (the teacher's voice) is similar to the spectra of the noise.

Low-frequency noises in a classroom (such as air-conditioning units) are usually more effective maskers of speech than high-frequency sounds because of the upward spread of masking. Additionally, the interaction of noise and reverberation adversely affects speech perception to a greater extent than the sum of both effects taken independently.

The distance a child is from the teacher can also strongly influence speech perception. However, reductions in classroom noise (via acoustical modification) has a significant effect on increasing concentration, attention, and participatory behavior in children.

**Knecht, H.A., Nelson, P.B., Whitelaw, G.M., & Feth, L.L. (2002). Background noise levels and reverberation times in unoccupied classrooms: Predictions and measurements. *American Journal of Audiology*, 11, 65–71.**

This study measured reverberation times and background noise levels in 32 different unoccupied elementary classrooms in 8 public schools in central Ohio. The results were compared with the limits recommended in the American National Standards Institute standard for acoustical characteristics of classrooms in the United States (ANSI S12.60-2002) and criteria variables from a checklist developed by Crandell, Smaldino and Flexer (1995) to predict unwanted classroom background noise levels and reverberation. The noise levels for the 32 classrooms ranged from 34.4 dB(A) to 65.9 dB(A). Out of all the classrooms, only 4 rooms had background noise levels below 35 dB(A). On average the background noise tended to be 5-15dB higher than recommended. The reverberation time measurements ranged from 0.2-1.27 s. The ANSI maximum recommended reverberation time is 0.6 seconds; resulting in 13 rooms out of the 32 exceeding the recommended reverberation time. The rooms with smaller volumes and lower ceilings (10 feet or less) had lower reverberation times. The results also suggested that a checklist was not a good predictor of the noisier and more reverberant rooms.

Overall, the results indicated that most classrooms were not in compliance with ANSI noise and reverberation standards. Background noise levels, reverberation times and SNR all impact communication in the classroom. These acoustical factors need to be controlled to allow children to be able to hear their teachers well. In a poor listening environment a child's comprehension ability may be compromised which can lead to poorer learning outcomes.

**Larsen, J.B., Vega, A., & Ribera, J.E. (2008). The effect of room acoustics and soundfield amplification on word recognition performance in young adult listeners in suboptimal listening conditions. *American Journal of Audiology*, 17, 50–59.**

The aim of this study was to compare speech recognition performance of young adult listeners with normal hearing in 2 different college classrooms, with and without the use of a classroom amplification system. Only 1 of the classrooms met American National Standards Institute (ANSI) S12.60-2002 acoustic standards. Listeners were randomly assigned seats in the 2 classrooms, and the Northwestern University Auditory Test No. 6 was presented via a loudspeaker from the front of the classroom for all listening conditions and additionally in a soundfield condition (through a soundfield infrared system with ceiling-mounted speakers).

The mean scores differed by 37% between the unamplified and amplified conditions in the room that did not meet the ANSI acoustic standards. The mean scores in the acoustically sound classroom differed by 11% between the amplified and unamplified conditions.

The results showed an improvement in word recognition scores for both classrooms with the amplification system. There was however a larger improvement in test scores in the acoustically poorer classroom compared to the classroom which met ANSI acoustic standards. The results from the study highlight that classrooms meeting the ANSI S12.60-2002 standard, which was written for elementary school classrooms, can benefit young adult listeners in post-secondary classrooms. The study also showed that speech recognition for students was improved in both the acoustically poor and acoustically sound classroom environment.

**Neuman, A.C., Wroblewski, M., Hajicek, J., & Rubinstein, A. (2010). Combined effects of noise and reverberation on speech recognition performance of normal hearing children and adults. *Ear & Hearing*, 31(3), 336–344.**

The aim of the study was to determine how combinations of noise levels and reverberation - typical of ranges found in current classrooms - will affect speech recognition performance of typically developing children with normal speech, language and hearing and compare their performance with that of adults with normal hearing. Participants consisted of a total of 63 children, between 6-12 years old with normal hearing and typically developing speech and language. Nine adults with normal hearing participated in the study.

The SNR-50 (SNR required to obtain 50% correct in the speech perception test) increased significantly with increased reverberation and decreased significantly with increasing age. On average, children required a positive SNR for 50% performance, whereas thresholds or SNR for adults were close to 0 dB or <0 dB for the conditions tested.

Results showed differences in speech recognition performance in elementary school children listening to speech in noisy, reverberant classrooms. The more reverberant the environment, the better the SNR required. The younger the child, the better the SNR required. Results support the importance of attention to classroom acoustics and emphasize the need for maximizing the SNR in classrooms, especially those designed for early childhood grades.

**Palmer, C.V. (1997). Hearing and listening in a typical classroom. Language, *Speech and Hearing Services in Schools*, 28, 213–218.**

This article outlines problems with classroom acoustics and provides potential solutions. There are six issues to think about when determining if every student in a classroom can hear the necessary information: (1) the teacher's delivery, (2) the noise in the room, (3) the reverberation in the room, (4) the distance from the teacher, (5) the hearing ability of the student, and (6) the linguistic experience of the student.

Teachers need to speak approximately 15 dB louder than the background noise in the classroom but this is rarely achieved throughout the day in a typical classroom. Classroom noise levels should not exceed 35 dB(A). However, typical classroom noise levels range from 41 to 51 dB(A). Classroom reverberation times should not exceed 0.4 seconds, yet the majority of classrooms have reverberation times between 0.4 and 1.25 seconds. Children should be within approximately 6 feet of the teacher in order to receive maximum intelligibility, but achieving this distance for all children is impossible due to typical class sizes. Additionally, on any given day about 43% of primary level children fail a pure-tone screening at 15 dB and/or an immittance screening.

Adults can miss parts of a message but still understand using their life and language experience. In contrast, young students are still learning language and have limited life experience to use to fill in the blanks. The use of soundfield amplification systems is the most cost-effective and acceptable technology for facilitating classroom listening. The use of a wireless microphone by the teacher and loudspeakers placed appropriately in the room may result in reduced student fatigue, increased on-task student behavior, improved classroom management, and decreased teacher vocal fatigue.

**Sato, H., & Bradley, J.S. (2008). Evaluation of acoustical conditions for speech communications in working elementary school classrooms. *Journal of Acoustical Society of America*, 123(4), 2064–2077.**

Acoustical measurements were made in 41 elementary school classrooms to obtain indications of the acoustical quality of conditions for speech communication during teaching activities. Students on average experienced teacher speech levels of 60.4 dB(A) and during teacher instruction the average measured noise level was 49.1 dB. The results showed a mean speech-to-noise ratio (SNR) of 11 dB(A) during teaching activities.

The authors concluded that average noise levels make it difficult to achieve ideal SNR ratios and near ideal speech communication conditions. The measurements found an average mid-frequency reverberation time of 0.41 seconds suggesting that excessive levels were a much more significant problem than poor room acoustics.

