Integrating Sound Distribution Systems and Personal FM Technology

Carol Flexer

Introduction

There are several different devices that use remote microphones: hardwire, personal-worn FM and sound distribution systems. The overall purpose of remote microphone usage is to improve the signal-to-noise ratio by overcoming the problems of distance and noise. Candidacy and application issues vary with each device; one device cannot necessarily substitute for another.

It is known that all children require a louder signal and a quieter environment than adults in order to distinguish words. This is the case because the brains of children are not mature, and children cannot perform the sophisticated automatic auditory cognitive closure that adults can. Therefore, to create an environment in which learning can occur, classrooms need acoustic management and a favorable signal-to-noise ratio.

Because all children are candidates for acoustically accessible environments, sound distribution systems ought to be recommended for every classroom based on a Universal Design rather than on a treatment paradigm. Just as clear light is necessary for learning, so is clear sound. Since many children with hearing loss and personal-worn FM systems are mainstreamed, they likely will be in classrooms that have sound distribution systems in place.

Questions naturally arise about this blending of personal-worn FM systems with sound distribution systems. Is one better than the other? Can personal-worn FM and sound distributions systems be used at the same time? Does the teacher need to wear two microphones? This paper will address those questions, beginning with the rationale for the use of sound field systems in the first place. The integration of personal-worn FM systems and sound distribution systems will be discussed, because the child who wears hearing aids (or a cochlear implant) will profit from using both technologies in a classroom environment. *Integrating sound distribution technology with personal FM systems is really a merging of Universal Design with special education mandates*. Thus, the concept of Universal Design will be distinguished from a treatment paradigm regarding the recommendation and use of technology.

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Rationale for the Use of Sound Field Technology in General Education Classrooms

The World has Changed

There is a "big picture" perspective to be considered when discussing classroom learning. Because the United States now has an information/knowledge-based economy, a sizeable proportion of our workforce needs to have high levels of spoken language and literacy skills in order to keep our country viable and progressing (Alter, 1999).

The world has changed rapidly during the past ten years, and the pace of change is escalating (Johnson, 1998). Technology is the driving force for change, and workforce skills need to keep pace with the change. The children that are in today's classrooms will be the leaders, contributors, and voters of the years 2030, 2040, and 2050. We are creating the future by instilling in our children a solid foundation of transferable skills and a life-long love for learning.

In this era of rapid change, proficient literacy skills will be necessary for our children to be able to manage the constant updating of their knowledge base (Trelease, 2001).

Literacy

Reading has a strong auditory foundation (Chermak & Musiek, 1997). Specifically, phonological awareness, the knowledge that language is composed of a system of words and syllables, is one of the primary building blocks for developing literacy skills. Phonemic awareness is the knowledge that words themselves are composed of individual sounds called phonemes. Clearly, phonemic awareness is an auditory skill dealing with the sounds of spoken language. Therefore, the better that speech sounds can be heard, the stronger will be the foundation for literacy (Robertson, 2000).

Because of the need for our children to keep pace with the changing world, literacy is a national priority (Trelease, 2001). We face substantial challenges. In the year 2000, data showed that the percentage of fourth-grade students reading at or above *Proficient*, the level identified by the National Assessment Governing Board (NAGB) as the goal for all students, has increased only slightly to 32% from 29% in 1992 (NAEP, 2001). These data mean that only about a third of fourth graders in the United States can read at their grade level. Moreover, while scores for the nation's highest performing students have improved over the years, scores of the lowest performing students have declined.

Of critical importance is the fact that there has been no closing of the education gap between students who are white and students who are minorities. Specifically, in the year 2000, 40% of fourth grade students who are white and 46% of students who are Asian/Pacific Islander could read at or above the Proficient achievement level (NAEP, 2001). However, only 12% of students who are African American, 16% of students who are Hispanic, and 17% of students who are Native American could read at or above the *Proficient* achievement level (NAEP, 2001). According to these data, large numbers of children who are minorities do not possess the literacy skills that would enable them to have flexibility and dynamism in the workforce.

