



EITI Newsletter

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PROVIDING AN OPTIMAL ACOUSTIC ENVIRONMENT FOR YOUNG CHILDREN IN CLASSROOMS

It seems a simple and obvious proposition: good hearing and listening conditions are essential for developing good speech, language, and learning skills. Yet, even today, our educators and school planners overlook the importance of effective noise reducing acoustic design in schools. Room acoustics have a significant impact on speech communication. Listening conditions vary in classrooms and often may not be good for children or special listeners (hearing impaired, speech impaired, learning disabled, or non-native listeners). For these listeners the speech signal will need to be even louder for good understanding.

Speech is described by audiologists as a type of "signal". In a preschool classroom, the teacher's voice is an important signal and should be heard clearly and intelligibly. In classrooms, clarity and intelligibility of speech are influenced by three factors: loudness, background noise, and reverberation. Background noise can originate from inside or outside a classroom, created by various student-teacher-environmental activities (e.g. talking students, shuffling feet, faulty fluorescent lights, noisy equipment, traffic noise). Reverberant sounds can occur from the reflection of both speech and noise sounds off hard surfaces, which creates an "echo effect". When background and reverberant noise mixes or competes with the teacher's voice, some part of his or her speech will be covered up and become less audible. This competition between the teacher's voice and background noise is described by audiologists as the "signal to noise ratio". When there is too much background noise for the speech signal (teacher's voice) to be heard clearly, the signal to noise ratio is reduced, and the signal and listening environment are said to be degraded. The importance of loudness of speech, background noise, and reverberation will depend on the distance of the listener from the source. Furthermore, the levels of direct and reflected sounds with background noise will vary across the room.

All children are at risk for speech recognition difficulties in degraded listening environments. This holds true especially for the very young who cannot cope with noise as easily as the adolescent or adult listener. With more mothers returning to the work force earlier, the last decade has witnessed a sizable increase in enrollment in nursery and preschool programs. As the classroom, rather than home, becomes the domain where young children are spending more of their waking hours, its suitability as a listening environment needs to be examined.

The first three to four years of life are the most critical for speech and language development. Preschoolers spend at least half of their school days engaged in activities directly related to listening. Much of their language development will occur from hearing incidental conversations around them. Learning would therefore be significantly hindered by a poor acoustic environment that does not promote good listening. The maximum acceptable noise level for children with normal hearing is 35 dB, the level of a loud whisper. Yet even in an empty classroom, noise levels can easily reach up to 44 dB of noise generated from the environment. Adding 28 students and a teacher could further increase this noise level to over 60 dB. This is significant when you consider the average sound level of a teacher's voice is approximately 60 dB, depending on the speaker's distance from the listener. Thus, the teacher's voice would be overshadowed by the extraneous noise and adversely affect the students' ability to hear and listen.

Not only does noise hamper learning, but speaker distance can degrade the signal as well. Speaker distance is an important factor when evaluating the learning environment. A child will hear much better when seated a few feet from the teacher than if he or she were at the other end of the classroom.

Whenever the speech signal is degraded in the classroom, the child will demonstrate more difficulty understanding. He or she often cannot hear the words clearly. This is a problem, particularly for very young children who have not yet developed a solid linguistic vocabulary base from which to draw inferences of meaning when some words or parts of words are not heard clearly. It is often hard to hear the subtle differences between words that give meaning to the conversation. The child may not hear many of the consonants which carry the meaning of the word but often are the most difficult sounds to pick up amid unwanted noise. Over time, we can expect to see subtle problems arise in vocabulary development, linguistic structure, and pragmatics. It is no wonder that under poor listening conditions, children may act inattentive or distracted and may demonstrate inappropriate behavior.

Teaching Approaches

There are many steps teachers can take to enhance younger children's classroom performance by reducing noise in the classroom. This can be done by:

- initiating classroom rules to emphasize quiet during language tasks, stories, conversations;
- developing good listening skill exercises for the whole class;
- avoiding talk near open windows or under duct openings;
- when in larger groups, making sure children are not

looking out the window or ignoring language directed to them;

- engaging the child in as much one-to-one interaction as possible to emphasize sustained attention to language;
- making sure children play in small groups.

Teachers can learn to think about poor hearing as a possible explanation for a child's inattentiveness, impulsiveness or inappropriate behavior during times of instruction. Children with listening difficulties should be positioned closer to the teacher during instruction, circle activities, or story time to prevent the speech signal from becoming softer through increased distance.

To further foster good hearing and listening skills, teachers and parents should:

- establish face to face contact before speaking to child;
- provide frequent feedback to cue the child as needed;
- be aware that noisy environments make it more difficult for the child to select and attend to conversation;
- speak slowly and clearly;
- repeat if the child seems confused.

Instructions may need to be repeated or rephrased and the child's attention refocused. It is often much harder for the child to listen and concentrate towards the end of the day.

School and Classroom Design

There are many simple modifications that can be made to reduce noise in the classroom. Almost all classrooms generate much of their noise from children talking and chairs or tables scraping on hard surfaced floors. To reduce the furniture noise, simply attaching a noise damping material, such as carpet pieces or even tennis ball halves, to the bottom of the legs of movable furniture would be beneficial.

Floors, ceilings, and walls are typically hard surfaces which can cause noise to be reflected or "bounced around" rather than absorbed. To reduce this reverberation (echo) effect and thus reduce the noise level, we can use carpets, drapes, bookshelves, storage areas, curtains, corkboard on walls, suspended acoustic tile on ceilings, and weather-stripping on classroom doors.

