Current Practices in Classroom Sound Field FM Amplification

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It has been amply demonstrated that sound field FM amplification, or sound reinforcement, systems can improve speech perception, reading/spelling ability, behavior, attention, psychosocial function, on-task behaviors, and psychoeducational achievement in children. To date, however, there exists a paucity of empirical data on the clinical practices of audiologists in recommending, dispensing, installing, and measuring the efficacy of such technology. The purpose of the present investigation was to examine current practices among audiologists regarding sound field FM technology. Specifically, a 20-item questionnaire was sent to 916 audiologists. Responses were received from 241 audiologists for a return rate of 26%. Theoretical and applied applications of the survey results are discussed.

Introduction

It is well recognized that sound field Frequency Modulation (FM) amplification, or sound reinforcement, systems can augment academic achievement when used in the classroom setting. It has been reported in the literature, for example, that classroom sound reinforcement can improve speech perception, reading/spelling ability, behavior, attention, psychosocial function, on-task behaviors, and psychoeducational achievement in children (see Crandell & Smaldino, 1992, 1995a, 1995b, 1996; Crandell, Smaldino, & Flexer, 1995, 1999; and Smaldino, Crandell, & Flexer, 1997 for reviews of past investigations). A classroom sound reinforcement system is similar to a small public address system, in which speech is picked up via an FM wireless microphone located near the teacher's mouth (where the effects of classroom acoustics are minimal). The teacher's speech is then converted to an electrical waveform and transmitted via an FM carrier frequency to an FM receiver. The electrical signal is then amplified, converted back to an acoustical waveform and delivered to the children in the classroom through one or more strategically placed loudspeakers. The overall objective for classroom sound reinforcement systems is to uniformly amplify the teacher's voice by approximately 8 to 10 dB, thus improving the signal-to-noise ratio (SNR) for all the children in the classroom.

Despite the reported improvements in speech perception, psychoeducational, and academic performance with the utilization of classroom sound reinforcement, there currently exists a paucity of empirical data on the clinical practices of audiologists in recommending, dispensing, installing, and measuring the efficacy of such technology. Hence, there is no sense of a "standard of practice" for delivery of this technology to the classroom. With these considerations in mind, the purpose of the present investigation was to examine current practices among audiologists in the recommendation, dispensing, installation and measuring of effectiveness of sound reinforcement technologies in the classroom. To obtain these data, a 20-item questionnaire was sent to 916 audiologists.

Methodology

A 20-question survey was designed by the authors to focus on factors that would clarify a "standard of practice" for classroom sound reinforcement offered by audiologists in the field. The survey was sent to 916 members of the Educational Audiology Association (EAA), because of the belief that the bulk of classroom sound reinforcement activity is conducted by audiologists working in an educational setting. Questionnaires, sent by mail or facsimile, were addressed directly to the audiologist. No identifying information was requested in an effort to ensure confidentiality. A self-addressed, stamped envelope was provided to return the questionnaire. The questionnaire sought information in the following areas of interest: (1) the percentage of classrooms in the audiologists' school district presently containing sound field amplification; (2) the number of sound field systems the audiologists recommended or dispensed each month; (3) the person who installed the sound field system in the classroom; (4) the individual who recommended the placement, directionality, and number of loudspeakers in the classroom; (5) the number of loudspeakers and what type of microphone was typically recommended; (6) the person who primarily provided teacher training of the sound field unit; (7) the populations of children for whom the sound field units were typically recommended; (8) how efficacy of the sound field installation was measured; and (9) where audiologists primarily learned about FM sound field technology. In addition, the survey provided questions concerning the audiologists' impressions of various sound field companies. Data concerning sound field FM companies will be presented in a subsequent report. The complete questionnaire, with total responses, is presented in Appendix A.

Results

Responses were received from 241 of the 916 educational audiologists (return rate of 26%). Due to the cost of sending out questionnaires to over 900 audiologists, a follow-up mailing was not conducted. The results of the responses from the first section of the questionnaire, which sought demographic information on

the audiologist completing the survey, are presented in Figures 1 to 3. Figure 1 illustrates, in percentage, the specific areas of audiology (educational, private practice, hospital, etc.) that the respondents worked in. As expected, survey results indicated that the vast majority of respondents were employed in educational settings (82%). The remainder the respondents were employed in university settings (7%), private practices (5%), hospitals (3%), ear, nose, and throat (ENT) offices (2%) and other settings (1%). Figure 2 presents the area of country (e.g., Northeast, Southeast, Midwest, Southwest, West) that the respondents worked in. Overall, the majority of the audiologists worked in the Midwest (37%), followed by the Northeast (27%), Southeast/West (16% each), and Southwest (4%). It is uncertain from these data if the low percentages for the Southwest were due to a low response rate from that geographical area or from a limited number of available educational audiologists in that region. Figure 3 shows the total number of students within the audiologists' school districts. As indicated in the figure, over three-fourths of the respondents (77%) worked in school districts in excess of 10, 000 children.