Clearly, we are not educating whole segments of our school population, and we haven't been for the last 10 years. Consequently, the gap between rich and poor is now greater than at anytime since the Great Depression (Alter, 1999). The richest 2.7 million Americans now have as much money as the poorest 100 million, and these trends are being fueled by technology and the notion that what you earn depends on what you learn.

So, what's missing in our classrooms? What have we failed to consider? The neglected concepts as discussed in this paper include the immature listening abilities of children, and the poor listening environments in classrooms.

Literacy and Classroom Sound Field Systems

There is evidence that classroom sound systems improve literacy development. Numerous studies have been reported. An article by Darai (2000) found that sound field systems, when appropriately used, provided significant improvement in literacy achievement of first-grade students. Flexer (2000) reported a study of three first-grade classrooms in Utah where 85% of the children were Native American. In the five years prior to sound field use, only 44 to 48% of first grade children scored at the "basic" level and above on the Utah State Core Reading Test. After only seven months of sound field use, 74% of the 54 children in the study scored at the "basic" level and above. Another study found that phonemic awareness skills were most effectively and efficiently taught in pre-school and kindergarten classrooms that had sound field distribution systems. In fact, the fewest at-risk readers came out of the classrooms that routinely used their sound field distribution systems (Flexer et. al, 2002). These studies support the strong auditory basis of literacy. Clearly, the ability to discriminate word/sound distinctions impacts literacy development.

The Listening Abilities of Children

We *hear* with the brain. The ears are just a way in. The problem with hearing loss and with poor auditory environments is that intact sound is barred from reaching the brain. The purpose of having favorable listening environments and amplification technologies is to channel complete words efficiently and effectively to the brain.

Recent studies in brain development show that stimulation of the auditory centers of the brain is critical (Berlin & Weyand, 2003; Boothroyd, 1997; Chermak & Musiek, 1997). Sensory stimulation influences the actual growth and organization of auditory brain pathways (Bhatnagar, 2002). Therefore, anything that can be done to access, grow, and program those important and powerful auditory centers of the brain with acoustic detail expands children's opportunities for enhancement of life function. A child's hearing loss, no matter how "minimal" can be a roadblock to sufficient sounds reaching the brain unless amplification technologies are used. *Amplification is really about brain stimulation with subsequent brain growth.*

It is important to recognize that children are not small adults. They are not able to listen like adults listen. Indeed, children bring different listening skills to a communicative and learning situation than do adults in two main ways. First, human auditory brain structure is not fully mature until about age 15 years; thus a child does not bring a complete neurological system to a listening situation (Bhatnagar, 2002; Boothroyd, 1997; Chermak & Musiek, 1997). Second, children do not have the years of language and life experience that enable adults to fill in the gaps of missed or inferred information; such filling in of gaps is called auditory/cognitive closure. Therefore, because children require more complete and detailed auditory information than adults, all children need a quieter room and a louder signal (Anderson, 2001). The goal is to *develop* the brains of children, unlike adults where sound enters an already *developed* brain.

Large populations of children who often are not identified are those with hearing problems caused by middle ear dysfunction. Indeed, the incidence of children with persistent minimal to mild hearing impairments caused by otitis media may be much higher than school screenings lead us to believe. Hearing screening environments in schools typically have less than ideal levels of ambient noise, causing hearing to be screened at 20 to 35 dB hearing level (HL). When 15 dB HL is used as the criterion for identifying an educationally significant hearing impairment, the numbers of identified kindergarten and first grade children increase dramatically. A study conducted in Putnam County Ohio found that 43 % of their primary level students failed a 15 dB HL hearing screen on any given day, and about 75 % of their primary level children in classes for children with learning disabilities failed a 15 dB hearing screening (Flexer, 1989). Another study projected that 14.9% of U.S. school children have hearing loss that can impact their educational progress – that's about 8 million school children! (Niskar, et. al, 1998).

Typical mainstream classrooms are auditory-verbal environments; instruction is presented through the teacher's spoken communication (Berg, 1993). The underlying assumption is that children can hear clearly and attend to the teacher's speech. Thus, children in a mainstream classroom, whether or not they have hearing problems, must be able to hear the teacher in order for learning to occur. If children cannot consistently and clearly hear the teacher, the major premise of the educational system is undermined.

