

Classroom Amplification to Enhance Student Performance

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Children learn a great deal through the auditory system. Classroom instruction is presented primarily through the teacher's speech, or through video or tape recordings. Many students are auditory learners: They learn best when information is presented to them verbally. Students with hearing loss or other learning disabilities, however, may have difficulty with comprehension of auditory information (Beattie & Zipp, 1990; Woglemuth, Kamhi, & Lee, 1998; see box, "What Does the Literature Say?").

What Are the Auditory Challenges of Inclusive Classrooms?

Legislation requiring the least restrictive environment has resulted in a greater number of students being educated in the general classroom. This inclusion concept is intended to reduce the negative effects of special education and resource room teaching (Kaufman & Pullen, 1996). Having to attend special

classes or receive individual tutoring may cause the students to develop low self-esteem because, unlike their classmates, they need additional help to learn. Also, teachers may become frustrated when their teaching efforts are ineffective in producing the desired result (Greyerbiehl, 1993). The assumption is made that these students are not motivated or that they are lazy and unwilling to learn. According to Richard Levoie of the FAT City Workshop (1989), however, there are several legitimate reasons for the student's lack of understanding:

- Students with learning disabilities have difficulty processing information. When asked a question in class, students with learning disabilities have to first process the question before they can process an answer. This is different for students without learning disabilities because they only have to process the answer, and can respond to the question more quickly. During class it appears as if students with learning disabilities do not know the answer or are not trying, when really they may just need more time to process all the information.
- Students with learning disabilities often can complete only one cognitive

task at a time. Because of this, they find it difficult to take notes in class. It is hard for these students to listen to the teacher's lecture and pick out the important parts to write down. Often their class notes end up being incomplete and hard to study from when it comes to reviewing for exams.

- Reading aloud in class is also something that students with learning disabilities can find difficult. Some stu-

What Does the Literature Say About Using Amplification in the Classroom?

Research has shown benefits from the use of amplification devices in classrooms of students who demonstrate learning disabilities, as well as in regular classroom settings (Arnold & Canning, 1999; Blake, Field, Foster, Platt & Wertz, 1991; Flexer, Richards, Buie, & Brandy, 1994; Rosenberg, Allen, Redmond, Phillips, & Stigers, 1995). Results of these studies show that the listening and attending behaviors of these students improved after implementation of the amplification system.

Many students are auditory learners: They learn best when information is presented to them verbally.

dents have spatial orientation problems that cause them to confuse certain letters such as *p* and *q*, and *b* and *d*.

If teachers are unfamiliar with the problems associated with a specific learning disability, they may misjudge the student as being unmotivated or unwilling to learn. Unfortunately, this sometimes becomes a self-fulfilling prophecy, and students unable to learn may become unwilling to learn. As we learn more about the difficulties these students have and how to best educate them, the student with a learning disability can have a greater possibility of a successful educational experience.

What About Changing the Classroom Environment to Reduce Noise?

One way to improve the learning behavior of these students is to improve their educational environment. Classrooms tend to be noisy. This can be distracting to all students, but noise can have a much more detrimental effect on the student with a learning disability. According to Blake, et al., (1991), students with learning disabilities have difficulty maintaining their attention to stimuli. These inattentive behaviors have been linked to the amount of noise present in the classroom. The student with a learning disability can have greater difficulty tuning out background noise than the student without a learning disability.

ASHA Guidelines

The American Speech-Language-Hearing Association (ASHA) Subcommittee on Acoustics in Educational Settings developed guidelines for acceptable acoustical classroom environments (American Speech-Language-Hearing Association [ASHA], 1995). They reported that poor acoustical environments can affect the student's attention and listening behaviors, speech perception, and ultimately academic performance. If a student also has a hearing loss, learning disorder, central processing disorder, or developmental delay, the effects of the acoustical environment are even greater. Classroom noise levels vary throughout the day,



A teacher using the wireless microphone and transmitter system in the classroom.

depending on such factors as hall traffic, street noise through open windows, fans blowing, lights humming, overhead projectors in use, and general noise caused by a group of children. ASHA recommends that the average unoccupied classroom should not exceed a 30-dB noise level. Average unoccupied classroom noise levels, however, range from 45 to 60 dB. When classrooms are occupied by students and teachers, these noise levels are even greater.