Figure 1. Responses (in percentage) to the question "What area of audiology do you primarily work in?" (N=240).

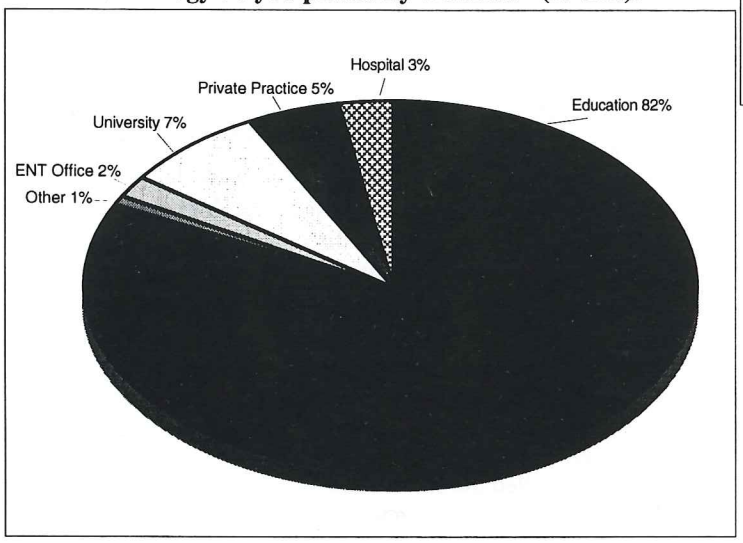


Figure 2. Responses (in percentage) to the question "What area of the country do you work in?" (N=241)

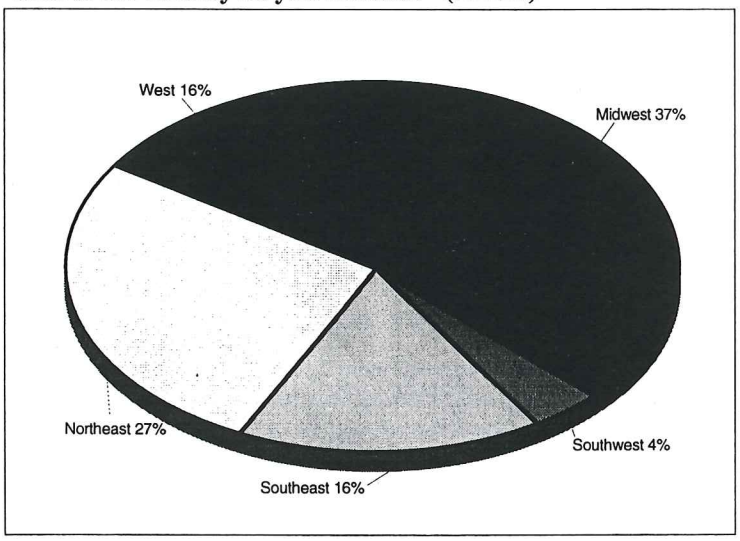
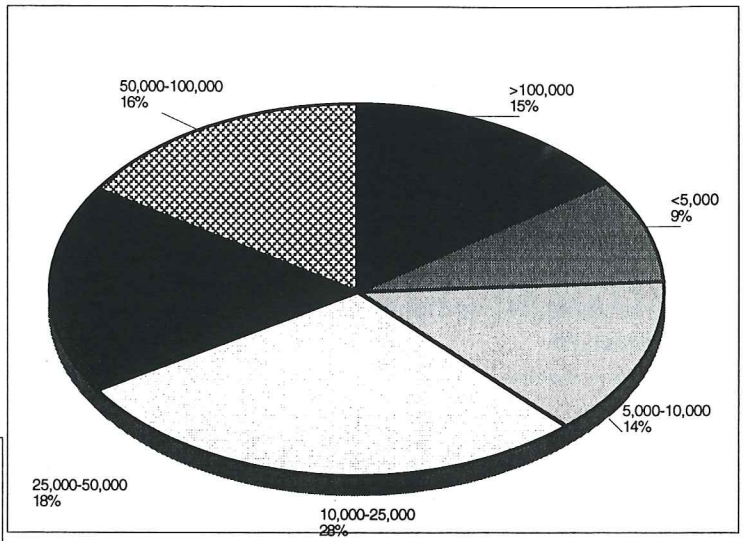


