DOCUMENT RESUME

ED 463 640		EF 006 073
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TITLE	Improving Classroom Acoustics (ICA): A Three-Year FM Sound Field Classroom Amplification Study.	
INSTITUTION	Educational Audiology Association, Tampa, FL.	
SPONS AGENCY	Florida State Dept. of Education, Tallahassee. Div. of Public Schools.	
PUB DATE	1999-00-00	
NOTE	22p.; Federal assistance provided by the Individuals with Disabilities Education Act (IDEA), Part B. Portions of this article presented at the Annual Convention of the American Academy of Audiology (Dallas, TX, 1995) and the Annual Convention of the Florida Association of Speech-Language Pathologists and Audiologists (Ft. Lauderdale, FL, 1996).	
PUB TYPE	Journal Articles (080) -- Reports - Research (143) -- Speeches/Meeting Papers (150)	
JOURNAL CIT	Journal of Educational Audiology; v7 p8-28 1999	
EDRS PRICE	MF01/PC01 Plus Postage.	
DESCRIPTORS	Acoustical Environment; *Audio Equipment; Listening; Noise (Sound); Primary Education; *Program Effectiveness	
IDENTIFIERS	*Frequency Modulation	

ABSTRACT

The Improving Classroom Acoustics (ICA) special project was designed to determine if students' listening and learning behaviors improved as a result of an acoustical environment enhanced through the use of FM sound field classroom amplification. The 3-year project involved 2,054 students in 94 general education kindergarten, first-, and second-grade classrooms in 33 elementary schools in Florida. The Easy Listener Freefield System[TM] by Phonic Ear was provided in 64 experimental (amplified) classrooms, and the remaining 30 classrooms served as control (unamplified) classes. Analysis of observational data on 1,750 students indicated that students in amplified classrooms demonstrated significant improvement in listening and learning behaviors and skills, and progressed at a faster rate than their grade-alike peers in unamplified classrooms, and that younger students demonstrated the greatest improvement. Data showed that noise levels (dBA) and acoustical treatments in elementary classrooms have not changed over the past decade. FM sound field classroom amplification provided teachers with an average 6.94 dBA increase in vocal intensity. Students, teachers, parents, and school administrators gave FM sound field classroom amplification a positive evaluation. Finally, data demonstrated that this instructional delivery equipment is a cost effective means to manage an important variable in early-grade classrooms--the intensity of the teacher's voice. (Contains 56 references, 11 tables, and 7 figures.) (Author/EV)

Improving Classroom Acoustics (ICA): A Three-Year FM Sound Field Classroom Amplification Study

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The *IMPROVING CLASSROOM ACOUSTICS (ICA)* special project was designed to determine if students' listening and learning behaviors improved as a result of an acoustical environment enhanced through the use of FM sound field classroom amplification. The three-year project involved 2054 students in 94 general education kindergarten, first, and second grade classrooms in 33 elementary schools in Florida. *The Easy Listener Freefield System*™ by Phonic Ear was provided in 64 experimental (amplified) classrooms, and the remaining 30 classrooms served as control (unamplified) classes. Analysis of observational data on 1750 students indicated that students in amplified classrooms demonstrated significant improvement in listening and learning behaviors and skills, and progressed at a faster rate than their grade-alike peers in unamplified classrooms, and younger students demonstrated the greatest improvement. Data showed that noise levels (dBA) and acoustical treatments in elementary classrooms have not changed over the past decade. FM sound field classroom amplification provided teachers with an average of +6.94 dBA increase in vocal intensity. Students, teachers, parents, and school administrators gave FM sound field classroom amplification a positive evaluation. Finally, data demonstrated that this instructional delivery equipment is a cost effective means to manage an important variable in early grade classrooms — the intensity of the teacher's voice.

Introduction

The better children can hear, the more they are able to learn (Ross, 1995). This is precisely the premise of the *IMPROVING CLASSROOM ACOUSTICS (ICA)* project. In today's classrooms, listening and learning opportunities for young children are often compromised when they are subjected to less than optimum acoustical educational environments. Many students who effectively use their hearing for speech recognition in quiet environments may have difficulty participating effectively and efficiently in the learning process due to noise and reverberation that often distort acoustic signals in the classroom (Crandell & Bess, 1987a; Crandell & Smaldino, 1995a, b). This is particularly disturbing because young children spend 45% to 60% of their school day involved in the listening process (Butler, 1975).

Among the most devastating acoustical barriers are internal and external classroom noise, reverberation, speaker-to-listener distance, and poor acoustical treatments in the classroom. Unfortunately, noise and reverberation levels in many classrooms exceed recommended acoustical standards (Crandell, Smaldino & Flexer, 1999). Numerous researchers have documented the difficulties that children experience when listening in the presence of background noise (Berg, Blair & Benson, 1996; Crandell, 1993b; Crum & Matkin, 1976; Downs & Crum, 1978; Finitzo-Hieber & Tillman, 1978; McCroskey & Devens, 1975; Nabelek & Pickett, 1974; Nabelek & Robinson, 1982; Olsen, 1981; Papso & Blood, 1989; Sanders, 1965). Flexer (1992) pointed out that the acoustic filter effect created by background noise interferes with children's efforts to make sense out of incomplete auditory input. Others have shown that young students expend so much effort listening in the presence of noise that the degraded listening conditions actually reduce the effort remaining available to students for performing cognitive operations utilizing speech material (Rabbit, 1966).

For maximum learning to occur in the educational environment, the teacher's voice must be highly intelligible to all children (Crandell & Smaldino, 1995a). It also is known that speech recognition in noise and reverberation achieves adult-like performance between 13 and 15 years of age (Crandell & Bess, 1987a; Elliott, 1979, 1982; Fior, 1972; Neuman & Hochberg, 1983). Thus, young listeners in the early grades have not achieved the level of sophistication necessary to listen effectively in a noisy classroom environment. In addition, they do not have the benefit of rich language learning experiences and sophisticated language systems that adult listeners have available to help "fill in the gaps" under a degraded listening situation.

Adult listeners require a signal-to-noise ratio (S/N) of at least +6 dB for maximum communication to occur. Subsequently, it has been estimated that children require at least a +10 dB S/N to achieve speech recognition at a level comparable to adult listeners (Berg, 1993; Lewis, 1994a, b; Crandell, Smaldino & Flexer, 1999). Leavitt & Flexer (1991) demonstrated through the Rapid Speech Transmission Index (RASTI) study that students experience significant loss of speech intelligibility when seated anywhere in the classroom other than very near the teacher. Their study showed that 100% speech recognition was achieved at a distance of 6 inches. Even with the "best seat in the house" (center front row at 2.65 meters) there was a 17% loss in critical speech recognition.

Poor classroom acoustics represent a barrier for students, often making it difficult to distinguish a student's own deficiencies or difficulties from learning problems specifically caused by unacceptable classroom acoustics. The landmark Mainstream Amplification Resource Room Study (MARRS) conducted in the Wabash and Ohio Valley Schools showed that students with mild hearing impairments who received instruction in mainstream classrooms using sound field amplification achieved at a faster rate, to a higher level, and at one-tenth the cost of students taken from regular classrooms and placed in resource rooms for instruction (Sarff, 1981).

Over the past 20 years, the efficacy of FM sound field classroom amplification has been demonstrated. Research has shown that FM sound field amplification is a proactive and effective way to produce significant change in students' listening behaviors and academic achievement (Rosenberg & Blake-Rahter, 1995a; Flexer, 1997). Stated very simply, an FM sound field amplification system in the classroom enhances listening and learning by:

- projecting the teacher's voice at a level where students can hear comfortably without straining
- improving the S/N to +5 to +10 dB by producing a nearly uniform loudness level in the classroom that is unaffected by the teacher's location
- reducing the effects of reverberation and distance from the teacher so those students in the back of the classroom can hear the teacher's voice as clearly and precisely as students seated near the teacher
- facilitating acoustic access to information for all students in the classroom.

Within the past five years, FM sound field amplification has emerged as a very popular classroom intervention strategy, and manufacturers have become more creative and responsive to marketplace needs by offering quality systems, a wide array of options, and competitive pricing. The FM sound field system appears to help all of the students some of the time and some of the students all of the time (Ross, 1995). The benefits of FM sound field amplification are numerous; however, among the most notable positive effects for students are: improvement in academic achievement, speech recognition, and attending and learning behaviors; increased seating options for students with hearing loss; improvement in listening and learning environments for "at risk" learners (e.g., those with severe language impairment, developmental delay, ESOL, minimal or mild hearing impairment, conductive hearing loss, history of otitis media, central auditory processing disorder, learning disability, attention deficit, reading disability); and increased self esteem (Crandell, Smaldino & Flexer, 1995; Crandell, 1998). Benefits identified for teachers include reduced vocal strain and vocal fatigue, increased ease of teaching, increased versatility of instructional techniques, and increased teacher mobility. Although the evidence is convincing, Williams, Tharpe & Bess (1994) estimated that only four percent of audiologists regularly recommend sound field FM amplification systems.