Improving the Signal-to-Noise Ratio

Davis (1991) stated that children who have difficulty factoring out distractions, both auditory and visual, frequently are helped by an improved signal-to-noise (S/N) ratio of the teacher's voice. By increasing the volume of the teacher's voice over the background disturbances, the child attends better and learning improves. People with normal hearing require a +6 dB signal-to-noise (S/N) ratio, meaning that the speech signal must be 6 dB louder than the background noise for it to be understood. But for students with a hearing loss or other disabilities, a higher S/N ratio may be required. ASHA recommends that the teacher's voice be 15 dB

above the background noise in a classroom. Reports show the S/N ratio to actually range from +5 dB to -7 dB (Palmer, 1998).

Unfortunately, the average S/N ratio in the classroom can vary from -20 to +5 dB, depending on noise and reverberation, and changes in teacher/student location (Richards, Flexer, Brandy, & Wray, 1993). These S/N ratios create a poor listening environment, not only for the students with learning disabilities, but for other listeners, as well.

Effects of Noise Levels on Learning

Johnson (2001) reports that noise or echo can affect a student's concentration, causing misinterpretation of the lesson. If this happens often, learning suffers, especially among students with learning disabilities and hearing impairment. Downs and Crum (1978) examined the effects of classroom noise lev-

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els on auditory learning. These authors used measures of learning accuracy (performance) and learning ease (attention or psychological effort) to assess processing demands during auditory learning under degraded listening conditions. They found that auditory processing requires much more effort when the subject is listening in a noisy environment rather than a quiet one. Listening in a degraded acoustical environment, such as a classroom, requires effort on the part of the student, and if not employed consistently, academic performance may suffer. They found that simply increasing the overall level of sound, while maintaining the same S/N ratio, does not result in an increase in performance. A possible explanation is that processing demands during auditory learning depend on the relationship of signal to noise, rather than absolute noise level. Thus, it can be proposed that no listener (hearing or hearing-impaired) is immune from deleterious effects of noise on auditory learning.

Concrete Ways to Improve S/N Ratio

There are several ways to improve the S/N ratio in the classroom. Physical modifications can be made to the walls, windows, floors, and ceilings. Carpeting floors and installing acoustical ceiling tile helps to absorb middle- and high-frequency sounds, reducing the reverberation present in the classroom. Because the ceiling and floor comprise approximately 60% of the classroom surface area, these two modifications alone can significantly improve the acoustical environment of the classroom. The most effective treatment for

windows is drapery, although blinds are an acceptable alternative.

Functional classroom furniture, such as cork bulletin boards and bookshelves placed at strategic positions will reduce reverberation within a classroom. Mobile bulletin boards and chalkboards placed at nonparallel angles to the walls will aid in the reduction of reflected sound. Children's artwork made of absorbent materials, such as egg cartons and carpet pieces, can also be displayed on walls or suspended from the ceiling to absorb noise, reducing reverberation (Crandell, Smaldino, & Flexer, 1995). However, these materials do not absorb classroom noise as well as other more highly absorbent materials.

Barriers to Improving S/N Ratio

Making physical changes to the classroom environment improves the S/N ratio by reducing the background noise, while the teacher's voice remains the same. But in most classrooms, teachers move around the classroom or occasionally face the chalkboard, thus impeding hearing by many students.

How Can Amplification Systems Help?

A way to improve the S/N ratio without directly addressing these issues is to use an amplification system that increases the sound of the teacher's voice and brings the signal closer to the student's ear. Educators can use several amplification systems to improve the S/N ratio in the classroom, such as personal FM systems, sound-field amplification, induction loop amplification, and infrared systems. These devices improve the S/N ratio by amplifying the teacher's voice and sending it directly to the listener's ear.