Figure 3. Responses (in percentage) to the question "If you work in educational audiology, pproximately how many students are in your school district?" (N=237)



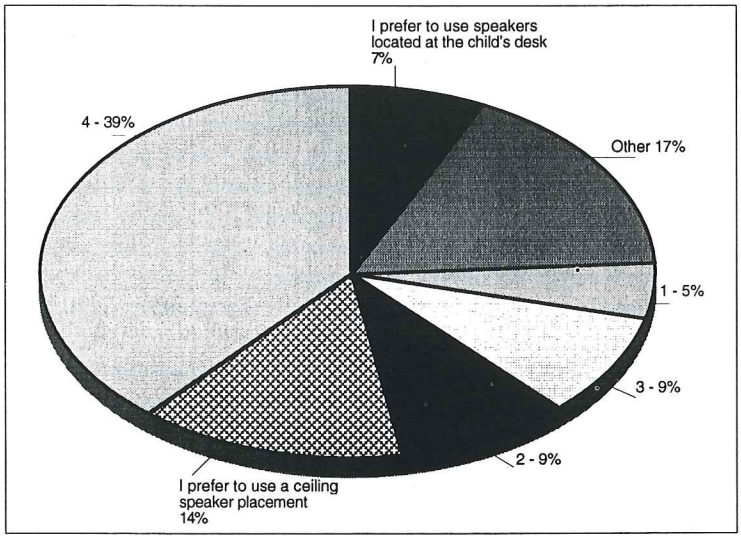
The following series of questions surveyed the respondents on the number of sound field systems currently used in classrooms in their districts, and the number of units they typically recommended or dispensed (sold) on a monthly basis. Although not shown in a figure, respondents indicated that 8.6% of the classrooms in their school districts currently had sound field amplification installed. Table 1 demonstrates that the vast majority of the audiologists surveyed in this investigation recommended, but did not dispense, sound field FM amplification. Specifically, as can be noted from Table 1, 73% of the respondents solely recommended the utilization of such technology, while 19% dispensed and recommended sound field technologies. Eight percent neither recommended nor dispensed sound reinforcement technologies. Finally, the respondents indicated that they recommended and/or dispensed approximately 2.4 sound field units on a monthly basis.

The next part of the questionnaire surveyed the respondents concerning who generally recommended where the sound field system would be placed in the classroom and who physically installed the technology within the classroom. Moreover, this series of questions was used to query the audiologists regarding who generally recommended the number of loudspeakers in the classroom, whether or not the Q factor of the loudspeakers was considered and the type of microphones that were routinely recommended. These questions were considered important because taken together they determine the uniformity and clarity of the sound delivered by the sound reinforcement system. [Note: The Q factor of a traditional loudspeaker is a measure of the angle with which sound is dispersed as it leaves the loudspeaker. If the dispersion is narrow, more loudspeakers are often needed in order to produce uniformity of amplification through-

out the room. If the dispersion pattern of loudspeaker is broad, then usually fewer speakers are required to accomplish uniform amplification.]

Table 2 shows the respondent data on who generally recommended where the loudspeaker(s) will be placed in the classroom. It is interesting to note that in the vast majority of cases (83%), the audiologist made the recommendation on where the loudspeaker(s) should be placed in the classroom. The audiologist also made the decision (79% of the time) on the number of loudspeakers to be placed in the classroom (see Table 3). In addition, as can be seen in Table 4, the audiologist physically installed the sound field system the majority of the time (65%). Figure 4 shows how many loudspeakers the audiologist generally recommended to be used in the classroom. Thirty-nine percent of the respondents preferred a 4-loudspeaker setup, while 14% preferred ceiling speaker placement. Additionally, 9% used either a 2- or 3-loudspeaker setup, 7% used desktop systems, while 5% used a one-speaker system. Interestingly, 17% of the respondents used other loudspeaker setups, such as a distribution of speakers across the entire classroom ceiling.

Figure 4. Responses (in percentage) to the question "How many loudspeakers do you generally prefer to use in the classroom?" (N=241)



Of some concern is the finding that only 14% of the audiologists evaluated the Q factor of the loudspeakers prior to placement in the classroom (see Table 5). Since Q is a measure of speaker directivity, it is unclear whether installers actually obtained the sound coverage they expected. When questioned about microphone type, over half of the respondents (56%) preferred a boom microphone (see Table 6). Twenty-one percent used lapel microphones, 18% recommended collar microphones, and 5% used other microphone types.