Purpose

The *IMPROVING CLASSROOM ACOUSTICS (ICA)* special project was designed to determine if students' listening and learning behaviors and skills improved as a result of an acoustical environment enhanced through the use of FM sound field classroom amplification. The Florida Department of Education made an attempt to evaluate the effectiveness of sound field classroom amplification 10 years prior to the ICA project. However, the experiment was relatively unsuccessful. Reasons cited as contributing to the lack of success were: 1) amplification placed in a small district with no on-site audiological support; 2) only one introductory training session provided, with no ongoing support, monitoring, or troubleshooting assistance; and 3) teacher resistance toward using the FM sound field system. The ICA project was designed to overcome these barriers to successful use of this exciting classroom amplification technology. The ICA project involved 2054 students in 94 kindergarten, first, and second grade general education classrooms in 33 elementary schools located in 23 Florida school districts with varying populations (2 large, 6 medium, 15 small). Phase I of the project began in 1993 with a 12-week pilot study with increasing participation from additional districts in Phase II through 1995. Educational audiologists were employed in the six districts participating in the first phase of the project, but none of the small or medium-size districts in Phase II employed an audiologist on a full-time basis. The ICA project provided FM sound field amplification in 64 experimental (amplified) classrooms while 30 classrooms served as control (unamplified) classrooms.

Methods

Subjects

Phase I. Subjects were 1319 kindergarten, first, and second grade students in 30 experimental (amplified) and 30 control (unamplified) general education classrooms. Subjects were enrolled in 14 schools in four medium and two large Florida school districts. Classes were paired only by grade level within each school site for the experimental (N = 663) and control (N = 656) treatment groups. Students (N = 804) in 20 classrooms from the ICA pilot project were followed for 30 weeks to examine change over a longer period of time. (See Table 1.) There were slightly more male than female subjects, and minority students accounted for 18.35% of the total group. Students participating in Exceptional Student Education (ESE) programs other than Speech/Language Therapy or Specific Learning Disabilities (SLD) represented 15.16% of the total group. The number of students enrolled in alternative programs, such as chapter classes or other district-provided remedial programs, accounted for 13.87% of the total group. The estimate of socio-economic status is based on free and reduced lunch data provided by districts. The classroom mean for students receiving free and reduced lunch was at 39.53% and this rate is below the state average of 45.97% for elementary schools (Florida Department of Education). Demographic information for subjects, districts, otologic history, and prevalence of special services is provided in Table 2.

Phase II. A total of 735 students in kindergarten, first, and second grade general education classes were participants in Phase II, which provided FM sound field amplification in all of the classrooms. Subjects were enrolled in 19 schools in 15 small and 2 middle-size Florida school districts. (See Table 1.) Pre- and post-treatment student observation data were completed for 20 of the 34 classes (58.82%) yielding a participant group of 431 students. The socio-economic status (SES) of district and school populations showed a district mean of 57.00% and the school mean of 61.38%, both of which are above the state average of 45.97%. These incidence levels are higher than the mean district SES of 37.79% identified for Phase I.

Table 1. Summary of Districts, Students, and Observational Periods for the ICA Project.

Project Phase	No. Districts	Student Participants	Observational Period
Phase I 1993-1994 Multi-District FM Sound field Classroom Amplification Pilot Project	4	855 students in 20 control (N = 425) and 20 experimental (N = 430) classrooms	12 weeks (pre-, mid-, and post-treatment observations)
1994 Multi-District FM Sound field Classroom Amplification Continuation Project	6	1319 students in 30 control (N = 656) and 30 experimental (N = 663) classrooms	12 weeks (pre-, mid-, and post-treatment observations)
		804 students in 20 control (N = 399) and 20 experimental (N= 405) classrooms	30-week observation: pre-treatment, 6, 12, 21, and 30 weeks
Phase II 1994-1995 Small District FM Sound field Classroom Amplification Project	17	735 students in 34 classrooms; pre- and post-observation data on 431 students	4 weeks (pre- and post-treatment observations)

Table 2. Subject and district demographic, otologic history, and special services information summary. (SES estimate is based on available free/reduced lunch district data.)

	Phase I		Phase II	Total
Characteristic	**Control**	**Experimental**	**Experimental**	**Combined**
Gender				
Male	345 (52.59%)	333 (50.23%)	230 (53.36%)	908
Female	311 (47.41%)	330 (49.77%)	201 (46.64%)	842
Minority Students	114 (17.38%)	128 (19.31%)	83 (19.25%)	325
Student participants by grade				
Kindergarten	217	211	*(210) 66	*(638) 494
Grade 1	211	217	*(269) 204	*(697) 632
Grade 2	338	235	*(256) 161	*(719) 624
Total Student Participants	656	663	*(735) 431	*(2054) 1750
Students receiving specialized services				
General in-school special services	179 (27.29%)	192 (28.95%)	116 (26.91%)	487
Remedial class	86 (13.11%)	92 (14.63%)	71 (16.47%)	249
Speech/language therapy	71 (10.82%)	78 (11.76%)	22 (5.10%)	171
SLD class	20 (3.05%)	24 (3.62%)	14 (3.25%)	58
ESOL class	9 (1.37%)	9 (1.36%)	9 (2.09%)	27
Other ESE services	92 (14.02%)	108 (16.29%)	7 (1.62%)	207
Otologic history				
Ear problems before age 1	169 (34.42%)	188 (33.81%)	126 (31.27%)	483
Ear problem within last 6 months	85 (17.31%)	99 (17.81%)	92 (22.83%)	276
More than 10 lifetime ear problems	64 (13.03%)	89 (16.01%)	56 (13.90%)	485
Myringotomy with PE tubes	39 (7.94%)	52 (9.35%)	32 (7.94%)	123
Four or more ear problems per year	27 (5.50%)	39 (7.01%)	45 (11.17%)	111
Negative history (colds, sinus, allergy)	341 (69.45%)	383 (68.88%)	229 (56.82%)	953
Total Otologic History Forms	491 (74.84%)	556 (83.86%)	403 (54.82%)	1450
	N	**Mean**	**N**	**Mean**
District SES ***	6	37.79%	17	57.00%
School SES ***	14	41.42%	19	61.38%
District population	6	67008.00	17	5583.76
School population	14	759.77	19	689.58
School age in years	14	28.18	19	19.84
Teaching experience in years	60	15.18	34	12.76

**Number of students using FM sound field amplification is in parentheses and the other number reveals the number of students for whom there were completed observation forms.*

*** Number of students reported by teachers on the Student Data section of the Listening and Learning Observation form.*

****The State of Florida average for elementary schools for free/reduced lunch reported by the Bureau of School Business Services is 45.97% (Florida Department of Education).*

Selection of Schools and Teachers

Phase I. School principals in the six districts were interviewed to ascertain interest in the FM sound field classroom amplification project. Teachers (N = 60) were selected based on the principal's recommendation and each teacher's willingness to participate in the project. None of the participating teachers presented with speech or voice pathology, and all used standard American dialect. Teachers were not selected to ensure specific ability groupings or specific classroom acoustic environments. The teachers possessed an average 15.18 years of teaching experience (R = 1-35 years). The 60 classes were equally divided with 20 classes at each grade level (kindergarten, first, and second grade).

Phase II. Target groups for this phase were small, small-middle, and middle-size districts. Information was sent to districts, and the Institute for Small and Rural Districts assisted in publicizing the project and in recruiting interested districts. Exceptional Student Education (ESE) directors contacted principals in their respective districts to promote participation in the project. Those districts willing to participate were asked to identify two general education classroom teachers in kindergarten, first, or second grade. In addition, they were asked to appoint an ICA contact person to serve as facilitator for sharing information and management of project forms such as pre- and post- student observation forms and project evaluation forms. Typically, small districts do not have an audiologist on staff to assist with a classroom amplification project. Thus, ICA contact persons included ESE directors, speech-language pathologists, ESE teachers, ESE district-level employees, and in one middle-size district, a part-time audiologist. Fifteen of 27 small districts (55.56%) committed to the project and two middle-size districts were invited to become part of this cohort to meet this project's goal of providing FM sound field amplification for a minimum of 34 classrooms. Participating teachers had an average 12.76 years of teaching experience.

Hearing Screenings

Hearing screenings (at both 15 and 20 dB HL, .5K, 1K, 2K, and 4KHz, plus tympanometry) were performed on 1252 students in Phase I only, following ASHA (1996) guidelines for hearing screening. Screenings were conducted by certified audiologists and speech language pathologists, supervised audiology and speech-language pathology graduate students, and trained district-employed hearing screening aides. Hearing screenings were not conducted in Phase II due to the inconsistent availability of personnel and the variability of existing district hearing screening guidelines. Parents of students participating in both phases of the project were given the opportunity to provide otologic history information for their child by completing an adaptation of the *History of Ear and Hearing Problems* (Anderson, 1991). (See Table 2.)

Teacher Inservice Training

Phase I. ICA inservice training sessions were provided for 60 general education classroom teachers and project support persons using materials from the *ICA Inservice Training Manual* (1995a) and accompanying *ICA Inservice Training Transparency Master Manual* (1995b). A minimum of four hours of inservice training was provided for participating teachers. Inservice sessions addressed an array of topics related to classroom acoustics, speech perception, strategies for improving student listening and learning behaviors, suggestions for acoustical modifications and managing classroom noise, as well as the benefits and use of FM sound field classroom amplification. In addition, teachers received instruction on the use of ICA project management forms (e.g., student observation forms, evaluation forms). A master inservice component was available to allow participating teachers the opportunity to earn credit by attending the inservice session and by completing student observations, other project forms, and related activities. Audiologists employed by each district provided inservice training, coordinated project implementation in their district, and served on the ICA Project Advisory Committee.