Personal FM Systems

The *personal* FM system works by receiving an audio signal which is frequency modulated onto a carrier wave that is sent from the transmitter to the receiver where it is demodulated and delivered directly to the listener's ear. The speaker wears a wireless transmitter which receives input from a microphone. The transmitter can also be connected to a television, tape recorder, or

radio. The listener wears a receiver, which can be attached to earphones, coupled inductively by a neckloop or silhouette or coupled electrically via direct audio input to a hearing instrument. FM systems can operate on as many as 40 or more different channels, allowing different frequencies to be used in one school. Therefore, adjacent classrooms can use FM systems without worrying about interference.

Sound-field Systems

The *sound-field* FM system is different in that the signal is sent out to loudspeakers placed in the classroom. The teacher still wears a microphone and wireless transmitter. The FM signal is sent from the transmitter to an amplifier which is connected to one or more loudspeakers. The transmitter can also be connected to a tape recorder or VCR, which improves the often degraded sound of these recordings. All students can benefit from use of sound-field amplification. Students with central auditory processing disorders, minimal hearing loss due to otitis media, and unilateral hearing loss—and even hearing students—can benefit from receiving a louder level of the teacher's voice.

Benefits to Students

In addition to student benefits, there are also significant benefits for the teacher. According to Gotass and Starr (1993), teachers experience a higher number of voice problems than the general population. Sapienza, Crandell, and Curtis (1999) found that FM systems in the classroom can reduce a teacher's overall speech volume, thus limiting the potential for voice problems.

Personal FM systems are typically prescribed for students with hearing loss and can be quite costly. Implementation of one *sound-field* system into the classroom costs considerably less than supplying personal FM devices for all students. Also, there is less stigma associated with sound-field systems because the students do not have to wear something different from their classmates. More students would be willing to listen to the teacher's amplified voice through loudspeakers than through a headset.

Educators can use several types of amplification systems to improve the S/N ratio in the classroom, such as personal FM systems, sound-field amplification, induction loop amplification, and infrared systems.

What Do Teachers Observe About Amplification?

The present study was an attempt to determine the effect of teacher bias on the results of classroom amplification use. Most studies that have examined the effects of group classroom amplification have used the observation of the classroom teacher alone.

We hypothesized that teachers who agree to undergo use of classroom amplification may already be convinced of its effectiveness. This may affect the manner in which they complete subjective evaluations documenting behavioral changes following a period of classroom amplification.

The present study was performed in a classroom setting that used a two-member team-teaching approach. Both classroom personnel had been providing services to the group of 9 students for more than 2 years and were familiar with all students in the class. Independent observations by each of the instructors were used to determine if performance changes occurred, and if so, the extent to which each observer documented the change.

Classroom Installation

A Phonic Ear wireless FM classroom amplification system was installed in a classroom for 9th- to 12th-grade students with learning disabilities for a period of 3 months. The Phonic Ear System consisted of a wireless transmitter and microphone worn by the teacher. The speech signal was sent by FM signal from the transmitter to an amplifier plugged into a wall outlet. Loudspeakers were wired to the amplifier and mounted to the walls in each of the four corners of the student seating area. Ambient noise levels in the unoccupied classroom were measured to be 49 dB(A).

The teacher's nonamplified speaking voice, measured 6 inches from her mouth, was 66 decibels. Under amplification conditions, the teacher's speaking voice, measured 6 inches from each of the loudspeakers, was 72 dB(A). Listening and learning behaviors were independently evaluated by the classroom teachers using the *Listening and Learning Observation* (LLO) form developed for