Levels of Auditory Skill Development

There is a great deal involved in *hearing* the teacher. Erber (1982) was one of the first to identify the levels of auditory skill development associated with hearing and listening, and Ling (2002) has expanded on them.

- Detection: This is the lowest, least sophisticated level of auditory skill development. Detection refers to the presence and absence of sound. Obtaining pure tone thresholds is a detection task.
- Discrimination: This involves distinguishing between two speech sounds. An example of a discrimination task would be noting if "da-tha" are the same or different.
- Recognition: Selecting a target from a known list of alternatives, *recognition* is a closed-set task.
- Identification: This is an open-set task that involves noting a target from an infinite set of alternatives.
- Comprehension: This is the highest level of auditory skill development. Comprehension is achieved when one can answer questions, follow directions and hold conversations.

It is critical to note that without basic *detection*, none of the higher levels of auditory processing are available. Therefore, *comprehension*, the goal of classroom instruction, is completely dependent on the initial detection of individual phonemes that comprise the spoken message. Challenging acoustic environments, hearing problems, and the immature listening skills of children, all compromise *detection*. Without detection, there can be no comprehension. Sound distribution systems facilitate detection.

Invisible Acoustic Filter Effect of Hearing Problems

The primacy of hearing in the communicative and educational process tends to be underestimated because hearing loss itself is invisible. The effects of hearing loss often are associated with problems or causes other than hearing impairment (Flexer, 1999; Ross, Brackett, & Maxon, 1991). For example, when a child is off-task or cannot keep up with the rapid pace of class discussion, the cause of that child's behavior may be attributed to noncompliant behavior or to attention problems or to slow learning rather than to hearing problems.

One cannot "see" a hearing problem; therefore, it is easy to confuse the causal hearing loss with the negative consequences of the hearing impairment. To explain, hearing problems act like an invisible acoustic filter than interferes with incoming sound (Ling, 2002). In addition to a reduction in loudness, sounds are often smeared together, or filtered out entirely. Speech, therefore, might be audible but not intelligible. A child with a hearing problem might be able to hear the presence of speech (audibility), but not be able to hear clearly enough to identify one speech sound as distinct from another. Words like i*nvitation* and *vacation* might sound the same. It is not difficult to imagine what such word confusions could do to a child's vocabulary and conceptual language development.

This acoustic filter effect is the beginning and the cause of an entire chain of negative events. If speech sounds are not heard clearly, then one cannot speak clearly (one speaks what one hears), unless deliberate intervention occurs. The second step in the chain involves reading ability. If one does not have good spoken language skills, then reading, which is a secondary linguistic function also will suffer (Robertson, 2000). *Said another way, we speak because we hear, and we read because we speak*. If reading skills are below average, an individual will have difficulty performing academically. Limited literacy leads to a reduction in professional options and subsequent opportunities for independent function as an adult. The cause of this entire unfortunate chain of events is the ambiguous, invisible, underestimated, and often untreated acoustic filter effect of hearing problems. Until the primary issue of poor classroom listening environments and the unsophisticated listening skills of children are understood and managed thus providing the brain with access to detailed sound, intervention at the secondary levels of spoken language, reading, and academics likely will be ineffective.

Managing the classroom listening environment, beginning with *detection*, is the crucial first step in the learning chain; providing an accurate and reliable keyboard is the prerequisite step to clear data entry. Once auditory brain centers have been accessed, a child has an opportunity to learn spoken language as the basis for developing literacy and academic skills, and acquiring knowledge about the world.

The Listening Environment of the Classroom

Speech-to-Noise Ratio

Unfortunately, children are expected to hear meaningful word/sound distinctions in unfavorable acoustic environments. They must listen to a speaker who is not close and who is moving about the room.