Phase II. The inservice training format previously described was applied in Phase II. Fifty teachers, ICA contact persons, and interested district level ESE staff received inservice training at one of four regional sessions conducted by the audiologist who served as project manager.

Classroom Environment

Teachers completed the *ICA Classroom Description Worksheet* (Florida Department of Education, 1995a), providing information about the classroom setting, acoustical treatments, noise measurements, classroom design, noise sources, and other pertinent information about the classroom environment (e.g., teaching style, grade level, student characteristics). In Phase I, fifty-four classes (90%) were self-contained, with the remainder housed in relocateable classrooms. This distribution was identical for both treatment groups. The majority of classrooms had central heating/ventilation/air conditioning (HVAC) systems. Teachers rated the loudness of various classroom noise sources on a scale of 1 (very quiet) to 5 (very noisy). The average rating for HVAC systems was moderate (3.27), suggesting that these have potential as intrusive noise sources. Average ratings for restrooms in classrooms (2.67) and lighting systems (1.53) did not suggest these to be major sources of classroom noise. Average ceiling height in classrooms was at an acceptable level of 9.57 feet. Hart (1983) states that a ceiling height of 12 feet is an optimal height to achieve a relatively diffuse sound field. Schools in Phase II were somewhat newer than those in Phase I (Table 2).

Figure 1. Noise Measurements portion of the ICA Classroom Description Worksheet for (Florida Department of Education, 1995a, pp. 133-134).

Classroom Grid

School ____________________

Teacher ____________________

___ **Experimental** ___ **Control**

Teacher's Voice Measurement

_____ dBA unamplified (6" from the mouth)

_____ dBA amplified (6" from the speaker)

Directions:

- Use the grid to mark the position number where each of the five measurements are taken.
- Take the dBC measurement in the center of the classroom.
- Take five measurements in the classroom under unoccupied and occupied conditions. (For control classes, measurements should be taken in the four corners and center of the room. For amplified classes, measurements should be taken at the four speaker positions and in the center of the room.)
- If unusual circumstances exist for a particular classroom (e.g., excessive hallway noise between 10:30 and 1:30 while students access the cafeteria, excessive noise between 10:00 and 12:00 due to construction), an additional noise measurement may be taken and recorded in the space provided.
- Take the dBA unamplified teacher's voice measurement 6" from the mouth. (Take the measurement in the unoccupied classroom.)
- Take the dBA amplified teacher's voice measurement 6" from a sound field speaker. (Take the measurement in the unoccupied classroom. Prior to making this measurement, check the output at each of the four speakers to determine uniformity of the signal.)

Noise Measurement Data

Date ________ Date ________ Date ________

Time ________ Time ________ Time ________

Position	Unoccupied (U)	Occupied (O)	Additional Measurement (U/O)	
1	_____ dBA	_____ dBA	_____ dBA	
2	_____ dBA	_____ dBA	_____ dBA	
3	_____ dBA	_____ dBA	_____ dBA	
4	_____ dBA	_____ dBA	_____ dBA	
5	_____ dBA	_____ dBA	_____ dBA	Special Notes:
Average	_____ dBA	_____ dBA	_____ dBA	
Center	_____ dBC	_____ dBC	_____ dBC	

Sound Level Measurements

During Phase I, dBA and dBC sound level measurements were taken in classrooms, using the Quest 2400 sound level meter according to protocol identified in the *ICA Classroom Description Worksheet.* (See Figure 1.) A representative sampling of ambient noise levels was obtained by taking measurements at five positions in the classroom and computing an average measurement for each weighting network under both unoccupied and occupied conditions. Unoccupied measurements were taken before and after normal school hours with the HVAC systems in operation because this is a component of typical classroom noise in Florida's schools. Occupied measurements were taken during regular classroom activities. Teachers' vocal intensities were measured on the dBA scale at a distance of six inches from the mouth. This distance was selected as it is a typical distance from the teacher's mouth to an FM system's microphone. Using this procedure, unamplified measurements were taken for all teachers (N = 60) and amplified measurements were recorded for all experimental teachers (N = 30). This information was used to determine the amount of amplified difference and unamplified measurements were used to set the intensity level of the amplifier/receiver. Teachers were instructed to maintain the volume level on the amplifier/receiver established during the first week of use. During that time teachers found that they could decrease their vocal intensity and vocal effort by carefully increasing the volume setting on the amplifier/receiver to achieve a subjectively comfortable listening level in the classroom.

FM Sound Field Classroom Amplification

The Phonic Ear *Easy Listener Free Field Sound System* ™ with a four-speaker arrangement was used in all amplified classrooms. Teachers used the PE300 transmitter, the PE200 receiver/amplifier (Phase I) or the PE210 receiver/amplifier (Phase II), and were given the option of using a traditional lapel microphone or a boom mic headset assembly. The majority of teachers (76.67%) chose to use the boom mic configuration. Teachers were provided with auxiliary input cords and adapters to encourage use of the FM system with external sound sources such as tape players, televisions, VCRs, computers, and CD ROMs. In Phase I, district audiologists installed the FM systems with assistance from the manufacturer's territory manager. During Phase II, equipment was installed by participating classroom teachers, ICA contact persons, and support personnel at the schools. The ICA project manager and the manufacturer's territory representative were available for telephone consultation as needed in Phase II. Classroom configurations and student safety were important factors considered when placing speakers in the main teaching area of the classroom. Whenever possible, speakers were placed at the ear height of students as recommended by Allen (1991). Speaker stands were not a very popular accessory, primarily due to space and safety concerns. In most instances, speakers were placed on bookshelves or other secure areas away from classroom traffic and use areas or mounted on walls using brackets. Teachers were provided with use and troubleshooting charts and product literature (Phonic Ear, 1993). Service/maintenance contracts also were provided through the ICA project.

Student Observations

The student observation instruments used in the ICA project were the *Listening and Learning Observation (LLO)* (Florida Department of Education, 1995a) and an adaptation of the *Evaluation of Classroom Listening Behaviors* (ECLB) (VanDyke, 1985). Written instructions were available to assist teachers in the completion of the LLO and ECLB observation forms. While there is merit to the use of standardized or criterion-referenced test data as well as observational data to measure improvement in student's abilities, it was not possible to use district-wide test data for purposes of this study. In Florida, each district selects the specific tests to be administered on an annual basis, and as a result, common standardized or criterion- referenced test data was not available.

Listening and Learning Observation (LLO). The LLO, shown in Figure 2, includes information on: 1) general student data (e.g., excessive absences, retention, general health status, participation in special service programs at school), 2) listening behaviors, 3) academic/pre-academic behaviors, and 4) academic/pre-academic skills. Teachers rated students' behaviors and skills in comparison to other students in the class. A 5-point scale (1 = frequently and 5 = seldom) was used to rate students on the Listening Behaviors and Academic/Pre-Academic Behaviors subsections. For Academic/Pre-Academic skills, 1 = below average and 5 = above average on the rating scale. The maximum total score on the LLO is 75, and maximum scores for the LLO subsections are: Listening Behaviors (45), Academic/Pre-Academic Behaviors (15), and Academic/Pre-Academic Skills (15). Information from the Student Data section is not included in the LLO total score.

Evaluation of Classroom Listening Behaviors (ECLB). The 10 items on the ECLB are paired for discrete classroom listening tasks (e.g., close and distant listening, listening in noise and quiet, following single and multi-step directions, group and one-to-one listening). Each behavior was rated on a 5-point scale (1 = seldom and 5 = frequently). Maximum score on the ECLB is 50.

Observation Schedule. Observations were conducted according to the schedule shown in Table 1. In Phase I, the LLO observation form was used for all students and the ECLB was completed for 10 students in each class who were selected using a random numbers set. Student observations were completed at pre-treatment, mid-treatment (six weeks), and post-treatment (12 weeks). The 12-week observation for students (N = 855) in four districts from the pilot project was initiated six weeks after the beginning of school in the fall. Pre-observation for the two districts joining the project mid-year occurred early in the second semester of the academic year. During the second semester, two additional observations were obtained on 804 students to demonstrate the effects of classroom amplification over a 30-week period. For this group of students, the fourth observation occurred at 21 weeks and the fifth observation at 30 weeks. For Phase II, teachers were requested to complete both observation forms for each student. A pre-treatment observation was taken and four weeks later the post-observation occurred.

Figure 2.

IMPROVING CLASSROOM ACOUSTICS

Listening and Learning Observation (LLO)

STUDENT DATA

Student Initials ________ Gender ________ D.O.B. ________ School ________

Grade ________ Teacher ________________ Date Completed ________

*Please complete the following student information. Do not complete * items on the initial observation.*

Yes	No	
☐	☐	* Excessive absences (more than 6 days during observation period).
☐	☐	* Frequent colds, earaches, health problems (more than twice/continual problem during observation period).
☐	☐	ESE or other special services (e.g., ESOL, Chapter Class)
☐	☐	Type of special service ________________
☐	☐	Has been retained
☐	☐	Suspect a hearing problem
☐	☐	Suspect a learning problem

LISTENING BEHAVIORS

Directions: Rate the student's listening behaviors on the 5-point scale.