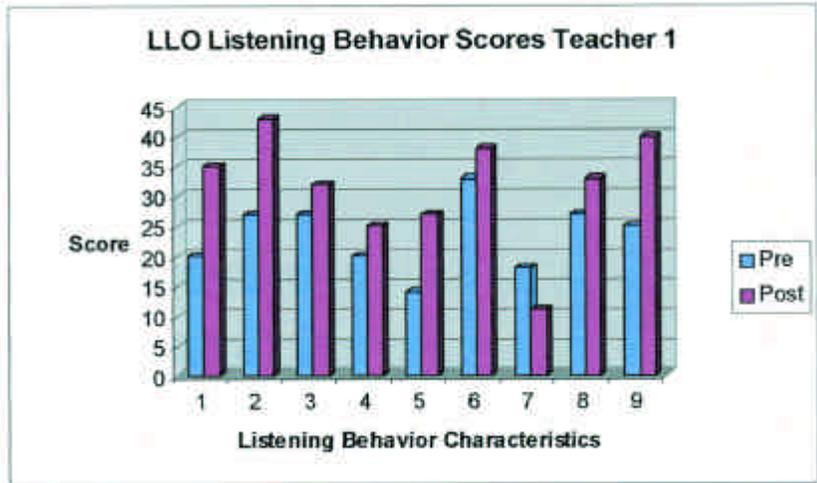
this project (Appendix A) and the *Evaluation of Classroom Listening Behaviors* (ECLB) form adapted from VanDyke (1985) (Appendix B). Teachers completed these forms before the installation of the amplification equipment, again at 6 weeks of amplification use, and at the termination of the project (12 weeks).

Results of Observations

Figures 1 and 2 shows the pre- and post-amplification scores for the Listening Behavior section of the LLO evaluation for Teacher 1 and Teacher 2.

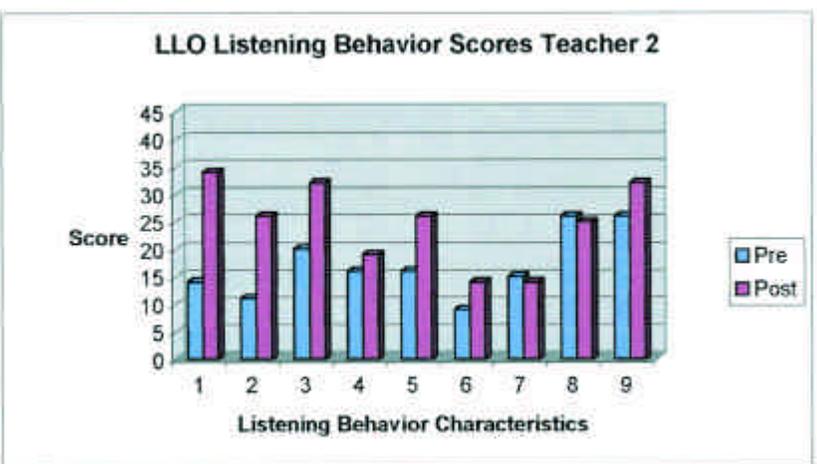
The scores on the nine listening behavior characteristics rated on the LLO for all subjects were summed and

Figure 1. Listening Behavior of Students, Observed by Teacher 1, Before and After Amplification



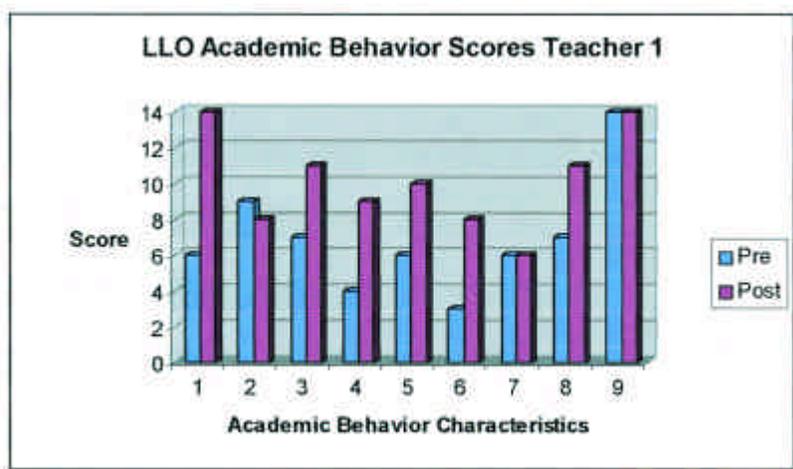
Note: LLO = Listening and Learning Observation (see Appendix A).