S/N ratio is the relationship between a primary signal such as the teacher's speech, and background noise. Noise is everything that conflicts with the auditory signal of choice and may include other talkers, heating or cooling systems, classroom or hall noise, playground sounds, computer noise, wind, among others. The quieter the room and the more favorable the S/N ratio, the clearer the auditory signal will be for the brain. The further the listener is from the desired sound source and the noisier the environment, the poorer the S/N ratio and the more garbled the signal will be for the brain. As stated previously, all children – especially those with hearing loss – need a quieter environment and a louder signal than adults do in order to learn (Anderson, 2001).

Adults with normal hearing and intact listening skills require a consistent S/N ratio of approximately +6 dB for the reception of intelligible speech (Bess & Humes, 2003). Children need a much more favorable S/N ratio because of their neurological immaturity and lack of life and language experience that reduces their ability to perform auditory/cognitive closure. In addition, because of internal auditory distortion, persons with any type and degree of hearing problem require a more favorable S/N ratio; about +20 dB. Due to noise, reverberation, and variations in teacher position, the S/N ratio in a typical classroom is unstable and averages out to only about +4 dB and may be

0 dB; often less than ideal even for adults with normal hearing (Crandell & Smaldino, 2002).

Sound Field Systems – FM or Infrared

Description

Sound field technology is an exciting educational tool that allows control of the acoustic environment in a classroom thereby facilitating acoustic accessibility of teacher instruction for all children in the room (Flexer, 1998). Sound field systems are like high fidelity, wireless, public address systems. By using this technology, an entire classroom can be amplified through the use of one, two, three, or four wall- or ceiling-mounted loudspeakers. The teacher wears a wireless microphone transmitter, just like the one worn for a personal FM unit, and her voice is sent via radio waves (FM), or light waves (infrared) to a receiver/amplifier that is connected to the loudspeakers. There are no wires connecting the teacher with the equipment. The radio or light wave link allows the teacher to move about freely, unrestricted by wires.

Proposed New Term: Sound Field Distribution System

The term *sound field distribution system* has been proposed as being more descriptive of sound field function. To explain, some teachers, parents, and acoustical engineers interpret the labels *sound field amplification*, or *classroom amplification* to mean that all sounds in the classroom are made louder. This misunderstanding may give the impression that sound is blasted into a room causing rising noise levels, interfering with instruction in adjacent rooms, and provoking anxiety in pupils. In actuality, when the equipment is installed and used appropriately, the reverse is true. The amplified teacher's voice can sound soothing as it is evenly distributed throughout the room easily reaching every child. The room quiets as students attend to spoken instruction. In fact, the listener is aware of the sound distribution and ease of listening only when the equipment is turned off. The overall purpose of the equipment is to improve *detection* by having the details of spoken instruction continually reach the brains of all pupils.

Children Who Might Benefit from Sound Field Distribution Systems

It could be argued that *virtually all children* could benefit from sound field distribution systems because the improved S/N ratio creates a more favorable learning environment. If children could hear better, clearer, and more consistently, they would have an opportunity to learn more efficiently (Rosenberg, et., al, 1999). Some school systems have as a goal the amplification of every classroom in their districts (Knittel, Myott, & McClain, 2002).

No one disputes the necessity of creating a favorable visual field in a classroom. A school building never would be constructed without lights in every classroom. However, because hearing is invisible and ambiguous, the necessity of creating a favorable auditory field may be questioned by school personnel.

The populations that seem to be especially in need of S/N ratio-enhancing technology include children with: fluctuating conductive hearing impairments; unilateral hearing impairments; "minimal" permanent hearing impairments; auditory processing problems; cochlear implants; cognitive disorders; learning disabilities; attention problems; articulation disorders; and behavior problems (Boothroyd, 2002).

Teachers who use sound field technology report that they also benefit. Many state that they need to use less energy projecting their voices, they have less vocal abuse, and are less tired by the end of the school day. Teachers also report that the unit increases their efficiency as teachers, requiring fewer repetitions, thus permitting more actual teaching time (Rosenberg, et., al, 1999).

With more schools incorporating principles of inclusion, where children who would have been in self-contained placements are in the mainstream classroom, sound field distribution systems offer a way of enhancing the classroom learning environment for the benefit of all children. It is a win-win situation.