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

(over)

ACADEMIC/PRE-ACADEMIC BEHAVIORS

Directions: Rate the student on the following academic/pre-academic behaviors on the 5-point scale.

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

ACADEMIC/PRE-ACADEMIC SKILLS

Directions: Rate the student on the following academic/pre-academic behaviors on the 5-point scale. The student should be rated according to his/her standing in comparison to that of his/her classmates.

		Below Average		Average		Above Average
1.	Math or number concepts.	1	2	3	4	5
2.	Language Arts (reading/pre-reading).	1	2	3	4	5
3.	Vocabulary and word usage.	1	2	3	4	5

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

Teacher Comments:

Hearing Screening Data
(This section will be completed by the audiologist.)

	Screening Date	Pure Tone		Tympanogram Pressure Peak	
		RE	LE	RE	LE
Initial Hearing Screening					
Hearing Rescreening					

Notes:

Project Evaluation

The same evaluation forms were used throughout both phases of the project. Students, teachers, parents, and school administrators completed forms to evaluate the use of FM sound field classroom amplification. Written directions were available for each evaluation instrument, including specific text for administration of the 5-item student evaluation form. Parents and school administrators were encouraged to observe classrooms when the FM system was in operation. All persons evaluating the ICA project were invited to give narrative comments on several items and parents were encouraged to solicit information from their child when completing the form. Some items included in the evaluation instruments were selected based on findings of previous research, such as a decline in referrals for special services and teacher's perceptions on the benefits of FM sound field amplification. All ICA forms are available in the *ICA Inservice Training Manual* (Florida Department of Education, 1995a). All evaluations were completed at the conclusion of the 12-week observation in Phase I, but additional evaluation was not conducted at the conclusion of the 30-week observation. Evaluation occurred after four weeks in Phase II.

Results and Discussion

Students and Treatment Groups

Analysis of Variance (ANOVA) for Phase I showed no significant differences between treatment groups for any effects other than the higher incidence of colds and health problems for the control group per teacher report on the LLO. However, the groups were not different for a similar item on the otologic history form according to parent report. For Phase II, the only significant finding through ANOVA was differences on both the pre- and post-LLO observations for gender and special services effects. The StatView statistical package was used to analyze data. The .05 significance level was used for all statistical applications.

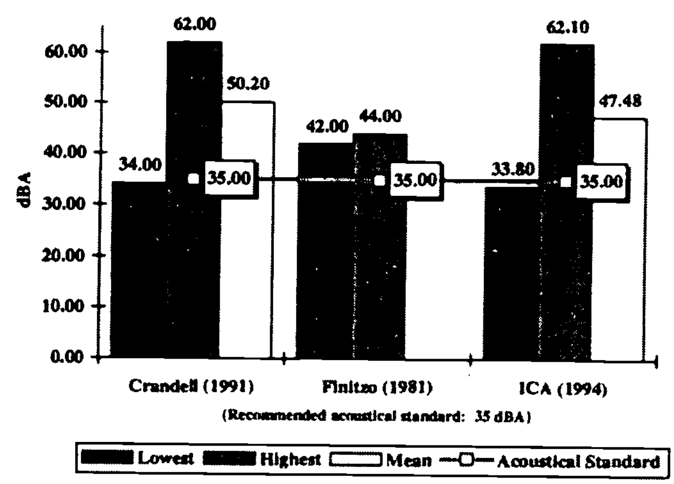
Hearing Screenings

Pure tone hearing screenings were performed during Phase I at 15 and 20 dB HL on 1258 students and tympanometry screenings were conducted for 1252 students. The pass rate for hearing screenings at 15 dB was 74.88% and 94.36% at 20 dB HL; 92.57% of the subjects had normal tympanometry results. A small number of students were not screened due to: 1) parent request for nonspecific or medical management reasons or 2) absenteeism. Hearing screening pass rates were compatible with contemporary research findings and also suggest that school facilities may not be quiet enough to conduct pure tone screenings at 15 dB HL successfully. Based on otologic history voluntarily provided by 1450 parents (67%) using an adaptation of the *Ear and Hearing History* form (Anderson, 1991), nearly 15% of the students had experienced 10 or more ear problems during their lifetime, and approximately 32% of the students had ear problems before age one. A majority of students (65.72%) were described by their parents as having no history of colds, sinus problems, or allergies. Data from the *Ear and Hearing History* (Table 2) form are consistent with prevalence levels reported by Richards, Flexer, Brandy and Wray (1993), who used a similar adaptation of the history form.

Classroom Ambient Noise Levels

Data from Phase I revealed that only two of 60 classrooms met the 35 dBA acceptable acoustical standard for unoccupied classrooms (ASHA, 1995). Figure 3 displays mean unoccupied classroom noise levels for the ICA project as well as data from Crandell (1991) and Finitzo (1981). In the current study, the unoccupied mean was 47.48 dBA (R = 33.80-62.10, SD = 7.37) and 59.37 dBC (R = 50.10-73.20, SD = 5.56). Unoccupied measurements were the quietest for kindergarten (46.40 dBA) and highest for first grade (48.50 dBA) classrooms . The mean occupied classroom noise level was 62.63 dBA (R = 47.00-73.30, SD = 5.99) and 69.50 dBC (R = 57.00-82.80, SD = 4.77). Occupied kindergarten classes were the noisiest (M = 65.20 dBA) and second grade classes the quietest (M = 60.76 dBA). The difference between dBA and dBC measurements may be attributed to the presence of low frequency noise in the 400 to 600 Hz range that is most likely due to electrical and building-generated vibratory noise. Findings show there has been little change in classroom ambient noise levels reported over the past 20 years for both dBA and dBC measurements (Crandell, 1991b; Crandell & Smaldino, 1992, 1995b; Finitzo, 1981).

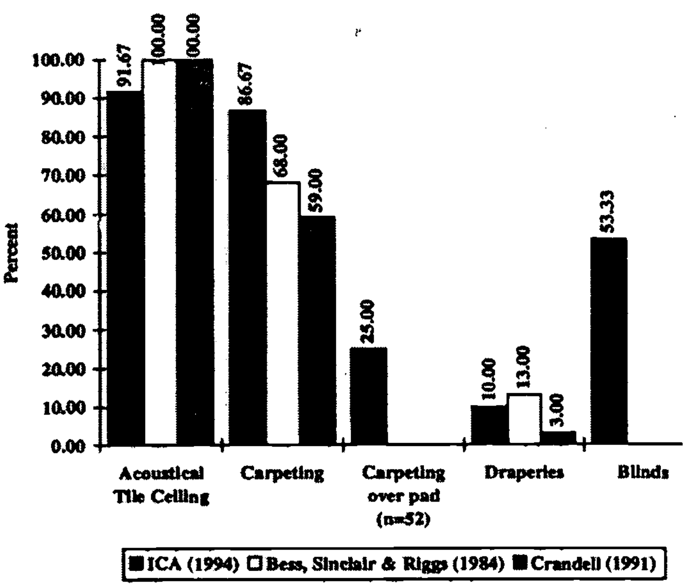
Figure 3. Summary of unoccupied classroom noise levels in dBA (Phase I) and the recommended acoustical standard (ASHA, 1995).



Acoustical Treatments

Figure 4 summarizes the acoustical treatments available in the 60 classrooms in Phase I and in studies by Bess, Sinclair and Riggs (1984) and Crandell (1991). Floor and ceiling surfaces of classrooms and study areas comprise approximately 60% of the room's total surface area (Crum & Matkin, 1976). Use of carpeting reduces the reverberation of middle and high frequency sounds, generally beginning around 1000 Hz, and it reduces reverberation in the classroom. Acoustical ceiling tile has a more uniform effect in producing a reduction of various sound frequencies, but typically with higher levels of reduction occurring in the 500-4000 Hz range (Berg, 1987). Acoustical treatment of both ceiling and floor surfaces was available in 86.67% of the classrooms. Draperies appear to be an unpopular classroom accessory; however, blinds were installed in 53.33% of classrooms, although the sound absorption capability of blinds is unknown at this time. Fire code requirements and dry cleaning costs appear to have influenced the decision not to install draperies. Complaints about cleanliness and allergy factors related to carpeting may also bring about change with this type of acoustical treatment. There has been little change in acoustical treatments in classrooms reported over the past two decades as shown in Figure 3, where ICA results are compared with two previous studies.

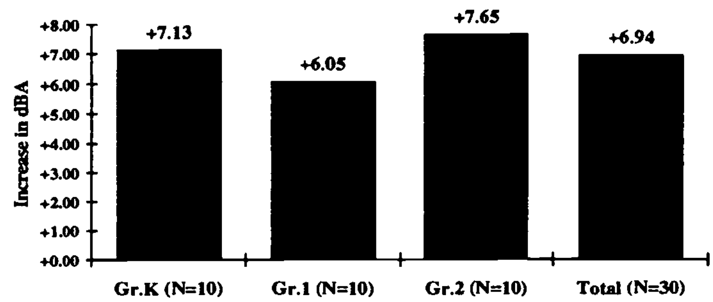
Figure 4. Summary of acoustical treatments in classrooms (Phase I).