Figure 2. Listening Behavior of Students, Observed by Teacher 2, Before and After Amplification



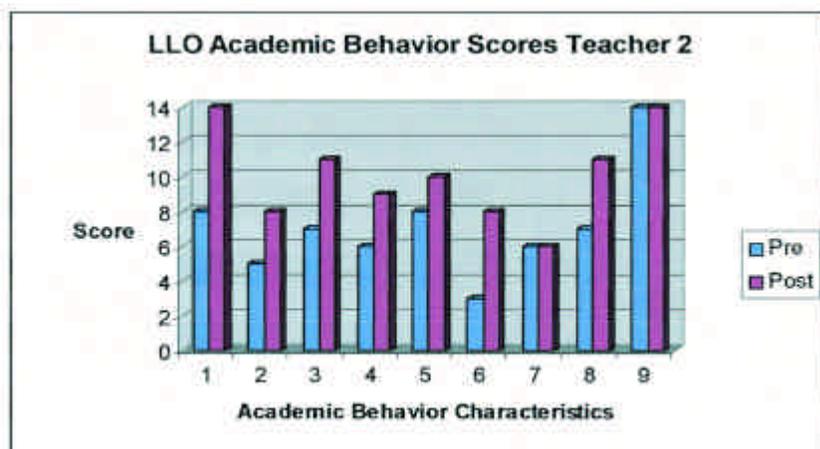
Note: LLO = Listening and Learning Observation (see Appendix A).

Figure 3. Academic Behavior of Students, Observed by Teacher 1, Before and After Amplification



Note: LLO = Listening and Learning Observation (see Appendix A).

Figure 4. Academic Behavior of Students, Observed by Teacher 2, Before and After Amplification



Note: LLO = Listening and Learning Observation (see Appendix A).

averaged across subjects at the beginning of the experiment, and again 3 months later. Higher scores on the LLO indicate better performance, or decreased difficulty on the behavior measured.

Each teacher independently observed student improvement in areas such as ability to follow oral instruction, less need to repeat instruction, as well as decreased reliance on assistance from

the teacher or peers when instructions were given.

Figures 3 and 4 show the pre- and post-amplification scores for the Academic Behavior section of the LLO for Teacher 1 and Teacher 2.

Results of this study show a significant improvement in students' listening and academic behaviors after 12 weeks of classroom amplification. This study has shown that the use of two independent evaluators can be a beneficial

Students with central auditory processing disorders, minimal hearing loss due to otitis media, unilateral hearing loss—and even hearing students—can benefit from receiving a louder level of the teacher's voice.

method of evaluating subjects' listening and attending skills. The use of a second evaluator lends credibility to the results, demonstrating that even if evaluators do not agree in terms of initial level prior to amplification, they both do agree that there is improvement in students' skills after use of the group FM system (for more information on research methodology and significance levels, contact the authors).

The implementation of the sound-field system into the classroom required an adjustment period for both the students and the teachers. By the end of the study, the teachers and the students wanted to continue using the FM system. We believe that this type of FM system requires less adjustment, especially by the students, because it is a wireless speaker system. Students may be less willing to wear a personal FM system; and a longer adjustment period, as well as greater cost, would result from such a system, as compared to the sound-field system.

Benefits and Classroom Implications

Reports made by the teachers in this study reveal that the main benefit of amplification in the classroom was an increase in the teachers' ability to get and maintain students' attention. The observations also reported a decrease in teacher vocal strain and fatigue. Both teachers reported that they would continue using the amplification in their classrooms and would recommend use of amplification systems in other classrooms.

The classroom teachers reported that the students grew more interested in the FM system as the observation period

Physical modifications can improve the acoustical environment of the classroom, though these may be too costly.

continued. By the end of the study, the teachers stated that students were coming to class eager to use the system, and would have the system on and ready to use before class began. Also, the teachers stated that the system was useful for the one student who was deaf in the class, especially when watching videos.

Final Thoughts

Many educators have shown that classroom amplification can be useful in a variety of settings, including the general classroom, classrooms for students with hearing impairments, and classrooms for students with learning disabilities. Use of group classroom amplification can be a simple and inexpensive way to improve many students' educational experiences.

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Helpful Web Sites

<http://www.classroomacoustics.com>

Classroom Acoustics: Resource for proposed standards for classroom acoustics.

<http://pages.ctime.net/cbristol>

CAPD Parent's Page: Provides resources for parents of children with auditory processing disorders.