**Siebein, G.W., Martin, A. G., Ermann, M.G. (2000). Ten ways to provide a high-quality acoustical environment in schools. *Language, Speech, and Hearing Services in Schools*, 31, 376–384.**

Researchers observed teachers and students in 10 classroom situations for 2-4 hours over 2-3 days. Numerous recommendations were made from their observations which are summarized below:

- Carefully select the air-conditioning system for the school
- Limit room volume
- Provide sound-absorbing surfaces
- Install carpeted floors
- Reduce the distance between the teacher and the students by furniture placement and teaching techniques
- Use FM and other sound reinforcement systems when needed
- Design the site plan wisely
- Design special-purpose acoustic rooms
- Work with audiologists, teachers, and acoustical consultants to design and plan classrooms
- Support a national technical research effort in this area to explore the issues related to speech perception and learning for all children

**Tibbetts, J. (2007, October 2). Classroom noise impedes learning. *CanWest News Service*. Retrieved from www.canada.com/canwestnewsservice/**

A study conducted by the New Brunswick government, professors at the University of New Brunswick and the Atlantic Baptist University in Moncton, reviewed 1,162 students from kindergarten to grade 3.

The researchers studied 31 classes with sound systems and 29 without. The results showed that students hear poorly if they are more than 2.75 meters away from the teacher. The study also highlighted that teachers voices become strained when they are trying to make themselves heard. They concluded that soundfield amplification is beneficial to young students and should be considered a "vital part" of helping them learn.

**United States Access Board (2003). A Checklist for Classroom Acoustics. Retrieved from www.access-board.gov**

The U.S. Access Board is committed to accessible design and encourages parents who are concerned about the environment their children are learning in to take some simple steps to determine if a classroom may need acoustical remediation. This 2-page checklist includes parents asking:

- Is reverberation a problem?
- Is background noise a problem?
- Is HVAC noise clearly audible?
- Can you hear outdoor noise, such as playground activity or automobile traffic from a nearby roadway?
- Is noise from adjacent spaces adding decibels to the background noise?

## Types of technology

This section discusses various types of technology available to help reduce the negative effects of poor classroom acoustics. These include: personal FM systems that attach directly to the hearing aid or cochlear implant, personal FM with headphones and soundfield enhancement systems.

The purpose of these technologies is to bring the voice of the person speaking closer to the listener and improve the speech intelligibility of the teacher's voice especially when the noise levels increase in the classroom. An FM system consists of a microphone/ transmitter which is worn by the talker and transmits the voice via radio waves to the receivers which is coupled to the ears. Soundfield amplification systems consist of a microphone/ transmitter also worn by the talker, an amplifier and one or more loudspeakers positioned throughout the classroom.

There are differences between these systems. The soundfield amplification system can provide an improved signal to all of the children in the class and the personal FM system is designed specifically for children with hearing loss or other hearing difficulties.

**Anderson, K. (2008, November 14). Classroom Acoustics: A first step toward education for all. Presented at ASA Convention, Miami.**

This study was performed in actual classroom settings and included 28 children, 22 of whom wore hearing aids and 6 had a cochlear implant. The children, aged 8-14 years, were good language users. Results that showed children listening with their hearing aids and cochlear implants alone did not score better when a soundfield sound enhancement system was used (and many actually scored worse).

When the teacher's voice was delivered to the child via a desktop or personal FM system, improved speech recognition was obtained. Therefore, it cannot be assumed that soundfield classroom amplification is of benefit to children with hearing loss using hearing aids and cochlear implants and may instead be detrimental. It has been shown that soundfield technology, although largely ineffectual for the child using amplification devices, provides some benefit to children with minimal, fluctuating, and unilateral hearing loss.

**Brett, R. (2009, September 3). Portable soundfield amplification systems – their place. *The British Association of Teachers of the Deaf Magazine*. Audiology Refresher No. A5.**

There is no real alternative to improving classroom acoustics, but there are systems available to help reduce the negative effects of poor classroom acoustics. The objective is to bring the speaker's voice closer to the listener within a direct field. There are four combinations of systems available based on the student's listening needs that can be utilized in the classroom to help overcome poor classroom acoustics and distance from the teacher. These include a personal FM system used in conjunction with hearing aids, a personal FM system used with headphones, a classroom soundfield amplification system, and a personal soundfield amplification system.

There are several advantages and limitations for each system. For instance, personal FM systems, provide a positive SNR of 20 dB, which is not possible with any other system. However, personal FM systems target one child only. Classroom soundfield amplification systems can improve the SNR for all children in the classroom, as well as ease the strain on the teacher's voice. They do not correct for poor classroom acoustics, especially long reverberation times.

Personal soundfield amplification systems are portable and they address the issue of distance between the speaker and listener. However, they can be cumbersome to move around between classrooms and can give feedback when the volume is turned up. Regardless of which system is selected, the main criterion is that it should be "easy" for the child to listen.

**Mülder, H. (2011). Traditional or Dynamic SoundField; Which one gives better speech understanding in noise? *Field Study News*. Retrieved from www.phonakpro.com/evidence**

Unlike traditional soundfield systems with fixed-gain settings, Dynamic SoundField automatically varies the gain of the loudspeaker with changes in the ambient noise level. The goal of this dynamic behavior is to improve speech intelligibility of the teacher especially when noise levels increase in class, but at the same time to offer a comfortable volume during more quiet moments.

To quantify the benefits, speech intelligibility measurements were carried out with 20 normal hearing students in a classroom in different noise levels. Speech understanding improved significantly with the Dynamic SoundField system switched on for all noise levels. Performance with Dynamic SoundField was also better than with one of two other popular (traditional, non-dynamic) soundfield systems. Average speech recognition scores in the no-soundfield condition were clearly affected by increasing noise levels, starting from 95.2% at 50 dB(A) ambient noise level down to 7.6% at 70 dB(A) noise.

All soundfield systems improved speech understanding for this group of students in all noise conditions, but performance varied considerably between systems, with performance difference increasing at higher noise levels. The results indicate that the participants achieved significantly better speech recognition in noise with Dynamic SoundField as compared to their performance with traditional soundfield systems. The benefits of Dynamic SoundField tended to increase with increasing noise levels. At 70 dB (A) noise level, which is not uncommon in classrooms, students achieved a minimum speech recognition score of 90% with Dynamic SoundField, where popular competitive products dropped as low as 14% and 34%.

**Wolfe, J., Morais, M., Neumann, S., et al. (2013). Evaluation of speech recognition with personal FM and classroom audio distribution systems. *Journal of Educational Audiology*, 19, 65–79**

This study evaluated speech recognition in quiet and noise for 15 normal hearing children, 15 hearing impaired children and 10 adults with normal hearing in a classroom environment. Speech recognition was evaluated with 2 types of soundfield amplification systems; fixed gain multiple loudspeaker and adaptive single tower soundfield system (Phonak DigiMaster 5000). Additionally speech recognition was evaluated for the 15 hearing impaired children using adaptive personal FM systems in conjunction with the soundfield amplification systems.