Increase in Teacher's Voice Level

The average increase in teachers' vocal intensities produced by the FM sound field system in Phase I is shown in Figure 5. The average increase was +6.94 dBA at a distance of six inches from the speaker when compared to a measure of loudness six inches from the mouth of the teacher. These findings are within the anticipated +5 to +10 dB of enhancement that an FM sound field system is reputed to provide. Teachers found during their first week of using the sound field system that they were able to decrease vocal intensity and effort by using the amplifier/receiver to achieve a comfortable listening level in the classroom. It is difficult, at best, to predict signal-to-noise (S/N) ratios in classrooms, because the teacher's voice level and classroom ambient noise levels are constantly changing. Markides (1986) estimated 59 dBA to be the level of a typical teacher's voice at a distance of 1 meter (3+ feet). Using this estimate, the average occupied classroom in Phase I produced a -3.63 dB S/N at a distance of slightly more than three feet. By adding the +6.94 average increase in amplified teachers' vocal intensities, the S/N may be speculated to be +3.31 dB. This level is slightly better than data reported by Zabel and Taber (1993). Interestingly, Crandell, Smaldino & Flexer (1999) reported that the signal-to-noise ratio in unamplified classrooms typically ranges from +5 to -7 dB.

Figure 5. Summary of increase in teachers' mean vocal intensity in dBA with FM sound field amplification (Phase I).



Listening and Learning Observation (LLO) Analysis

Table 3 provides a summary of mean scores for the LLO total score and its three subsections for Phase I. Data from Phase I showed that students in amplified (experimental) classrooms demonstrated significantly greater improvement in listening and learning behaviors and skills and changed at a faster rate than their peers in unamplified classes. Interestingly, students in experimental classes exhibited lower pre-treatment scores than control classes. Students in control classrooms exhibited a more gradual change in listening and learning behaviors and skills over the 12-week observation period. Results of paired t-test scores (Table 3) for the LLO total score showed the experimental group to be significantly different from the control group for pre-treatment to mid-treatment, mid-treatment to post-treatment, and pre-treatment to post-treatment. Table 4 shows that for Phase II, significant change was noted after only four weeks of sound field use based on the LLO and ECLB total scores as well as the LLO subsection scores.

Table 5 shows that experimental first graders in Phase I demonstrated the greatest improvement in LLO total score for observation 1 to 2 (6 weeks) and 1 to 3 (12 weeks). Kindergarten students in unamplified (control) classes showed the least amount of improvement for the same observation periods. The p values from paired t-tests for each treatment group further amplify the observed differences between groups and demonstrate the significantly higher scores attained by the experimental group when using FM sound field amplification. First grade students showed the greatest change on each of the four LLO measures and second grade students demonstrated the least improvement. However, first graders exhibited lower pre-treatment mean scores for all measures and also showed the highest percentage of students receiving special services (30.88%).

Table 3. Summary of mean scores for the LLO total score and subsections and the ECLB and paired *t*-test results (Mean differences and *p* values) by treatment group for Phase I.

Observation Instrument	Control Mean Score (N=656)	Experimental Mean Score (N=663)	Observation 1 to 2 (Mean Diff.)	Observation 2 to 3 (Mean Diff.)	Observation 1 to 3 (Mean Diff.)
LLO#1 Total	53.93	51.92	*C -0.646*	*C -1.139**	*C -1.785**
LLO#2 Total	54.58	58.36	*E -6.541**	*E -1.050*	*E -7.591**
LLO#3 Total	55.72	59.41			
LLO (LB)#1	32.81	31.02	*C -0.366*	*C -0.602*	*C -0.968**
LLO (LB)#2	33.17	35.55	*E -4.523**	*E -0.623*	*E -5.146**
LLO (LB)#3	33.77	36.17			
LLO (AB)#1	11.29	10.97	*C -0.096*	*C -0.189*	*C -0.285*
LLO (AB)#2	11.39	12.17	*E -1.202**	*E -0.219*	*E -1.421**
LLO (AB)#3	11.58	12.39			
LLO (AS)#1	9.84	9.83	*C -0.184*	*C -0.348**	*C -0.532**
LLO (AS)#2	10.02	10.65	*E -0.816**	*E -0.208*	*E -1.024**
LLO (AS)#3	10.37	10.86			
ECLB#1	41.45	39.01	*C -0.094*	*C -0.512*	*C -0.606*
ECLB#2	41.54	43.68	*E -4.677**	*E -0.694*	*E -5.371**
ECLB#3	42.06	44.38			

*Significant ($p<0.05$)

Maximum score for the Listening and Learning Observation (LLO) total is 75, LLO Listening Behaviors (LB) is 45, LLO Academic Behaviors (AB) is 15, and LLO Academic Skills (AS) is 15. Maximum score for the Evaluation of Classroom Listening Behaviors (ECLB) is 50.

Table 4. Summary of mean scores for the LLO total score and subsections and the ECLB and paired *t*-test results (*p* values) for Phase II (N=431).

Observation Instrument	Mean Score	Observation 1 to 2 (*p* value)
LLO#1 Total	52.48	
LLO#2 Total	57.33	<.0001
LLO (LB)#1	31.81	
LLO (LB)#2	35.12	<.0001
LLO (AB)#1	11.36	
LLO (AB)#2	12.13	<.0001
LLO (AS)#1	9.66	
LLO (AS)#2	10.11	<.0001
ECLB#1	39.54	
ECLB#2	43.30	<.0001

Maximum score for the Listening and Learning Observation (LLO) total is 75, LLO Listening Behaviors (LB) is 45, LLO Academic Behaviors (AB) is 15, and LLO Academic Skills (AS) is 15. Maximum score for the Evaluation of Classroom Listening Behaviors (ECLB) is 50.

Table 5. Summary of greatest and least improvement by grade level and treatment group (C = control, E = experimental) on the *Listening and Learning Observation (LLO)* and the *Evaluation of Classroom Listening Behaviors (ECLB)* for Phases I and II.

Observation Instrument	Greatest Improvement (Phase I)	Least Improvement (Phase I)	Greatest Improvement (Phase II)	Least Improvement (Phase II)
LLO Listening Behaviors				
Observation 1 to 2	Grade 1 (E)	Kindergarten (C)	Grade 1	Grade 2
Observation 1 to 3	Grade 1 (E)	Kindergarten (C)		
LLO Academic/Pre-academic Behaviors				
Observation 1 to 2	Kindergarten (E) Grade 1 (E)	Grade 2 (C)	Grade 1	Grade 2
Observation 1 to 3	Kindergarten (E)	Grade 2 (C)		
LLO Academic/Pre-academic Skills				
Observation 1 to 2	Kindergarten (E)	Kindergarten (C)	Grade 1	Grade 2
Observation 1 to 3	Kindergarten (E)	Grade 2 (C)		
LLO Total Score				
Observation 1 to 2	Grade 1 (E)	Kindergarten (C)	Grade 1	Grade 2
Observation 1 to 3	Grade 1 (E)	Kindergarten (C)		
Observation 1 to 4	Kindergarten (E)	Grade 2 (C)		
Observation 1 to 5	Kindergarten (E)	Grade 1 (C)		
ECLB				
Observation 1 to 2	Kindergarten (E)	Grade 1 (C)	Grade 1	Grade 2
Observation 1 to 3	Kindergarten (E)	Grade 2 (C)		
Observation 1 to 4	Kindergarten (E)	Grade 1 (C)		
Observation 1 to 5	Kindergarten (E)	Grade 1 (C)		

<u>*Evaluation of Classroom Listening Behaviors (ECLB)* Analysis</u>

Results of the *Evaluation of Classroom Listening Behaviors (ECLB)* (N = 741) for Phase I were similar to those shown for the LLO (Table 3). Again the lower pre-treatment score is noted for the experimental group, and dramatic growth is seen for the experimental group after six weeks of FM sound field amplification use. Paired t-test results show no significant mean differences for the control group from pre-treatment (ECLB#1) to mid-treatment (ECLB#2) or from pre-treatment (ECLB#1) to post-treatment (ECLB#3). For the experimental group, both observation periods showed significant findings. The greatest improvement on the ECLB at six and 12 weeks was shown by kindergarten students in amplified classrooms and the least improvement by first and second graders in unamplified classes respectively (Table 5). Crandell et al. (1995) have suggested that the greater change for younger students may be, at least in part, due to the fact that younger children are often plagued by otitis media and require speech to be louder in order to hear more clearly. Also, their immature linguistic and auditory systems make it less easy for them to "fill in the gaps". Phase II showed the same trend for the ECLB as noted for the LLO (Table 4). First graders showed the greatest improvement and second grade students showed the least improvement (Table 5). Other studies have shown that young students exhibit improved attending and listening behaviors in the presence of FM sound field amplification (Allen & Patton, 1990; Benafield, 1990).

<u>LLO and ECLB 30-week Observation</u>

LLO data collected from five observations on 804 students over 30 weeks during Phase I are depicted in Figure 6. (This included students from the pilot study whose teachers continued with observations for the 30-week period.) The experimental group exhibited significantly greater improvement in LLO total score than the control group for pre-treatment score to measurements taken at 6, 12, 21, and 30 weeks. Mean total scores for the *Evaluation of Classroom Listening Behaviors (ECLB)* (N = 369) for treatment groups over 30 weeks of observation are plotted in Figure 7 for students participating in Phase I. As on the LLO, the experimental group showed significantly higher mean differences from pre-treatment to each of the subsequent observations at 6, 12, 21, and 30 weeks. Treatment groups were not significantly different for other observation comparisons.