Suggestions for Using Sound Distribution Systems and Personal FM Systems in the Same Classroom

Is one better than the other? Can personal-worn FM and sound distributions systems be used at the

Figure 1. The transmitter of a personal-worn FM system can be coupled, via an appropriate cord, to a specified jack, or audio-output port, of a sound distribution system. With this arrangement, the teacher need wear only the transmitter of the sound distribution system, and the child who wears the personal FM will have access to both the teacher's transmitter and the second pass-around microphone that accompanies the sound distribution system. Photo courtesy of Audio Enhancement.

same time? Does the teacher need to wear two microphones? At this point, it is critical to emphasize that sound field systems are not replacements for personal-worn FM systems. Most children who wear hearing aids or cochlear implants continue to need the superior signal-to-noise ratio provided by personal-worn FM systems that channel the signal directly from the talker, through the hearing aids or cochlear implant, to the brain of the listener.

However, both sound-field distribution systems and personal FM systems can be used effectively in the same room. In many instances, using both at the same time can create the best listening and learning environment because each serves a different purpose. The sound field distribution system, appropriately installed and used in a mainstream classroom improves and equalizes acoustic access for all pupils and creates a quieter listening environment in the room. Moreover, if the teacher has been appropriately inserviced, she employs the vocal strategies of using a softer and more interesting voice (Rosenberg, et., al, 1999). In addition, she will implement listening strategies that benefit everyone in the room. Another substantial advantage is that static or system malfunction is noticed by all. When there is only a personal FM in use in a classroom, only the child who is wearing the FM receiver hears static; thus system malfunction can last for days or weeks (Ross, Brackett, & Maxon, 1991).

The individual-worn FM system allows the particular child with hearing aids or a cochlear implant to have the most favorable signal-to-noise ratio. The teacher need wear only a single microphone/transmitter if the sound field unit and the individual FM are on the same radio frequency – or if the personal-worn FM transmitter can be coupled to the sound field amplifier as shown in figure 1.

A significant advantage to integrating a personal-worn FM with a classroom sound system as noted in figure 1 is pupil access to the second, pass-around microphone of the sound field system. Most sound distribution systems use two microphones; one for the teacher and the second to be passed-around to whomever is speaking as shown in figure 2.

A personal-worn FM system has access to only one microphone – the teacher's. If the personal FM transmitter is coupled to the sound distribution system as shown in figure 1, the child will hear pupils speaking through the pass-around microphone as well. The two microphones will provide the child who wears hearing aids or a cochlear implant plus a personal-worn FM system, with much greater access to classroom information.

Figure 2. The second, pass-around microphone of the sound field distribution system allows all pupils to have enhanced access to classroom information. Photo courtesy of Audio Enhancement.

Understanding Sound Field Technology from a Universal Design Rather than from a Treatment Perspective

Historically, amplification technologies such as hearing aids, personal FM systems, and now cochlear implants have been recommended as *treatments* for hearing loss. Because there certainly are populations for whom an enhanced signal-to-noise ratio can mean the difference between passing and failing in school, sound field technologies came to be recommended as treatments for hearing problems. If viewed as a treatment, sound field technology is recommended for a particular child on a case-by-case basis and managed through the special education system.

However, with the recognition that all children require an enhanced signal-to-noise ratio comes the necessity of moving beyond thinking of sound field technology as a *treatment*. Sound field distribution systems need to be integrated into the general education arena. The concept of *Universal Design* can be useful in this regard.

The concept of Universal Design originated in the architectural domain with the common examples of curb cuts, ramps, and automatic doors. After years of use, it was found that the modifications that were originally believed to be relevant for only a few people turned out to be useful and beneficial for a large percentage of the population.

In terms of learning, Universal Design means that the assistive technology is not specially designed for an individual student but rather for a wide range of students. Universally designed approaches are implemented by general education teachers rather than by special education teachers (Research Connections, 1999).

The concept of Universal Design has been defined as the design of products and environments so that they are useable by all people, to the greatest extent possible, without the need for adaptation or specialized design (Bremer, Clapper, Hitchcock, Hall, & Kachgal, 2002). In other words, Universal Design is preemptive. If an environment is designed right to begin with, additional accommodations will be unnecessary.