All groups experienced difficulty understanding speech in the presence of a moderate level noise, especially the hearing impaired children. The highest scores for speech recognition for the hearing impaired children were seen with use of the adaptive personal FM system. The results showed the performance from the participants improved significantly with the use of a soundfield system and highlighted a significant improvement with the adaptive single tower soundfield system compared to the multiple loudspeaker soundfield system.

## Impact on student learning

In this section, we discuss how soundfield amplification can help children overcome problems with noise, distance and reverberation in the classroom. If children are unable to hear their teacher clearly and consistently, their ability to learn is compromised. Further, when children increase their listening effort in poor listening conditions, there are less cognitive resources available for other educational tasks, which can result in reduced academic achievements. It should be noted, however, that for children with hearing loss, a personal amplification system is recommended in the classroom (Wolfe et al., 2013).

Implementing soundfield amplification in classrooms can have a positive impact on students' academic achievement, behavior, speech recognition, listening abilities, and teacher vocal health. The benefits of soundfield amplification can be seen regardless of ethnic group, history of middle ear dysfunction, or schools of particular socio-economic status. Research has shown that younger children with access to soundfield amplification learn faster compared to their hearing peers in unamplified classrooms (Rosenberg, 1999).

**Bennett-Long, A. (2001). The effects of soundfield amplification on reading achievement. Valdosta State University. Retrieved from http://citeseerx.ist.psu.edu**

This study involved a class of 16 first grade students at a primary school. The effects of using a soundfield amplification device on phonemic awareness and phonics achievement were studied. The teacher and researcher delivered reading instructions using a soundfield amplification system to the class and measured phonemic segmentation fluency and nonsense word fluency. Data was collected before, during and after the implementation of the intervention using both qualitative and quantitative strategies. For phonemic segmentation fluency, an average increase of 20.56 more phonemes per minute on the test was observed and for the nonsense word fluency, an average of 17.13 more letter sounds per minute was observed on the test.

The results post-test indicated an increase in phonemic awareness and phonic skill when the soundfield amplification system was used. Using the amplification system resulted in an improvement in student achievement for reading and could also result in an improvement for other areas of the curriculum. Positive effects on students attitudes and engagement were noticed and students responded with comments such as "good" and "happy" when asked about the teacher using the amplifier. Students also expressed that they could hear better or that the teacher was louder with the soundfield system.

**Boswell, S. (2006, May 23). Soundfield systems on the rise in schools: Improved test scores cited as benefit. *The ASHA Leader*, 11(7), 1, 32–33.**

Approximately 160,000 classrooms in the United States have soundfield systems, and this number increases by 20% annually, according to manufacturer estimates. A school district in West Orange, NJ, invested in soundfield systems for every classroom after noting a significant improvement in test scores with the use of these systems. Before using soundfield systems, test score results found that 59% of the students in the first grade classroom were at or above grade level. A few months later, with use of the soundfield systems, test score results showed that 89% were at or above grade level.

In Milwaukee, a pilot study of soundfield amplification systems was launched in effort to improve the acoustical conditions in the large urban district. An informal survey of teachers showed a significant decline in absences. The year before, the same teachers had a combined 35 absences, compared to 5 during the study year. The teachers also responded positively to the systems: 100% said the soundfield systems were very easy to use; 92% wanted to keep the systems; 89% reported less vocal fatigue; and 86% reported less overall stress.

Overall, soundfield systems reduced teacher's vocal fatigue and throat infections and they also decreased the tension in the classroom when teachers projected their voice to command attention.

**Cornwell, S. & Evans, C.J. (2001). The effects of soundfield amplification on attending behaviours. *Journal of Speech-Language Pathology and Audiology*, 25(3), 135–144.**

This study evaluated the effects of using a soundfield amplification system on 15 students with and without attending/focusing difficulties. The students were chosen from three classrooms in a public school in Winnipeg, Manitoba, Canada. Data was collected by observing the amount of time students spent on task during a 20 minute interval in the school day. Three sets of these 20 minute

observations were completed for each student in both unamplified and amplified settings.

The students demonstrated an increase in the amount of time spent on task in an amplified environment by as much as 16%. Dependent on the student, more time on task may turn into a greater ability to learn information, follow directions, and acheive higher academic achievement. Students reported they were able to hear and listen better when amplification was in place. Teachers also saw amplification as beneficial in their classrooms both for their students and for themselves, as it reduced voice fatigue and gave them more mobility.

**Crandell, C.C. (1998). Using Soundfield FM amplification in the educational setting. *The Hearing Journal*, 51(5), 10–19.**

The acoustic environment in a classroom is an important variable in the academic achievement of children. However, many classrooms are so noisy or reverberant that it would be costly to modify the room acoustically to meet recommended standards.

A soundfield FM system in a classroom can help to amplify the teacher's voice by approximately 8-10 dB, thus improving the SNR of the listening environment and providing uniform amplification throughout the classroom. Soundfield amplification systems can be used with all populations of children with normal hearing who exhibit perceptual difficulties. Soundfield amplification systems are often the least expensive method for improving classroom acoustics.

**Extron Electronics. (2008, December 15). Classroom soundfield amplification: An introduction [White paper]. Retrieved from http://www.extron.com/**

A first study compared the standardized test scores of first, third, fourth, and fifth grade students with normal hearing ability, in unamplified and amplified classrooms in Oregon. The authors found that first grade students in the amplified classroom scored an average of 35% higher on the literacy test scores than students in the unamplified classroom. Third grade students in amplified classrooms scored an average of 21% higher on test scores and increased by an average of 32 words per minute in reading fluency. Fourth and fifth graders in amplified classrooms averaged 35% higher in words per minute on a reading fluency test than students in unamplified classrooms.

In another study in Utah, there were three first grade classrooms in which 85% of the children were Native American. All students had normal hearing ability. In the 5 years prior to the installation of classroom amplification systems, only 44 to 48% of the students scored at the basic level or above on the Utah State Core Reading Test. After seven months in amplified classrooms, 74% of the students in the study scored at the basic level or above. It was concluded that a classroom amplification system results in increased student attention, improved speech recognition, fewer distractions, and decreased off-task behavior.

**Flexer, C. (2002). Rationale and use of soundfield systems: An update. *The Hearing Journal*, 55(8), 10–18.**

Children's auditory brains need stimulation in order to grow and develop, as it is not fully developed until about the age of 15. Because children's brains are in the process of developing, they listen differently from adults. For verbal instruction to be meaningful, students must be able to hear and listen to the words.

There are five levels of auditory skill development. The lowest, least sophisticated level is detection, which is the basic perception that sound is present. Discrimination involves distinguishing between two speech sounds, such as "pa" and "ba." Recognition means selecting a target sound from a known list of alternatives, and is a closed-set task. Identification is an open-set task that involves recognizing a target from an infinite set of alternatives. Lastly, comprehension is achieved when a person can answer questions, follow directions, and hold conversations.