Information regarding teacher training and the evaluation of sound field installation efficacy is shown in Figure 5 and Tables 7 to 9. Overall, as indicated in Figure 5, 87% of the audiologists provided teacher training. Tables 7 to 9 show how teacher, parent and student perception of sound field FM amplification is measured. In each case, the most common procedure for evaluating the sound field unit was speaking to the individual personally. Overall, commercially-available efficacy forms, such as the Screening Instrument for Targeting Educational Risk (SIFTER) (Anderson, 1989) or the Listening Inventory for Education (LIFE) (Anderson & Smaldino, 1998) were only used 25% of the time for teachers, 13% of the time for students, and 1% of the time for parents.

Figure 5. Responses (in percentage) to the question "Who primarily provides the teacher training of the sound-field unit?" (N=236)

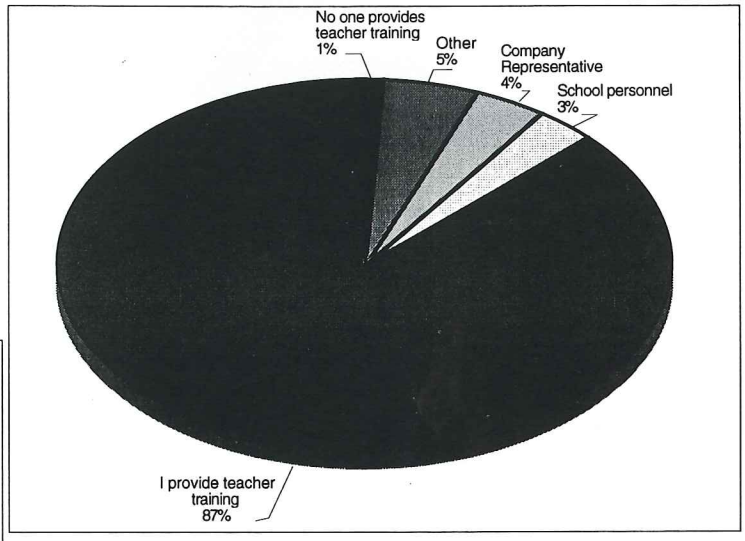


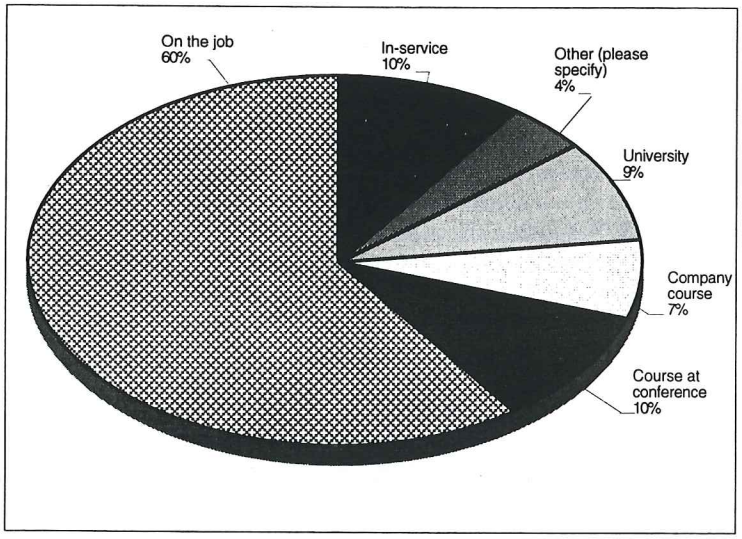
Table 10 shows the populations of children for which audiologists typically recommended sound field FM amplification. As can be noted from this table, the foremost group of children recommended for sound field amplification was children with conductive hearing loss (69%). Children with central auditory processing deficits (68%), children with minimal degrees of sensorineural hearing loss (SNHL) (66%) and younger children (63%) were also likely to receive this recommendation.

Tables 11 and 12 show whether the audiologist conducted classroom observation and/or classroom acoustical modifications prior to sound field FM amplification installation. Results indicated that while 72% of audiologists observed the classroom prior to installing sound field amplification in those rooms (Table 11), only 32% attempted to conduct acoustical modifications in that classroom (Table 12). Finally, Figure 6 presents data on where respondents had primarily learned about sound field FM technology. As can be noted, approximately 60% of the audiologists learned about sound field FM technology "on the job," while 27% obtained information from professional and company conferences/in-services. Only 9% learned about such technology in university settings.