A major reason that there is an emphasis on designs that benefit everyone is to avoid stigmatizing or segregating people who need the Universal Design feature (Wehmeyer, Lance, & Bashinski, 2002). If students feel singled-out or stigmatized they may not be motivated to use the equipment, independent of whether or not the equipment is effective (Bowe, 2000).

In terms of learning, Universal Design means that the assistive technology is not specially designed for an individual student but rather for a wide range of students. Universally designed approaches are implemented by general education teachers rather than by special education teachers (Research Connections, 1999).

So, personal-worn FM systems are recommended for a given child on a case-by-case basis through the special education system using a *treatment paradigm*. Sound field systems, on the other hand, ought to be placed in general education classrooms to benefit all learners based on a *Universal Design* paradigm.

Summary

Hearing is a first-order event in a mainstream classroom. If a child cannot clearly hear spoken instruction, the entire premise of the educational system is undermined. Due to poor acoustic conditions and a variety of hearing and attending problems, there are millions of children who are being denied an appropriate education due to the lack of acoustic accessibility.

Sound field distribution systems must be included when discussing the classroom listening environment because these systems improve the S/N ratio. The better and more consistent the S/N ratio, the more accessible will be the teacher's spoken instruction to the brains of pupils.

Because all children benefit from an enhanced S/N ratio, sound systems can be beneficial in general education classrooms. Appropriately installing sound systems in classrooms can be accomplished using a Universal Design imperative.

Children who are deaf or hard of hearing are fit with personal-worn FM systems via the special education network. Both sound distribution and personal-worn FM systems can be used in a complementary fashion in a classroom to create a favorable listening environment, improve the S/N ratio, and provide enhanced classroom access through the addition of a pass-around microphone.

References

Alter, J. (1999). Bridging the digital divide. *Newsweek*, September 20, 55.

Anderson, K.L. (2001). Voicing concern about noisy classrooms. *Educational Leadership*, April, 77–79.

Berg, F.S. (1993). *Acoustics & Sound Systems in Schools*. San Diego: Singular Publishing Group.

Berlin, C.I., & Weyand, T.G. (2003). *The brain and sensory plasticity: Language acquisition and hearing*. Clifton Park, NY: Thompson Delmar Learning.

Bess, F.H. & Humes, L.E. (2003). *Audiology the fundamentals, 3rd ed*. Philadelphia: Lippincott Williams & Wilkins.

Bhatnagar, S.C. (2002). *Neuroscience for the study of communicative disorders, 2nd ed*. Philadelphia: Lippincott Williams & Wilkins.

Boothroyd, A. (1997). Auditory development of the hearing child. *Scandinavian Audiology*, 26 (Suppl. 46), 9–16.

Boothroyd, A. (2002). *Optimizing FM and sound-field amplification in the classroom*. Paper presented at the American Academy of Audiology National Convention, Philadelphia.

Bowe, F.G. (2000). *Universal design in education: Teaching nontraditional students*. Westport, CT: Bergin & Garvey.

Bremer, C.D., Clapper, A.T., Hitchcock, C., Hall, T., & Kachgal, M. (2002). Universal design: A strategy to support students' access to the general education curriculum. *Information Brief*, 1(3), 1–5.

Chermak, G.D., & Musiek, F.E. (1997). *Central auditory processing disorders: New perspectives*. San Diego: Singular Publishing Group.

Crandell, C., & Smaldino, J. (2002). *Classroom acoustics*. Paper presented at the American Academy of Audiology National Convention, Philadelphia.

Darai, B. (2000). Using sound field FM systems to improve literacy scores. *ADVANCE for Speech-Language Pathologists & Audiologists*, 10 (27), 5,13.

Erber, N. (1982). *Auditory training*. Washington,DC: The Alexander Graham Bell Association for the Deaf.

Flexer, C. (1989). Turn on sound: An odyssey of sound field amplification. *Educational Audiology Association Newsletter*, 5, 6–7.