Comprehension, the goal of classroom instruction and literacy, relies on the initial detection of individual phonemes that make up the spoken message. Soundfield systems, when properly installed and used, make detection possible for every child in the class. In a previous study, phonemic awareness skills were most effectively and efficiently taught in preschool and kindergarten classrooms that had soundfield systems. The fewest at-risk readers came out of the classrooms that routinely used their soundfield systems.

The author concluded that hearing is a first-order event in regular education classrooms. If a child cannot clearly hear spoken instruction, the child will have a negative educational experience. Soundfield systems should be integrated into the general education arena to improve children's classroom learning and literacy development.

**Flexer, C. (2004, Sept/Oct). SoundField technology: Enhancing listening, literacy and learning for all children. *Hearing Loss*. Retrieved from www.hearingloss.org**

If children cannot consistently and clearly hear the teacher, the premise of the educational system is ineffective as children must be able to hear the teacher in order to learn. To improve the SNR ratio in classrooms, soundfield systems should be considered. The higher and more consistent the SNR ratio, the more accessible the teachers' verbal instructions are to the students.

In a Universal Design paradigm, soundfield technology should be implemented in general education classrooms and not be limited to special education. Additionally, by improving the SNR ratio and enhancing acoustic accessibility, soundfield technology can provide the evidence-based outcomes needed for school districts to be in compliance with the No Child Left Behind Act of 2001. Difficulties with soundfield technology can result from lack of teacher and administrator information about the purpose and use of the technology, and inappropriate set-up and function of the equipment. Thus, in-service training programs for teachers and administrators are necessary to highlight children's auditory development and acoustic accessibility.

**Gegg Rosenberg, G., Blake-Rahter, P., Heavner, J., Allen, L., Myers Redmond, B., Phillips, J., & Stigers, K. (1999). Improving classroom acoustic (ICA): A three-year FM soundfield classroom amplification study. *Journal of Educational Audiology*, 7, 8–28.**

Analysis of observational data on 1,750 students indicated that students in amplified classrooms demonstrate significant improvement in listening and learning behaviors and skills, and progresse at a faster rate than their grade-alike peers in unamplified classrooms, with younger students demonstrating the greatest improvement.

Data showed that noise levels (dBA) and acoustical treatments in elementary classrooms have not changed over the past decade. FM soundfield classroom amplification provided teachers with an average of +6.94 dB(A) increase in vocal intensity. Students, teachers, parents, and school administrators gave FM soundfield classroom amplification a positive evaluation. Finally, data demonstrated that this instructional delivery equipment is a cost-effective means to manage the intensity of a teacher's voice in early grade classrooms.

**Heeney, M. (2007). Classroom soundfield amplification listening and learning. (Unpublished Doctor of Philosophy thesis). The University of Newcastle. Retrieved from file:///C:/Users/11lbacic/AppData/Local/Microsoft/Windows/INetCache/IE/40KFT5S9/Abstract.pdf**

A study was performed to investigate the efficacy of soundfield distribution in 30 New Zealand classrooms from 5 primary schools, the benefit it can provide for groups from specific populations, and the effects on teachers who use this equipment.

The results obtained from this study revealed that soundfield distribution can improve the listening and learning environment, resulting in significant benefits and increased achievement levels of the students. The results were observed in listening comprehension, phonologic skills, reading comprehension and reading vocabulary. Furthermore, benefits from using soundfield distribution was obtained in all mainstream school settings, regardless of whether the students were from a particular ethnic group, had a history of middle ear dysfunction, or attended schools of particular socio-economic status. The author concluded that classroom soundfield distribution had a positive effect for learning in all students.

**Howard, C., Plack, C., & Munro, K. (2011). Effect of background noise on listening effort in normal hearing 9-11-year-olds. *International Journal of Audiology*, 50(10), 717–780.**

This study involved 31 children, aged 9-11 years, with normal hearing. The children performed a speech perception task, a digit recall task, and a combination of the two to form a dual task situation. Results illustrated that the children were able to perform the speech perception and digit recall tasks simultaneously, but more effort was required as the background noise increased. This increase in effort was reflected in poorer performance on the secondary digit recall task.

The results have implications regarding acceptable classroom noise levels and the need to improve the SNR to reduce listening effort, especially for children with hearing loss or learning difficulties. If there is increased listening effort in poor listening conditions, there will be less resources available for other tasks, compromising educational attainment. The dual task paradigm used in this study has the potential to demonstrate reduced listening effort in listeners after being fitted with hearing aids and/or FM systems.

**Kreisman, B.M., & Crandell, C.C. (2002). Frequency modulation (FM) systems for children with normal hearing. *Journal of Education Audiology*, 10, 21–25.**

The use of an FM system is an effective way to reduce effects of noise and reverberation. An FM system amplifies the speakers voice by approximately 8-10 dB, resulting in an improvement of SNR in the environment. FM systems also provide a uniform distribution of sound within the classroom regardless of the position of the teacher or students. There are 2 types of FM systems typically used in a classroom setting; personal and soundfield.

Using soundfield FM amplification in the classroom can benefit all children and is an inexpensive technology to improve speech perception. The soundfield system does not stigmatize children and students willingly accept the FM system which can in turn improve classroom interaction and participation. Teachers also accept the soundfield system and reported less vocal strain during their teaching activities with the FM amplification. The FM system can also be used to enhance other educational equipment such as TVs and audio players.

**Mainstream Amplification Resource Room Study (MARRS): Key studies on soundfield amplification sheet. Retrieved from http:// www.marrs-study.info/marrs-study.html**

This project reported teachers noticed an improvement in students' attention, students were less distracted and teachers needed to repeat instructions less frequently with the use of a soundfield amplification system.

Teachers used the soundfield amplification on average for 4.2 hours per day. The teachers found that classroom management was improved and discipline problems reduced due to improved voice command in the classroom. Students reported they found it easier to understand and pay attention. Younger students demonstrated significantly greater change in listening, learning behaviors and skills, and learned faster than their peers in unamplified classrooms.

More than 95% of students reported that soundfield amplification made it easier for them to hear their teachers and helped them listen better. Additionally, 96% of teachers said students behaviors related to attentiveness, listening and comprehension improved with soundfield amplification. And every teacher reported decreased vocal strain using soundfield amplification.

There were statistically significant improvements in reading and language test scores for K-6 students, both those with normal hearing and those with mild hearing loss with the use of the soundfield amplification system. The significant gains in academic scores were clearly evident in less than one school year and were maintained for the study periods of up to three years. Soundfield amplification costs less than a resource room to achieve the same or superior academic test scores.