Figure 6. Summary of LLO mean total scores for five observations (Phase I).

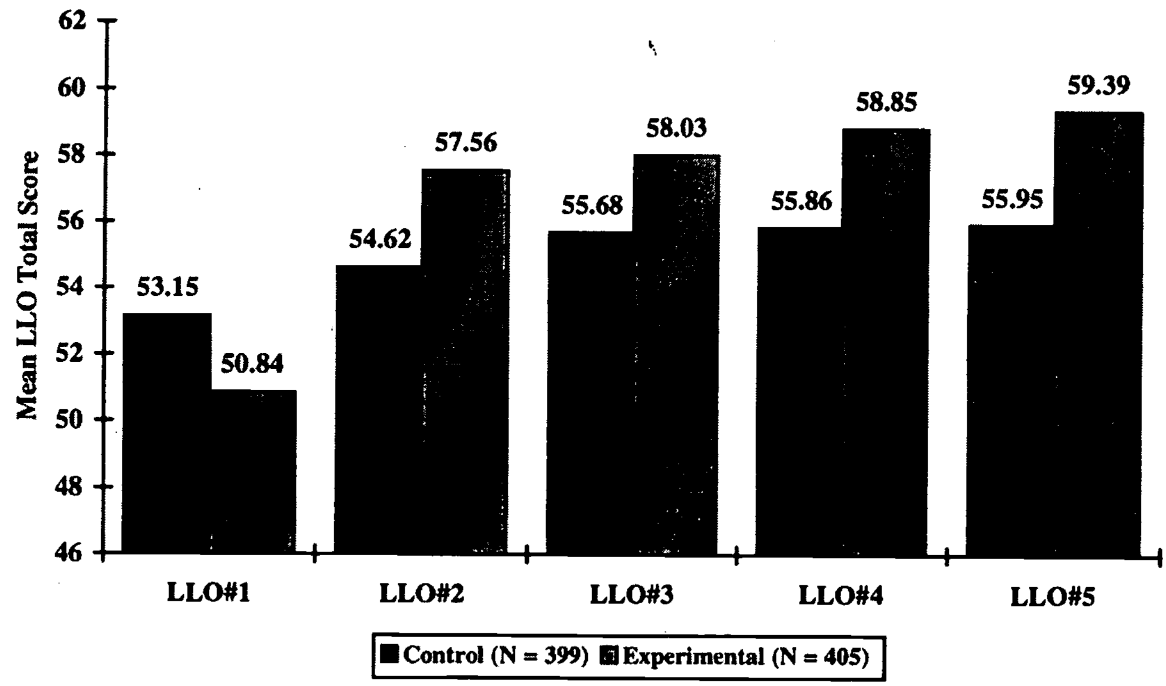
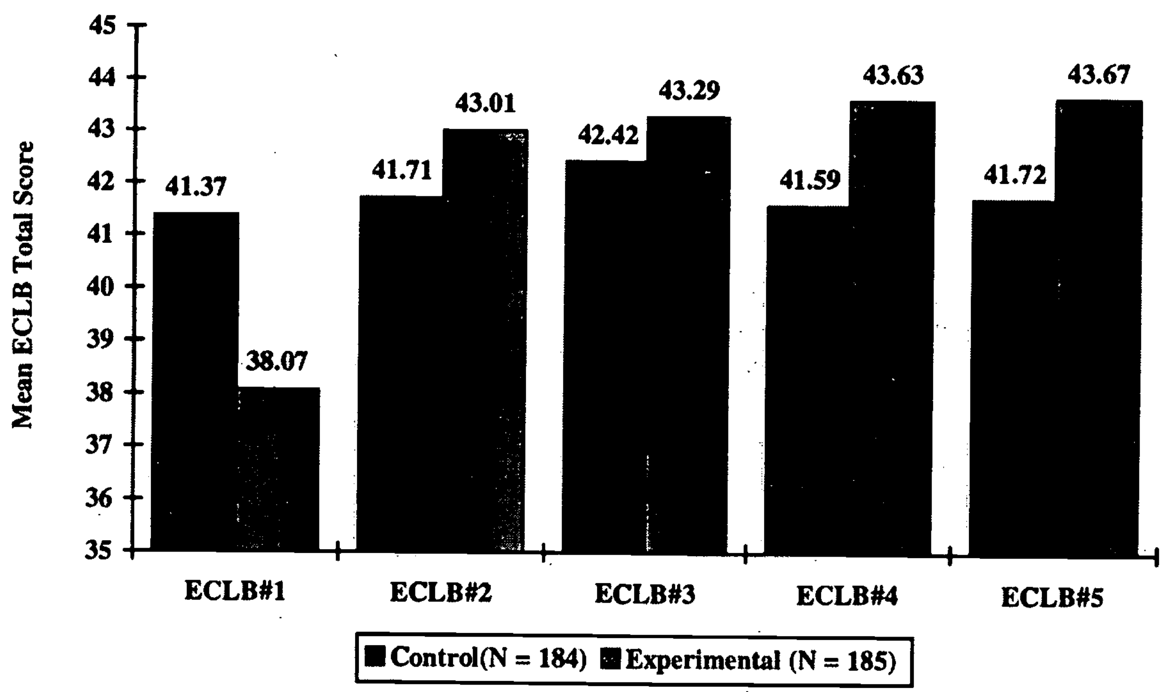


Figure 7. Summary of ECLB mean total scores for five observations (Phase I).



LLO and ECLB Correlations

Correlations for the ECLB and LLO are strong, suggesting that these observation instruments are measuring similar abilities. Correlations for the total mean scores for the two instruments for Phase I and II respectively are: 0.831 and 0.828 (observation #1), 0.788 and 0.705 (observation #2), and 0.832 (observation #3, Phase I only). It also is important to note that for Phase I, from observation 1 to observation 2, the experimental group also showed significant change on nine of the 10 listening behaviors on the ECLB, but the control group showed no significant change for any item. These findings further support the appropriateness of these instruments for the observation of students' classroom listening behaviors.

Table 6. Summary of student, teacher, parent, and administrator comments about FM sound field classroom amplification (Phase I of the ICA Project).

Student comments.

- The microphone helps me hear better because my teacher has a soft voice and you can't always hear her.
- When my teacher turns off the speakers we cannot hear that good.
- It helps a lot of people who sit in the back and can't hardly hear without the microphone.
- Our teacher lets us read with it and that's good for shy people.
- When other kids tell stories to the class we can all hear real good.
- The speakers make us all pay attention better than we used to last year.
- I hope we get to have it in our classroom next year to hear better some more.

Teacher comments.

- Students could hear and understand better.
- The system encourages shy children to speak and share information in front of the class; it builds confidence in all students when they use the microphone.
- It helps students follow directions and enhances listening skills, especially low ability students.
- More seating options are available to students with hearing loss.
- It decreases teacher's voice problems, reduces vocal strain, produces a more relaxed feeling when teaching, and teachers feel less tired at the end of the day.
- It improves student attention; the system assists in getting and holding student's attention.
- It improves rate of learning phonics because students listen and understand better.
- It is an effective tool for chalkboard writing, giving tests, and playing tapes in class.
- Everyone benefits by using the FM system in the classroom. Every class should have one.

Parent comments.

- It improves the student's ability to hear the teacher more easily and clearly.
- It improves the student's ability to understand the teacher more easily.
- It makes learning easier.
- It increases self-confidence when students use the microphone in front of the class.
- It improves the attention and focus of students.
- It improves the student's ability to hear the teacher from any location in the room, when writing on the chalkboard, when speaking softly, and above classroom noise.
- It improves student's ability to concentrate and ignore classroom noise.
- It improves student's behavior.
- It is easier on the teacher when using the FM system.
- Students enjoy using the FM sound field classroom amplification system. Every classroom should have one.

Administrator comments.

- It saves the teacher's voice and they are less fatigued at the end of the day.
- Students could hear the teacher equally as well from any point in the classroom and able to hear the teacher clearly at all times.
- Students seemed to listen better.
- Students seemed to focus more quickly and consistently.
- Students were more in tune with the teacher.
- Students like using the amplification and felt important.
- Class time was saved because instructions did not have to be repeated.

Project Evaluation

FM sound field amplification was evaluated by 1221 students (Table 6), 55 general education classroom teachers (Table 7), 630 parents (Table 8), and 27 school administrators (Table 9) using evaluation forms devised for the project (Florida Department of Education, 1995a). Evaluations from both phases of the project were generally positive based on perceived benefits. A summary of convincing comments provided by students, teachers, parents, and school administrators who participated in Phase I is provided in Table 6.

Student Evaluation. Use of the FM sound field amplification system was evaluated by student participants in Phases I (N = 663) and II (N = 558). Students were requested to respond "yes" or "no" to five statements read by the teacher according to a prepared script. A summary of the students' affirmative responses is given in Table 7. Students in Phase II gave slightly higher affirmative responses on four of the five statements than did those in Phase I. As may be seen, students were very strong in supporting the use of FM sound field amplification, which suggests that they felt the FM system was a valuable contribution to enhanced listening in the classroom.