Flexer, C. (1998). *Enhancing classrooms for listening, language, and literacy*. (Videotape). Layton, Utah: Info-Link Video Bulletin.

Flexer, C. (1999). *Facilitating hearing and listening in young children, 2nd edition*. San Diego: Singular Publishing Group.

Flexer, C. (2000). The startling possibility of soundfield. *ADVANCE for Speech-Language Pathologists & Audiologists*, 10, 5,13.

Flexer, C., Biley, K.K., Hinkley, A., Harkema, C., & Holcomb, J. (2002). Using sound-field systems to teach phonemic awareness to pre-schoolers. *The Hearing Journal*, 55 (3), 38–44.

Johnson, S. (1998). *Who moved my cheese?* New York: G.P. Putnam's Sons.

Knittel, M.A.L., Myott, B., & McClain, H. (2002). Update from Oakland schools sound field team: IR vs FM. *Educational Audiology Review*, 19(2), 10–11.

Ling, D. (2002). *Speech and the hearing impaired child, 2nd ed*. DC: The Alexander Graham Bell Association for the Deaf and Hard of Hearing.

National Center for Education Statistics: National Assessment of Educational Progress (NAEP) (2001). *1992–2000 Reading Assessments*. Washington DC: U.S. Department of Education Office of Educational Research Improvement.

Niskar, A.S., Kieszak, S.M., Homles, A., Esteban, E., Rubin, C., & Brody, D.F. (1998). Prevalence of hearing loss among children 6 to 19 years of age: The third national health and nutrition examination survey. *Journal of the American Medical Association*, 279(14), 1071–1075.

Research Connections in Special Education. (1999). Universal design: Ensuring access to the general education curriculum, 5, 1–2.

Robertson, L. (2000). *Literacy learning for children who are deaf or hard of hearing*. Washington, DC: The Alexander Graham Bell Association for the Deaf and Hard of Hearing.

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

Ross, M., Brackett, D., & Maxon, A. (1991). *Assessment and Management of Mainstreamed Hearing-Impaired Children*. Austin TX: Pro-Ed.

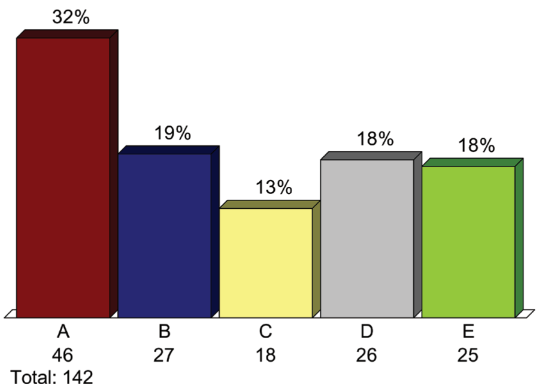
Trelease, J. (2001). *The read-aloud handbook, 5th ed.* New York: Penguin Books.

Wehmeyer, M.L., Lance, G.D., & Bashinski, S. (2002). Promoting access to the general curriculum for students with mental retardation: A multi-level model. *Education and Training in Mental Retardation and Developmental Disabilities*, 37(3), 223–234.

Participant Surveys

Which situation best describes your current use of Sound Field and Personal FM systems in the same classroom:

A. I don't use them together.
B. I couple the personal FM transmitter to the sound field amplifier and don't emphasize the pass-around mic.
C. I have the teacher wear two transmitters
D. I couple the personal FM transmitter to the sound field amplifier and really emphasize the pass-around mic.
E. I have both systems (teacher mic of sound field system and mic of personal FM system) on the same transmission frequency.



Which situation might best describe your intended use of Sound Field and Personal FM systems in the same classroom:

A. I don't intend to use them together.
B. I will attempt to couple the personal FM transmitter to the sound field amplifier, but not emphasize the pass-around mic.
C. I probably will have the teacher wear two transmitters.
D. I will attempt to couple the personal FM transmitter to the sound field amplifier and really emphasize the pass-around mic.
E. I will attempt to have both systems (teacher mic of sound field system and mic of personal FM system) on the same transmission frequency.