**Massie, R. & Dillon, H. (2006). The impact of soundfield amplification in mainstream cross-cultural classrooms: Part 1 educational outcomes. *Australian Journal of Education*, (50)1, 62–77.**

The study involved twelve classes of Year 2 students, totaling 242 students. For classes 1 to 8, the listening environments alternated between amplified and unamplified conditions with each condition having a duration of one semester of the school year. The authors found that the students performed well in all three skill areas of reading, writing, and numeracy in the amplified conditions compared to the unamplified conditions. The beneficial effects were obtained regardless of whether English was considered a native language or a second language. For classes 9 to 12, the listening environments alternated between single-channel and dual-channel transmissions with each condition having a duration of one semester of the school year. The authors concluded that soundfield amplification improves listening and learning in the classroom.

**Mendel, L., Roberts, R.A., & Walton, J.H. (2003). Speech perception benefits from soundfield FM amplification. *American Journal of Audiology*, 12, 114–124.**

The effects of soundfield FM amplification on speech perception performance was investigated in a 2-year study. Kindergarten children with normal hearing were randomly assigned to a treatment group and were followed from the beginning of kindergarten through to the end of first grade. The treatment group was placed in 7 different classrooms that had soundfield amplification systems and the control group were placed in another 7 classrooms that did not have amplification available. Improvements in speech perception performance were measured in both groups and the results showed that the treatment group demonstrated progress much sooner than the control group. However, this difference was not apparent at the end of the study.

The treatment group performed significantly better than the control group when the stimuli were presented with soundfield amplification for the treatment group and without soundfield amplification for the control group. The children in the treatment group demonstrated significant speech perception improvements at the beginning of the study showing that the benefits were immediate.

The study highlights that soundfield amplification improves speech perception performance of young children in kindergarten and first grade. The teachers in the study who used soundfield amplification reported that they enjoyed using the system in their classroom and felt that their students also enjoyed it being used.

**Millett, P. (2008). Soundfield amplification research summary. York University. Retrieved from http://simeoncanada.com/technology/research-innovation/**

Research with hearing children indicates that they are able to discriminate words and spoken language more accurately with the use of a soundfield amplification system than without (Arnold & Canning, 1999; Prendergast, 2005). 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 than students did in unamplified classrooms.

The rationale for the use of soundfield amplification in regular classes is based on an extensive body of literature documenting a higher incidence of ear infections 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; Moore, 2002; Nelson & Soli, 2000; Gil-Loyzaga, 2005; Stelmachowicz, Hoover, Lewis, Kortekaas, & Pittman, 2000).

Sapienza, Crandell and Curtis (1999) found that teachers exerted less vocal effort, were able to speak softer and were heard more effectively by their students when they used a soundfield system.

**Millett, P. & Purcell, N. (2010). Effect of soundfield amplification on grade 1 reading outcomes. *Revue canadienne d'orthophonie et d'audiologie*, 34(1), 17–24.**
This study examined changes in reading outcomes for Canadian grade 1 students (N=486) in 24 classrooms, 12 with soundfield 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 versus unamplified classrooms, although results were not statistically significant.

Positive trends were also seen with improved reading outcomes for students identified at risk for reading difficulties, although not statistically significant. Finally, teacher experiences with the soundfield systems were extremely positive.

**Rubin, R., Aquino-Russell, C., & Flagg-Williams, J. (2007). Evaluating soundfield amplification technology in New Brunswick Schools. Paper presented at the annual conference of the Canadian Association of Speech-Language Pathologists and Audiologists, Moncton, NB, Canada.**
This pilot study involved 60 classrooms in 3 New Brunswick school districts. They evaluated the use of soundfield amplification technology.

Key findings were:
Improvement in student's communicative responses to teacher's statements:

- Decreased attention to statements directed to peers
- Better responses to teacher's 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

**Voor in 't holt, A., De Lange, R., & Van Den Bogaerde, B. (2010, June). Effects of using soundfield equipment in five Frisian schools for primary education. Utrecht University of Applied Sciences.**
This study investigated the effect of soundfield equipment on 177 students, grades 3-8 in 5 primary schools. In each listening situation an improvement was found in the average score achieved by pupils.

The greatest improvements were noted in the following conditions:

1. 44% improvement when listening to noise from the corridor
2. 33% improvement when listening to 2 teachers talking at a time in class
3. 27% improvement listening while other students were noisy in the classroom
4. 25% improvement when listening to the teacher during a change of activities

Without the soundfield amplification, 54% of teachers reported that the acoustics and listening conditions were not optimal in their classroom and 23% of teachers reported moderate to high levels of noise in their classrooms. Also, 75% of the teachers used the soundfield equipment regularly during group discussions and found their students were more focused in class.

## Advantages for special populations

In this section, we discuss the advantages of providing soundfield amplification to specific populations of students. Special populations in education are children with needs that require special consideration and attention in an educational setting (e.g., children with syndromes, children with English as a second language, attention deficit disorders and developmental delays).

It is important that children are viewed as individuals and not representative of a particular group. Some students may be at a disadvantage because their needs may be different compared to their peers. These students may often need more attention from teachers and different support.

**American Speech-Language-Hearing Association. (2002). Guidelines for audiology service provision in and for schools [Guidelines]. Available from www.asha.org/policy**
A child with hearing loss experiences both auditory and sensory deprivation which effect communication, learning, and psychosocial development. Children with auditory

processing disorder (APD) often exhibit similar behaviors and problems that children with hearing loss experience.

Children with hearing loss and/or APD require a clear auditory signal to understand oral instructions, class discussions, and other spoken communications. Even with appropriately fitted amplification devices, the child still may have difficulty understanding spoken language. The high levels of noise and reverberation that exist in most classrooms often reduce the effectiveness of hearing aids and cochlear implants.

The complex interactions of noise, distance from the speaker, acoustic characteristics of the room, and type of amplification make recommendations for preferential seating inadequate in ensuring good hearing in the classroom.

**Australian Hearing. (2009, July 3). Soundfield systems helping close the gap in classrooms [Media release]. Retrieved from https://www.hearing.com.au/**

Many indigenous children have disadvantages, including conductive or mild hearing loss, middle ear infection, English as a second language and/or auditory processing disorder. Soundfield systems can offer benefits to these children to better hear in the classroom.

National Acoustics Laboratory (NAL) conducted an experiment evaluating soundfield systems and found a 41% increase in the rate of attainment of educational indicators, despite the fact that most of the children had no hearing problems. It is anticipated that the benefits would be even greater for classrooms that have a high proportion of children with hearing loss such as those in remote areas.

A study conducted at primary schools in Victoria indicated that 11% of children have a hearing loss of some type in one or more ears at any given time. Therefore, with this high prevalence of hearing loss among indigenous communities, soundfield amplification systems help many Aboriginal children hear their teachers while in the classroom.

**Bennetts, L.K. & Flynn, M.C. (2002). Improving the classroom listening skills of children with Down Syndrome by using soundfield amplification. *Down Syndrome Research and Practice*, 8(1), 19–24.**

Many children with Down Syndrome have fluctuating conductive hearing losses reducing their speech, language and academic development. In the school environment, it is crucial for children to have access to auditory information, but many children with Down Syndrome are disadvantaged due to their fluctuating hearing loss.