<http://www.phonicear.com/>

Phonic Ear: Products for FM amplification.

<http://www.lifelineamp.com>

Lifeline Amplification Systems: Describes Lifeline's products, prices, and information about the company.

<http://www.lightspeed-tek.com/>

Lightspeed Technologies: Contains information on company, products, and contact information.

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Some equipment manufacturers offer a free 30-day evaluation of their classroom soundfield equipment to schools. Most systems cost under \$1,000; further information may be obtained from the Web sites.

Appendix A. Listening and Learning Observation

LISTENING BEHAVIORS

DIRECTIONS: Rate the student's listening behaviors on the five-point scale.
(1 = frequently, 3 = sometimes, 5 = seldom)

| | | | | | |
|---|---|---|---|---|---|
| Difficulty paying attention to oral instruction | 1 | 2 | 3 | 4 | 5 |
| Difficulty following oral directions | 1 | 2 | 3 | 4 | 5 |
| Needs directions or information repeated | 1 | 2 | 3 | 4 | 5 |
| Demonstrates off-task behaviors | 1 | 2 | 3 | 4 | 5 |
| Exhibits slow or delayed responses | 1 | 2 | 3 | 4 | 5 |
| Learns poorly through auditory channel | 1 | 2 | 3 | 4 | 5 |
| Seeks assistance from teacher or peers | 1 | 2 | 3 | 4 | 5 |
| Has a short attention span | 1 | 2 | 3 | 4 | 5 |
| Is easily distracted by background noise | 1 | 2 | 3 | 4 | 5 |

ACADEMIC BEHAVIORS

DIRECTIONS: Rate the student's listening behaviors on the five-point scale.
(1 = frequently, 3 = sometimes, 5 = seldom)

| | | | | | |
|---|---|---|---|---|---|
| Difficulty completing tasks | 1 | 2 | 3 | 4 | 5 |
| Difficulty participating appropriately in class (e.g., does not raise hand or take turns, shouts out, etc.) | 1 | 2 | 3 | 4 | 5 |
| Slow starter | 1 | 2 | 3 | 4 | 5 |

ACADEMIC SKILLS

DIRECTIONS: Rate the student's listening behaviors on the five-point scale.
(1 = frequently, 3 = sometimes, 5 = seldom)

| | | | | | |
|----------------------------------|---|---|---|---|---|
| Math or number concepts | 1 | 2 | 3 | 4 | 5 |
| Language Arts (reading) | 1 | 2 | 3 | 4 | 5 |
| Vocabulary and word usage skills | 1 | 2 | 3 | 4 | 5 |

Score: LB ____/45 AB ____/15 AS ____/15 LLO Total Score: ____/75

Appendix B. Evaluation of Classroom Listening Behavior

STUDENT DATA

Student Initials: _____ Sex: _____ Date of Birth: _____ School _____
Grade _____ Teacher _____ Date Completed _____

DIRECTIONS: Rate the student's listening behaviors on the five-point scale.
(1 = frequently, 3 = sometimes, 5 = seldom)

| | | | | | |
|--|---|---|---|---|---|
| Responds when name is called at a close distance | 1 | 2 | 3 | 4 | 5 |
| Responds when name is called at a far distance of six to twenty feet | 1 | 2 | 3 | 4 | 5 |
| Attends to a single oral direction | 1 | 2 | 3 | 4 | 5 |
| Attends to a series of oral directions | 1 | 2 | 3 | 4 | 5 |
| Attends to oral instruction | 1 | 2 | 3 | 4 | 5 |
| Comprehends oral instructions in a one-to-one situation | 1 | 2 | 3 | 4 | 5 |
| Comprehends oral instructions in a group situation | 1 | 2 | 3 | 4 | 5 |
| Comprehends oral instructions in a quiet environment | 1 | 2 | 3 | 4 | 5 |
| Comprehends oral instructions in a noisy environment | 1 | 2 | 3 | 4 | 5 |
| Comprehends oral instructions without visual cues | 1 | 2 | 3 | 4 | 5 |

ECLB Score _____/50

Comments:

Adapted from VanDyke, 1985.