Table 7. Summary of percentage of affirmative responses by students on the evaluation of FM sound field classroom amplification for Phase I (N = 663) and Phase II (N = 558) of the ICA Project.

Statement	Phase I	Phase II
It is easier to hear my teacher when he/she uses the microphone.	97.44%	98.59%
My teacher's voice is loud and clear when he/she uses the microphone.	94.57%	95.41%
The speakers help me listen better.	95.78%	96.47%
When my teacher is writing on the board I can still hear him/her.	96.53%	96.29%
I want to use the listening equipment again next year.	94.70%	94.70%

Teacher Evaluation. As may be seen in Table 8, teachers were unanimous in their agreement that decreased vocal strain was their greatest perceived benefit from FM sound field amplification. This result is not unexpected since research has shown that teachers present a significantly higher frequency of vocal problems than the general population (Sargent, Gidman, Humphreys, & Utley, 1980). Crandell and Smaldino (1995b) suggested that teachers' vocal problems may result, at least in part, from their need to increase vocal output to be heard over the classroom noise. There were no *strongly disagree* responses offered by teachers in either phase of this study. The marked difference for assistance from the audiologist may be explained because an audiologist was available in each of the districts participating in Phase I. For Phase II, the audiologist/project manager provided the inservice training and was then available only by telephone for consultation. Teachers in Phase II cited more technical difficulties than the Phase I group. In Phase I, teachers reported that they used the sound field system an average of 4.43 hours per day and the second group averaged 3.88 hours of daily use. Teachers indicated that their use of the sound field amplification system was influenced by their class schedules (e.g., learning centers, out of classroom time for special classes).

Parent Evaluation. There was a 67.42% response rate for parent evaluations in Phase I (N = 447) and a 42.46% response for Phase II (N = 183). Of that number, 38.03% and 24.59% of parents observed the sound field system in use in the classroom in Phases I and II respectively. A summary of their appraisal is provided in Table 9.

Administrator Evaluation. Like the 14 school administrators in Phase I, the 13 administrators completing the evaluation form at the conclusion of Phase II were in 100% agreement that teachers enjoyed using the FM sound field systems (Table 10.) The sound field system was observed in use at least five times by 42.86% (Phase I) and 61.54% (Phase II) of the administrators, with the remainder observing five to ten times during the project's designated observation period.

Table 8. Summary of teacher evaluation of FM sound field classroom amplification for Phase I (N = 30) and Phase II (in italics) (N=25).

Statement	Rank	Strongly Agree	Agree	Neutral	Disagree
Less emotional strain and fatigue during teaching.	8 *7*	73.33% *60.00%*	20.00% *40.00%*	6.67%	
Students seem more attentive.	8 *9*	73.33% *56.00%*	20.00% *44.00%*	6.67%	
Decrease in need to repeat directions and information.	11 *7*	56.67% *64.00%*	43.33% *32.00%*	 *4.00%*	
Students seemed to listen and understand better.	10 *10*	66.67% *60.00%*	26.67% *32.00%*	6.67% *8.00%*	
Teacher's voice seemed to reach all students no matter where they were seated.	5 *3*	90.00% *80.00%*	10.00% *20.00%*		
Did not have to strain voice to reach students.	1 *1*	100.00% *92.00%*	 *8.00%*		
FM equipment helped with classroom control and managing student behavior.	12 *11*	50.00% *48.00%*	30.00% *48.00%*	16.67% *4.00%*	3.33%
FM equipment was easy to use.	2 *6*	93.33% *76.00%*	6.67% *20.00%*	 *4.00%*	
Teacher enjoyed using FM sound field system.	5 *3*	90.00% *80.00%*	10.00% *20.00%*		
Teacher felt comfortable using the FM equipment.	5 *2*	90.00% *88.00%*	10.00% *8.00%*	 *4.00%*	
Teacher would like to keep the amplification system in their classroom.	2 *3*	93.33% *88.00%*	6.67% *4.00%*	 *8.00%*	
Assistance from the audiologist prepared teacher to use FM system.	2 *11*	93.33% *68.00%*	6.67% *8.00%*	 *24.00%*	

The "strongly disagree" category was available but not selected by any of the respondents.

Table 9. Summary of parent evaluation of FM sound field classroom amplification for Phase I (N = 447) and Phase II (in italics) (N=183).

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
My child seemed to enjoy using the classroom amplification system.	64.27% *65.57%*	18.88% *20.22%*	13.48% *12.02%*	1.35% *1.09%*	2.02% *1.09%*
My child's behavior seemed to improve at school when the classroom amplification was used.	24.65% *28.42%*	22.00% *28.42%*	48.07% *44.81%*	3.63% *2.73%*	2.04% *3.83%*
My child's grades improved when using the classroom amplification system.	19.50% *24.59%*	26.98% *24.59%*	46.71% *43.72%*	4.31% *4.37%*	2.49% *2.73%*
My child would like to continue using the classroom amplification equipment at school.	69.51% *65.85%*	16.14% *16.94%*	8.74% *8.74%*	3.59% *3.83%*	2.02% *1.09%*

Table 10. Summary of school administrator evaluation of FM sound field classroom amplification for Phase I (N = 14) and Phase II (in italics) (N=13).

Statement	Strongly Agree	Agree	Neutral
Teachers seemed to enjoy using FM sound field classroom amplification.	78.57% *76.92%*	21.43% *23.08%*	
FM sound field amplification enhanced class instruction and management.	64.29% *38.46%*	28.57% *61.54%*	7.14%
Decreased number of absences for teachers in amplified classes.	14.29% *7.69%*	7.14% *30.77%*	78.57% *61.64%*
Decrease in behavior referrals from amplified classes.	14.29%	50.00% *53.85%*	35.71% *46.15%*
Decrease in referrals for special services or interventions from classes with amplification.	14.29% *7.69%*	28.57% *15.38%*	57.14% *76.92%*

Cost Effectiveness

In addition to other benefits, FM sound field technology is noted to be a cost effective means to enhance the listening and learning environment. It is well known that young listeners require an enhanced signal-to-noise ratio to achieve adult-like speech recognition skills (Crandell & Smaldino, 1995a, b; Nabelek & Pickett, 1974; Nabelek & Robinson, 1982; Neuman & Hochberg, 1983; Papso & Blood, 1989;). Table 11 reveals that the daily per person cost ($.14) for the FM sound field system is less than the daily per person cost for several other frequently used types of instructional delivery equipment. Adding a minimum five year longevity factor, the cost of the basic system would decrease to $.03 per student per day for the system with or without the boom mic assembly.

Table 11. Summary of daily per person cost for the FM sound field classroom amplification system and other instructional delivery equipment. (Per person cost for equipment is based on a typical class of 1 teacher and 25 students.)

Instructional Delivery Equipment	Daily Per Person Cost
FM Sound Field Classroom Amplification System	$ 0.14
FM Sound field Classroom Amplification System with Boom Mic	$ 0.16
Computer with CD and Reference Bundle	$ 0.41
Basic Computer	$ 0.33
TV (25") with VCR	$ 0.18
Overhead Projector	$ 0.10
Filmstrip Projector with Sound	$ 0.08
Cassette Tape Player	$ 0.04

Cost for instructional equipment is based on the bid list held by the School Board of Sarasota County, FL.

Summary

The *IMPROVING CLASSROOM ACOUSTICS (ICA)* project implemented in 33 Florida school districts over a three-year period demonstrated that FM sound field classroom amplification is an effective intervention strategy to produce significant change in students' listening and learning behaviors and skills. Students in early grade general education amplified classrooms demonstrated significantly greater change in listening and learning behaviors and skills and progressed at a faster rate than grade-alike peers in unamplified classrooms, with younger students showing the greatest improvement. Support from students, teachers, parents, and administrators was positive toward the use of the sound field system, and the success of this project has enabled each of the participating districts to provide sound field amplification in additional classrooms. This study also showed that unoccupied classroom noise levels and acoustical treatments have not changed over the past two decades. If this study were to be repeated, it would be important to include reverberation measurements, for this characteristic, along with noise, is one of the major contributors to poor classroom acoustics. Because there are no enforceable standards for classroom acoustics at this time, FM sound field amplification may be viewed as at least a part of the solution to improving listening conditions in classrooms. However, audiologists also should advocate for acoustical standards and modifications to enhance the listening environment in addition to recommending the use of sound field amplification. Finally, the vast array of sound field technology and options available as we enter the new millennium should continue to make sound field amplification a very desirable and affordable means to enhance listening and learning in the classroom.

Acknowledgements

The *IMPROVING CLASSROOM ACOUSTICS (ICA)* project was funded by the Florida Department of Education, Division of Public Schools, Bureau of Student Services and Exceptional Education, through federal assistance under the Individuals with Disabilities Education Act (IDEA), Part B, as a special project. The primary author managed the project.

Portions of this manuscript were presented at the 1995 American Academy of Audiology Annual Convention, Dallas and the 1996 Florida Association of Speech-Language Pathologists and Audiologists (FLASHA) Annual Convention, Ft. Lauderdale, FL.

References

Allen, L. (1991). *A school handbook on classroom amplification equipment.* Elkader, IA: Keystone Area Education Agency.