This investigation examined the efficacy of soundfield amplification for four children with Down Syndrome. Evaluation of speech perception was performed with and without the soundfield system. The researchers found that the children perceived significantly more speech in all conditions where the soundfield system was used. Additionally, listening performance with the soundfield system was not affected by reducing the SNR through increasing the level of background noise. The authors concluded that soundfield amplification provides improved access to speech for children with Down Syndrome and as a consequence leads to improved classroom success.

**Flexer, C., Millin, J.P., & Brown, L. (1990). Children with developmental disabilities: The effect of soundfield amplification on word identification. *Language, Speech and Hearing Services in Schools*, 21, 177–182..**

This study aimed to determine whether soundfield amplification reduced the effects of distractibility, minimal hearing difficulties, and typical classroom noise in a class for students with development disabilities. The study included nine students enrolled in a primary-level class for children with developmental disabilities. The students had additional disabilities/syndromes, including attention deficit disorders, Apert's syndrome, and seizure disorders. Six of the nine children had histories of fluctuating hearing loss; however, none of them wore hearing aids.

Soundfield amplification increased the intensity of the teacher's voice by 10 dB. Results showed the students made significantly fewer errors on a word identification task compared to without amplification. Soundfield amplification overcame the effects of ambient noise and distance from the speaker, providing an improved and consistent SNR throughout the classroom. Observations showed the children were more relaxed, responded quicker, and made more accurate responses when the teacher's speech was amplified.

**Langlan, L.A., Ravichandran, S., Caissie, R., Kreisman, B.M. (2009). The benefit of soundfield amplification in First Nations elementary school children in Nova Scotia, Canada. *The Australian and New Zealand Journal of Audiology*, 31(2), 55–71.**

This study investigated the effects of soundfield FM amplification on student classroom performance in a First Nations Elementary School classroom in Pictou Landing, Nova Scotia, Canada.

Temporary hearing loss as a result of glue ear may fluctuate and go undetected. Therefore, children may suffer unknowingly with a hearing loss which could affect their ability to hear their teachers. The purpose of the study was to review student's classroom performance over a 7-month period before, during and after soundfield amplification use for both hearing impaired students and students with normal hearing.

Forty Mi'kmaq indigenous students with a mean age of 7.75 years ( SD = 1.86 years) and ranging from 5 to 11 years were used in the study. Teachers completed the SIFTER questionnaires to document student's performances. An analysis of the results revealed a significant difference between the mean SIFTER score from pretreatment to treatment condition and from treatment to posttreatment condition.

The results suggested student performances for both hearing impaired and normal hearing students in the classroom improved when the soundfield system was used. The areas where improvement was noticed when the FM system was used were academic, attention, communication, class participation and school behavior.

**Leung, S.W., & McPherson, B. (2006). Classrooms for children with developmental disabilities: Soundfield and public address amplification systems compared. *International Journal of Disability, Development and Education*, 53(3) 287–299.**

Unoccupied-room noise levels and reverberation times were measured in 8 classrooms for children with special needs in 4 primary schools in Hong Kong. The speech levels in each classroom were measured under 3 conditions: without amplification, with public address system amplification and with soundfield amplification. The speech-to-noise ratios were then calculated for each of these conditions. The noise and unamplified speech-to-noise ratio values were higher than the recommended acoustic standards in classrooms.

The results showed that when the soundfield and public address amplification systems were used, signal-to-noise ratios improved. Installation of both amplification systems led to an improvement in SNR. The soundfield amplification system improved with an SNR + 24 dB(A) and the public address amplification system led to an improvement of +20 dB(A) SNR. Both systems provided a uniform distribution of amplified sound throughout the classrooms.

**Massie, R., Theodoros, D., McPherson, B., & Smaldino, J. (2004). Soundfield amplification: Enhancing the classroom listening environment for Aboriginal and Torres Strait Islander children. *The Australian Journal of Indigenous Education*, 33, 47–53.**

This report discusses the effects of soundfield amplification intervention on the communication in the classroom of Aboriginal and Torres strait Islander children. At the start of the trial, 67% of the children had a slight hearing loss. The trial involved a 8 week field trial of soundfield amplification in 4 classrooms, 2 in each rural Queensland community.

The listening environments of the 4 classrooms were alternated between amplified and unamplified at 2-weekly intervals over 8 weeks. Teachers were asked to rate the child's performance before and after the trial in terms of academic performance, attention, communication, class participation, and school behavior. The findings indicated that soundfield amplification intervention encouraged children to interact with teachers and peers in a proactive way. Teachers identified voice-related factors to be a major personal benefit of the system. The greatest improvements were noticed in the classes where a non-indigenous teacher taught the class.

**Nelson, P., Kohnert, K., Sabur, S., & Shaw, D. (2005). Classroom noise and children learning through a second language: Double jeopardy? *Language, Speech and Hearing Services in Schools*, 36, 219–229.**

This article looks at the effects of classroom noise on the attention and speech perception of typically developing children who are listening in their second language (L2) as compared to their English-only (EO)-speaking peers.

On-task behavior during instructional activities with and without soundfield amplification revealed no significant condition (pre-/postamplification) or group differences. Word recognition performance declined significantly for both L2 and EO groups in a noisy condition (+10 dB SNR). However, the impact was disproportionately greater for the L2 group. The conclusion was that children learning in their second language appear to be at a distinct disadvantage when listening in rooms with typical noise and reverberation.

**Nelson, P.B., Soli, S. (2000). Acoustical barriers to learning: Children at risk in every classroom. *Language, Speech and Hearing Services in Schools*, 31, 356–361.**

There are surprisingly large numbers of children with various auditory disorders in schools. Their classrooms are often noisy, reverberant, and active places for learning. For these children, their auditory problems plus the poor classroom acoustics cause significant learning problems. Poor listening conditions can affect all children, but they affect those with auditory disorders more.

Improving classroom acoustics can significantly reduce the negative educational impact of auditory disorders. This article reviews relevant literature on acoustical barriers to successful learning and provides guidance for school personnel.

Children at risk:

- Young listeners
- Children learning English as a second language
- Children with minimal hearing loss
- Children with hearing loss
- Children with otitis media

The authors concluded that students who do not have full access to spoken information in classrooms either from their teacher or from peers cannot be expected to learn at a normal rate.

**The use of soundfield amplification of the teacher's voice in the regular education classroom – A summary of studies. THE MARRS PROJECT: Mainstream Amplification Resource Room Study. Retrieved from http://www.classroomhearing.org/research/marrsStudy.html**

In 1994, the listening abilities of children who learned English as a second language were studied under amplified and non-amplified conditions. The results indicated that students experience significant difficulty understanding spoken English in a noisy classroom environment without amplification. However, in amplified classrooms, a significant improvement in understanding of English was noted for the students.