More careful school design and construction can also reduce noise. Architects could avoid placing classrooms near gyms, playgrounds, music rooms, and heating and air conditioning equipment. Builders should be required to damp and seal openings around pipes and ventilating ducts and to apply caulking around other potential sources of acoustic leakage.

Noise generated outside the school can also be substantially reduced by using double-paned windows and keeping those windows closed whenever possible. Again, better school design can help. Classrooms can be placed away from busy streets or, if this is not possible, the size and number of windows on such walls can be minimized so most outside noise bounces off solid wall rather than penetrating the classroom.

It is clear then that we need to pay more attention to acoustic design in schools to reduce harmful extraneous noise. It is the responsibility of the

audiology profession to make school planners and architects more aware of the relation between good acoustic design and efficient teaching and learning.

The FM Advantage

Reducing noise in the classroom is only the beginning. One of the best ways to maximize listening ability for all children is sound enhancement technology. Sound field FM (frequency modulation) systems in regular classrooms have been found to increase the academic achievement of all students, not only in reading and language arts, but in listening and language, vocabulary, math concepts, and computation. It has been demonstrated that the FM system is most beneficial for young children, under age twelve.

The FM system is a self-contained unit in the classroom, which uses a wireless microphone and 3 to 5 loudspeakers mounted on walls or the ceiling. It allows the teacher's voice to be transmitted and amplified throughout the room at a uniform speech level. The teacher's speech remains well above the level of other classroom noise and is received by the child at about the same level as the child's own speech. The system further provides an increased signal to noise ratio of 10 dB, which helps defeat background noise. The increase in the signal level and signal to noise ratio constitute the FM advantage.

With the FM system, we observe improvement in sentence recognition by all children at a distance from the teacher. This translates into meaningful improvement in academic achievement, understanding of speech, reduced repetition of classroom instructions, and more consistent attending skills. The FM system benefits the teacher as well by reducing vocal strain and fatigue. The teacher is also able to cover more material or spend more time in review and explanation once wasteful repetition and inappropriate behavior is reduced.

Many preschoolers and school age students in normal classes have hearing loss of varying degrees, selected auditory deficits, or developmental disorders that place them at higher risk in noisy environments. With these children, good classroom acoustics are even more essential. The FM system especially benefits the large group of children who are prone to otitis media. Otitis media (OM), or middle ear infection, has become a major health problem in preschool and lower elementary school children and almost always is accompanied by a fluctuating mild to moderate hearing loss. This loss may last several days or months and is often recurrent during the child's initial acquisition of speech and language skills. It is estimated that at least 75% of children have one or more episodes of OM in their preschool years and as many as one-third of all young children have at least three episodes a year. At any one time, 20-25% of these students will fail a school hearing screen and reveal a mild conductive hearing loss. This hearing loss is similar to the effect you experience when you gently plug your ears with your fingers. Since this disease is often unnoticed by the child, the parent or teacher may not identify the problem. Such children are at risk for developing learning, speech and language, and behavioral problems. The severity of secondary consequences is directly related to the severity and frequency of hearing loss and the acoustic environment where learning takes place.

What often becomes apparent in preschoolers with chronic OM is their poor listening skills. Such children appear to distrust the inconsistent information provided by their ears and to stop paying attention to sounds. This can predispose the child to a lack of cognitive development and can directly affect phonetic and reading skills. These children may attempt to control their environment by inappropriate behavior because they feel unable to control it with language.

Another group of children who can benefit from the FM system and an improved acoustic environment in the classroom are those with varying degrees of hearing loss in one or both ears. These children often cannot hear clearly enough to distinguish subtle differences between words, even though they can hear speech. Such children may arrive at school with hearing aids, and the teacher may erroneously assume that the device has corrected any hearing impairment. Unfortunately, hearing aids cannot replace the normal ear in sorting out a speaker's voice from background noise, and children will still have trouble understanding speech in a noisy classroom. Hearing aids typically amplify all sounds. The FM system, by achieving a better signal to noise ratio for the teacher's speech, helps the child with a hearing aid to single out that speech. The FM system, along with other acoustic modifications in the classroom, would give the hearing impaired child the advantage of a good listening environment.

Children suffering from low attention and high distractibility are also at greater risk in a noisy

classroom environment. Like those who are hearing impaired, children with attention deficit disorder (ADD) also fail to hear the teacher, but in a different manner. This child's ability to remain focused on the teacher's voice or a particular task is diminished by his or her highly sensitive reaction to extraneous noise, however slight. Therefore, increasing the volume of the teacher's voice and reducing background noise through the use of the FM system and acoustic improvements in the classroom will help this child to focus on the teacher or the task at hand.

The list of children who will benefit from acoustically sound classrooms is long. It includes normal hearing children who evidence listening difficulties from auditory processing deficits. It also includes children who are learning in a second language in which they are not fluent. It is apparent that children with varying degrees of learning disabilities, developmental delays, articulation disorders and, indeed, all young children, will benefit.

Acoustic enhancement in the classroom and school is surely one of the most effective and efficient methods available to us to improve our children's learning, and to reduce and eliminate the risk to many children of academic and developmental failure. The acoustically treated classroom with the FM advantage should be widely adopted, since it is one of the most cost effective means of improving academic achievement in young children.

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