Allen, L. & Patton, D. (1990, November). *Effects of sound field amplification on students' on-task behavior.* Paper presented at the American Speech-Language Hearing Association Convention, Seattle, WA.

American Speech-Language-Hearing Association. (1996). *Guidelines for audiologic screening.* Rockville, MD: Author.

American Speech-Language-Hearing Association. (1995). Guidelines for acoustics in educational environments. *Asha, 37(Suppl. 14)*, 15-19.

Anderson, K. (1991). Hearing conservation in the public schools revisited. *Seminars in Hearing, 12*(4), 340-363.

Benafield, N. (1990). *The effects of sound field amplification on the attending behaviors of speech and language-delayed preschool children.* Unpublished master's thesis, University of Arkansas at Little Rock.

Berg, F. (1987). *Facilitating classroom listening: A handbook for teachers of normal and hard of hearing children.* Boston: College-Hill Press.

Berg, F. (1993). *Acoustics and sound systems in schools.* San Diego, CA: Singular Publishing Group.

Berg, F., Blair, J. & Benson, P. (1996). Classroom acoustics: The problem, impact and solution. *Language, Speech and Hearing Services in Schools, 27*, 16-20.

Bess, F., Sinclair, J. & Riggs, D. (1984). Group amplification in schools for the hearing-impaired. *Ear and Hearing, 5*, 138-144.

Butler, K. (1975, November). *Auditory perceptual skills: Their measurement and remediation with preschool and school-age children.* Paper presented at the American Speech-Language-Hearing Association Convention, Washington, D.C.

Crandell, C. (1991). The effects of classroom amplification on children with normal hearing: Implications for intervention strategies. *Educational Audiology Monograph, 2*, 18-38.

Crandell, C. (1993). Speech recognition in noise by children with minimal degrees of sensorineural hearing loss. *Ear & Hearing, 14*(3), 210-216.

Crandell, C. (1996). Effects of sound field FM amplification on the speech perception of ESL children. *Educational Audiology Journal, 4*, 1-5.

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

Crandell, C. & Bess, F. (1987a, November). *Developmental changes in speech recognition in noise and reverberation.* Paper presented at the American Speech-Language-Hearing Association Convention, New Orleans, LA.

Crandell, C. & Bess, F. (1987b, November). *Sound-field amplification in the classroom setting.* Paper presented at the American Speech-Language-Hearing Association Convention, New Orleans, LA.

Crandell, C. & Smaldino, J. (1992). Sound field amplification in the classroom setting. *American Journal of Audiology, 1*(4), 14-16.

Crandell, C. & Smaldino, J. (1995a). Classroom acoustics. In R. Roeser & M. Downs (Eds.) *Auditory disorders in school children* (3rd ed.) (pp. 219-234). New York: Thieme Medical Publishers, Inc.

Crandell, C. & Smaldino, J. (1995b). Speech perception in the classroom. In C. Crandell, J. Smaldino & C. Flexer (Eds.), *Sound-field FM amplification: Theory and practical applications* (pp. 29-48). San Diego: Singular Publishing Group, Inc.

Crandell, C., Smaldino, J. & Flexer, C. (Eds.) (1995). *Sound-field FM amplification: Theory and practical applications.* San Diego: Singular Publishing Group, Inc.

Crandell, C., Smaldino, J. & Flexer, C. (1999). An overview of sound field FM amplification. *The Hearing Review, 6* (6), 40-42.

Crum, M. & Matkin, N. (1976). Room acoustics: The forgotten variable. *Language, Speech & Hearing Services in the Schools, 3*, 106-110.

Downs, D. & Crum, M. (1978). Processing demands during auditory learning under degraded listening conditions. *Journal of Speech & Hearing Research, 21*, 702-714.

Elliott, L. (1979). Performance of children aged 9 to 17 on a test of speech intelligibility in noise using sentence material with controlled word predictability. *Journal of the Acoustical Society of America, 66*, 651-653.

Elliott, L. (1982). Effects of noise on perception of speech by children and certain handicapped individuals. *Sound and Vibration, 12*, 9-14.

Fior, R. (1972). Physiological maturation of auditory function between 3 and 13 years of age. *Audiology, 11*, 317-321.

Finitzo, T. (1981). Classroom acoustics. In R. Roeser & M. Downs (Eds.), *Auditory disorders in school children (2nd ed.)*, (pp. 221-233). New York: Thieme-Stratton.

Finitzo-Hieber, T. & Tillman, T. (1978). Room acoustic effects on monosyllabic word discrimination ability for normal and hearing impaired children. *Journal of Speech and Hearing Research, 21*, 440-448.

Flexer, C. (1992). Classroom public address systems. In M. Ross (Ed.), *FM auditory training systems: Characteristics, selection & use* (pp. 189-209). Timonium, MD: York Press.

Flexer, C. (1997). Sound-field FM systems: Questions most often asked about classroom amplification. *Hearsay, 11*, 5-14.

Florida Department of Education (1995a). *Improving classroom acoustics: Inservice training manual.* Tallahassee, FL: Author.

Florida Department of Education (1995b). *Improving classroom acoustics: Inservice training transparency master manual.* Tallahassee, FL: Author.

Hart, P. (1983). Classroom acoustical environments for children with central auditory processing disorders. In E. Lasky & J. Katz (Eds.), *Central auditory processing disorders: Problems of speech, language, and learning* (pp. 343-352). Baltimore: University Park Press.

Leavitt, R. & Flexer, C. (1991). Speech degradation as measured by the rapid speech transmission index (RASTI). *Ear & Hearing, 12*, 115-118.

Lewis, D. (1994a). Assistive devices for classroom listening. *American Journal of Audiology, 3*(1), 58-69.

Lewis, D. (1994b). Assistive devices for classroom listening: FM systems. *American Journal of Audiology, 3*(1), 70-83.

Markides, A. (1986). Speech levels and speech-to-noise ratios. *British Journal of Audiology, 20*, 115-120.

McCroskey, F. & Devens, J. (1975). Acoustic characteristics of public school classrooms constructed between 1890 and 1960. *NOISEXPO Proceedings*, 101-103.

Nabelek, A. & Pickett, J. (1974) Monaural and binaural speech perception through hearing aids under noise and reverberation with normal and hearing-impaired listeners. *Journal of Speech and Hearing Research, 17*, 724-739.

Nabelek, A. & Robinson, P. (1982). Monaural and binaural speech perception in reverberation for listeners of various ages. *Journal of the Acoustical Society of America, 71*(5), 1242-1248.

Neuman, A. & Hochberg, I. (1983). Children's perception of speech in reverberation. *Journal of the Acoustical Society of America, 73*(6), 2145-2149.

Olsen, W. (1981). The effects of noise and reverberation on speech intelligibility. In F. Bess, B. Freeman & J. Sinclair (Eds.), *Amplification in education* (pp. 151-163). Washington, D.C.: A.G. Bell Assn. for the Deaf.

Papso, C. & Blood, I. (1989). Word recognition skills of children and adults in background noise. *Ear and Hearing, 10*(4), 235-236.

Phonic Ear, Inc. (1993). *Easy listener free field sound system: User instructions*. Petaluma, CA: Author.

Rabbit, P. (1966). Recognition: Memory for words correctly heard in noise. *Psychonomic Sciences, 6*, 383-384.

Richards, C., Flexer, C., Brandy, W. & Wray, D. (1993). Signal-to-noise enhancing devices can improve kids reading skills. *Hearing Instruments, 44*(1), 12-15.

Rosenberg, G. & Blake-Rahter, P. (1995a). Sound-field amplification: A review of the literature. In C. Crandell, J. Smaldino & C. Flexer (Eds.), *Sound-field FM amplification: Theory and practical applications* (pp. 107-124). San Diego: Singular Publishing Group, Inc.

Rosenberg, G. & Blake-Rahter, P. (1995b). Inservice training for the classroom teacher. In C. Crandell, J. Smaldino & C. Flexer (Eds.), *Sound-field FM amplification: Theory and practical applications* (pp. 149-190). San Diego: Singular Publishing Group, Inc.

Ross, M. (1995). Foreword. In C. Crandell, J. Smaldino & C. Flexer (Eds.), *Sound-field FM amplification: Theory and practical applications* (pp. vii-ix). San Diego: Singular Publishing Group, Inc.

Sanders, D. (1965). Noise conditions in normal school class rooms. *Exceptional Children, 31*, 344-353.

Sarff, L. (1981). An innovative use of free-field amplification in classrooms. In R. Roeser & M. Downs (Eds.), *Auditory disorders in school children* (pp. 263-272). New York: Thieme-Stratton.

Sargent, J., Gidman, M., Humphreys, M. & Utley, W. (1980). The disturbance caused by school teachers to noise. *Journal of Sound and Vibration, 62*, 277-292.

VanDyke, J. (1985). Evaluating amplification in the classroom. *Rocky Mountain Journal of Communication Disorders (1)*.

Williams, A., Tharpe, A. M., & Bess, F. (1994, October). The status of amplification and earmolds worn by children in the U.S. Paper presented at the International Symposium on Amplification for Children with Auditory Deficits, Palm Springs, CA.

Zabel, H. & Tabor, M. (1993). Effects of classroom amplification on spelling performance of elementary school children. *Educational Audiology Monograph, 3*, 5-9.

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