## Benefits for teachers

This section covers the benefits that soundfield amplification can have for teachers. Teachers who use soundfield amplification systems often report they are less tired and do not have to raise their voice or repeat themselves. Teachers also notice more clarity in their speech and greater ease in voice production. Other benefits noticed by teachers include less vocal strain and throat infections, which can result in less teacher absences.

**Kirketerp, M. & Larsen, N.B. (2006). Soundfield enhances sounds and learning environments for teachers and students. Danish Soundfield study. *Phonic Ear*. Retrieved from www.phonicear.dk**

Subjective data was obtained from 384 students and 24 teachers in the form of questionnaires before and after the installation of soundfield systems. Subjective data showed that with the implementation of a soundfield system, students were better able to hear what other students were saying and they were more focused when their teacher was speaking.

In addition, the teachers reported being less tired, and that they did not have to raise their voices or repeat themselves as frequently during class. Overall, 90.9% of the teachers acknowledged many advantages with the soundfield system and 87.5% of the teachers wished to continue using the soundfield system in class after the end of the trial. The results indicated that soundfield systems improved the sound environment in the classroom for both students and teachers.

**Mülder, H. (2011). Dynamic SoundField: Teachers' ratings students perform better, classrooms are quieter, teacher vocal strain is removed. *Field Study News*. Retrieved from www.phonakpro.com/evidence**

In this study, teachers at a primary school in New Zealand used Dynamic SoundField in their classrooms for an average of two months. The teachers then each completed a questionnaire of 13 targeted questions with a response rate of 100%. The teachers reported a significant improvement in student performance when using Dynamic SoundField; their own vocal strain was reduced; it was quieter in class; the equipment was easy to use and the sound quality was highly rated. These results indicated high acceptance of Dynamic SoundField by teachers.

**Roy, N., Weinrich, B., Gray, S.D., Tanner, K., Toledo, S.W., Dove, H., Corbin-Lewis, K. & Stemple, J.C. (2002). Voice amplification versus vocal hygiene instruction for teachers with voice disorders: A treatment outcomes study. *Journal of Speech, Language and Hearing Research*, 45, 625–638.**

Forty-four teachers with voice disorders were randomly assigned to one of three groups: voice amplification using a portable amplifier, vocal hygiene, and a non-treatment control group. Before and after a 6-week treatment phase, all teachers completed: the Voice Handicap Index (VHI), and a voice severity self-rating scale and an audio recording for later acoustic analysis.

Based on pre- and post-treatment comparison, only the amplification group experienced significant reductions on mean VHI scores and voice severity self-rating. The amplification group also reported that after the study they noticed more clarity in their speaking and singing voice, greater ease of voice production and there was a greater compliance with the treatment program. The findings from this study strongly support the use of voice amplification as an alternative for the treatment of voice problems in teachers.

**Sapienza, C.M., Crandell, C.C., & Curtis, B. (1999). Effects of soundfield frequency modulation amplification on reducing teacher's sound pressure level in classroom. *Journal of Voice*, 13(3), 375–381.**

Ten adults with professional teaching experience participated in a study to investigate the effects of soundfield amplification on reducing the sound pressure level (SPL) of teachers' voices in classrooms. The study looked into the mean SPL levels of the participants for the amplified and unamplified speaking conditions.

The results suggested soundfield amplification can reduce teachers overall SPL by 2.42 dB (63.35 dB in the unamplified speaking condition, 60.93 dB in the amplified speaking condition). The results further suggest that soundfield

amplification can reduce a teacher's voice level. Additionally, 9/10 participants experienced a reduction in SPL with the use of the soundfield system.

## Conclusion and final thoughts

Inappropriate levels of reverberation and/or noise in an educational environment can affect student achievement. Although for those with hearing loss, a personal amplification system is still the recommended choice (with well-fit hearing aids or cochlear implants), there is overwhelming evidence to support the use of soundfield amplification in classrooms for children with normal hearing (e.g., improves speech perception, reading/spelling ability, classroom behavior, attention, concentration, and educational achievement).

Soundfield amplification is considered cost effective as it can provide benefit to all the children in the classroom and their teachers (e.g., teachers report reduced vocal fatigue and fewer cases of throat infections with the use of soundfield amplification).

Audiologists hold the responsibility for not only making appropriate clinical decisions for their young patients but also educating teachers, school staff and families regarding their needs in the classroom setting. Since every child is unique, it is of the utmost importance that audiologists work with these children and their families to determine the most appropriate combination of amplification, intervention services, and follow-up monitoring.

## References


American Speech-Language-Hearing Association. (2002). Appropriate school facilities for students with speech-language-hearing disorders [Technical report]. Available from www.asha.org/policy

American Speech-Language-Hearing Association. (2002). Guidelines for audiology service provision in and for schools [Guidelines]. Available from www.asha.org/policy.

American Speech-Language-Hearing Association. (2005). Acoustics in educational settings: Position statement [Position statement]. Available from www.asha.org/policy

American Speech-Language-Hearing Association. (2005). Acoustics in educational settings: Technical report [Technical report]. Available from www.asha.org/policy

American Speech-Language-Hearing Association. (2005). Guidelines for addressing acoustics in educational settings [Guidelines]. Available from www.asha.org/policy

Anderson, K. (2008, November 14). Classroom acoustics: A first step toward education for all. Presented at ASHA Convention, Miami.

Australian Hearing. (2009). Soundfield systems helping close the gap in classrooms [Media release]. Retrieved from https://www.hearing.com.au/

Bennett-Long, A. (2001). The effects of soundfield amplification on reading achievement. Valdosta State University. Retrieved from http://citeseerx.ist.psu.edu/

Bennetts, L.K. & Flynn, M.C. (2002). Improving the classroom listening skills of children with Down Syndrome by using soundfield amplification. *Down Syndrome Research and Practice*, 8(1), 19-24.

Boothroyd, A. (2002). Room Acoustics and speech perception. *Seminars in Hearing*, 25(2), 155-166.

Boswell, S. (2006). Soundfield systems on the rise in schools: Improved test scores cited as benefit. *The ASHA Leader*, 11(7), 1, 32-33.

Bradley, J.S. (2002). Acoustical design of rooms for speech. *Construction Technology Update*, 51.

Brett, R. (2003). Portable soundfield amplification systems–their place. *The British Association of Teachers of the Deaf Magazine*. Audiology Refresher No. A5.

Cornwell, S. & Evans, C.J. (2001). The effects of soundfield amplification on attending behaviours. *Journal of Speech-Language Pathology and Audiology*, 25(3), 135-144.

Crandell, C.C. (1998). Using soundfield FM amplification in the educational setting. *The Hearing Journal*, 51(5), 10-19.

Crandell, C.C., & Smaldino, J.J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. *Language, Speech and Hearing Services in Schools*, 31, 362-370.

Extron Electronics. (2008, December 15). Classroom soundfield amplification: An introduction [White paper]. Retrieved from http://www.extron.com/

Flexer, C., Millin, J.P., & Brown, L. (1990). Children with developmental disabilities: The effect of soundfield amplification on word identification. *Language, Speech and Hearing Services in Schools*, 21, 177-182.

Flexer, C. (2002). Rational and use of soundfield systems: An update. *The Hearing Journal*, 55(8), 10-18.

Flexer, C. (2004, Sept/Oct). SoundField technology: Enhancing listening, literacy and learning for all children. *Hearing Loss*. Retrieved from www.hearingloss.org

Heeney, M. (2007). Classroom soundfield amplification listening and learning. (Unpublished Doctor of Philosophy thesis). The University of Newcastle. Retrieved from file:///C:/Users/11lbacic/AppData/Local/Microsoft/Windows/INetCache/IE/40KFT5S9/Abstract.pdf

Howard, C., Plack, C., & Munro, K. (2011). Effect of background noise on listening effort in normal hearing 9-11-year-olds. *International Journal of Audiology*, 50(10), 717-780

Kirketerp, M. & Larsen, N.B. (2006). Soundfield enhances sounds and learning environments for teachers and students. Danish Soundfield study. *Phonic Ear*. Retrieved from www.phonicear.dk

Knecht, H.A., Nelson, P.B., Whitelaw, G.M., & Feth, L.L. (2002). Background Noise Levels and Reverberation Times in Unoccupied Classrooms: Predictions and Measurements. *American Journal of Audiology*, 11, 65-71.

Kreisman, B.M., & Crandell, C.C. (2002). Frequency modulation (FM) systems for children with normal hearing. *Journal of Education Audiology*, 10, 21-25.

Langlan, L.A., Ravichandran, S., Caissie, R., & Kreisman, B.M. (2009). The benefit of soundfield amplification in First Nations elementary school children in Nova Scotia, Canada. *The Australian and New Zealand Journal of Audiology,* 31(2), 55-71.

Larsen, J.B., Vega, A., & Ribera, J.E. (2008). The effect of room acoustics and soundfield amplification on word recognition performance in young adult listeners in suboptimal listening conditions. *American Journal of Audiology*, 17, 50-59.

Leung, S. W., & McPherson, B. (2006). Classrooms for children with developmental disabilities: Soundfield and public address amplification systems compared. *International Journal of Disability, Development and Education*, 53(3) 287-299.

Mainstream Amplification Resource Room Study (MARRS): Key studies on soundfield amplification sheet. Retrieved from http://www.marrs-study.info/marrs-study.html

Massie, R., Theodoros, D., McPherson, B., & Smaldino, J. (2004). Soundfield amplification: Enhancing the classroom listening environment for Aboriginal and Torres Strait Islander children. *The Australian Journal of Indigenous Education*, 33, 47-53.

Massie, R., & Dillon, H. (2006). The impact of soundfield amplification in mainstream cross-cultural classrooms: part 1 educational outcomes. *Australian Journal of Education*, (50)1, 62-77.

Mendel, L.L., Roberts, R.A., & Walton, J.H. (2003). Speech perception benefits from soundfield FM amplification. *American Journal of Audiology*, 12, 114-12.

Millett, P. (2008). Soundfield amplification research summary. York University. Retrieved from http://simeoncanada.com

Millett, P., & Purcell, N. (2010). Effect of soundfield amplification on Grade 1 reading outcomes. *Revue canadienne d'orthophonie et d'audiologie*, 34(1), 17-24.

Mülder, H. (2011). Traditional or Dynamic SoundField; Which one gives better speech understanding in noise? *Field Study News*. Retrieved from www.phonakpro.com/evidence

Nelson, P., Kohnert, K., Sabur, S., & Shaw, D. (2005). Classroom noise and children learning through a second language: Double jeopardy? *Language, Speech and Hearing Services in Schools*, 36, 219–229.

Nelson, P.B., & Soli, S. (2000). Acoustical barriers to learning: Children at risk in every classroom. *Language, Speech and Hearing Services in Schools*, 31, 356-361.

Neuman, A.C., Wroblewski, M., Hajicek, J., & Rubinstein, A. (2010). Combined effects of noise and reverberation on speech recognition performance of normal hearing children and adults. *Ear & Hearing*, 31(3), 336-344.

Palmer, C.V. (1997). Hearing and listening in a typical classroom. *Language, Speech and Hearing Services in Schools*, 28, 213-218.

Rubin, R., Aquino-Russell, C., & Flagg-Williams, J. (2007). Evaluating sound field amplification technology in New Brunswick Schools. Paper presented at the annual conference of the Canadian Association of Speech-Language Pathologists and Audiologists, Moncton, NB, Canada.

Sato, H. & Bradley, J.S. (2008). Evaluation of acoustical conditions for speech communications in working elementary school classrooms. *Journal of Acoustical Society of America*, 123(4), 2064-2077.

Siebein, G.W., Martin, A.G., & Ermann, M.G. (2000). Ten ways to provide a high-quality acoustical environment in schools. *Language, Speech, and Hearing Services in Schools*, 31, 376-384.

Tibbetts, J. (2007, October 2). Classroom noise impedes learning. CanWest News Service. Retrieved from www.canada.com/canwestnewsservice/

United States Access Board (2003). A Checklist for Classroom Acoustics. Retrieved from www.access-board.gov

Voor in 't holt, A., De Lange, R., & Van Den Bogaerde, B. (2010, June). Effects of using soundfield equipment in five Frisian schools for primary education. Utrecht University of Applied Sciences.

Wolfe, J., Morais, M., Neumann, S., et al. (2013). Evaluation of speech recognition with personal FM and classroom audio distribution systems. *Journal of Educational Audiology*, 19, 65-79

## Authors of this compendium

Jennifer Appleton-Huber received her MSc in Audiology from the University of Manchester in 2004. Until 2013, she worked as an audiological scientist mainly in the UK and Switzerland, where she worked with adults and pediatrics, in the areas of hearing aids and cochlear implants. Her current role is Technical Editorial Manager at Phonak Headquarters.

Lisa Bacic worked as a clinical speech-language pathologist in Canada for over 15 years before moving to Switzerland and joining Phonak HQ in 2016. She is both Editorial Manager of the Phonak Audiology Blog and Pediatric Rehabilitation Resource Manager in the Pediatric team.

Jacqueline Drexler received her Doctorate of Audiology from the University at Buffalo. She joined Sonova in 2017 for a one-year formal development program. During that time she worked at Unitron US, Connect Hearing Canada, Advanced Bionics, Phonak US, and Phonak HQ.

Ananya Venkatesan received her BSc (Hons) degree from the University of Leeds, England, and has worked as a pediatric audiologist at Great Ormond Street Hospital and the Royal Surrey County Hospital before moving to Switzerland to join Sonova.

.