Discussion

The present investigation examined current practices among audiologists in the recommendation, dispensing, installation and efficacy measurement of sound reinforcement technologies in the

Figure 6. Responses (in percentage) to the question "Where did you primarily learn about FM sound-field technology?" (N=241)



classroom. To obtain these data, a 20-item questionnaire was sent to 916 audiologists, all members of the EAA. Responses were received from 241 audiologists, which accounted for a return rate of 26%. A number of the findings from this investigation are pertinent in establishing a "standard of practice" for the delivery of sound field FM technology into the classroom setting. First, it was encouraging to note that respondents indicated that almost one out of every ten (8.7%) classrooms in their school districts already had sound reinforcement systems installed. Moreover, respondents indicated that they recommended and/or dispensed an additional 2.4 sound field FM units on a monthly basis. While these data suggest that many classrooms still require sound field technology, they also indicate that such technologies (and the audiologists recommending sound field technologies) are making a significant impact on improving educational strategies in the United States.

On perhaps a slightly discouraging note, data from this study also indicated that only 19% of audiologists surveyed actually dispensed or sold, sound field FM amplification systems. One reason for the lack of dispensing sound field FM amplification is the fact that, unlike hearing aids, such instrumentation is usually minimally profitable. However, if the installation of a sound field FM system could be viewed as a component of an overall room acoustics evaluation and modification, the audiologist could charge for the evaluation and modification services and be able to justify the low profit margin on the hardware itself. A second reason for the low number of audiologists dispensing sound field FM amplification is contractual arrangements with school districts. That is, due to contractual restrictions with various school districts, many educational audiologists may not be currently able to dispense sound field FM amplification nor personal amplification devices. Hopefully, results from the next survey will indicate a greater number of audiologists dispensing sound field FM amplification for profit.

Because of the many factors that need to be considered when selecting and installing sound reinforcement equipment, it was encouraging to see that, in the majority of cases, audiologists recommended the placement (83%) and number (79%) of loudspeakers in the classroom. In addition, audiologists were typically the ones actually physically installing the sound reinforcement equipment (65% of the time). This suggests that audiologists are becoming highly aware of the needs of the classrooms in their venues and are taking the responsibility for deciding what placement and number of loudspeakers would work the best. Despite a lack of empirical data concerning the "best" loudspeaker strategy in the classroom, the more traditional concept of a four-loudspeaker installation remained the most popular (39% of audiologists). However, it also appeared that newer loudspeaker strategies, such as ceiling speakers (14%) and desktop units (7%) are gaining popularity. The one area of reticence regarding loudspeaker placement concerned how few audiologists (14%) considered a specific Q value for the loudspeaker recommended. Since Q is a measure of speaker directivity, it is unclear whether audiologists actually obtained the sound coverage they expected from a particular speaker arrangement. Interestingly, the majority of audiologists are recommending boom microphones (56%) over other types of microphones (e.g., collar, lapel). This finding was encouraging as it is it is well recognized that boom microphones can offer a more consistently advantageous improvement in SNR over other microphone strategies (Crandell et al., 1995).

It is also clear from these data that audiologists recognize the importance of training teachers how to effectively use sound reinforcement technology. Specifically, audiologists personally trained the teacher about the use of such technology 87% of the time. Although not evaluated in the survey, it should be recognized that listening training for the students would further enhance the effectiveness of the technology. Enlisting the understanding and support of parents for the technology could help with generalization of good listening skills outside the classroom into the home. While there was an awareness that efficacy should be evaluated, the unstructured interview format used by most of the respondents could miss important variables. The more structured forms such as the SIFTER and LIFE were not used frequently. Since these efficacy forms assess characteristics known to relate to listening and learning in the classroom, audiologists may be missing important information that could be used when developing overall intervention strategies. Clearly, there is a need for a greater emphasis on measuring the effectiveness of the sound field systems installed.

Another finding of this investigation was that sound field FM amplification was most typically recommended for children with conductive hearing loss, children with central auditory processing deficits, children with minimal degrees of SNHL and younger children (<15 years old). Certainly, these results were encouraging as past investigations have directly demonstrated, or strongly suggested, that sound field FM amplification can significantly augment the academic performance of such populations of children. However, audiologists also commonly recommended sound field technologies for populations of children (children with cochlear implants, children with moderate or profound

degrees of SNHL, children with hearing aids) that have limited empirical support for the utilization of sound field FM amplification. For example, Crandell, Holmes, Flexer and Payne (1998) showed that traditional sound field amplification (4-loudpseaker system) did not improve the speech-perceptual abilities of children with cochlear implants. It must be noted, however, that recommendation of sound field FM technology for such populations is not prohibited as long as efficacy of the technology and installation is measured. Certainly, the authors have seen individual cases where sound field FM technology has proved beneficial for children with moderate degrees of SNHL or cochlear implants. This is to just caution the audiologist that there are limited empirical data to support utilizing sound field amplification for some populations of children. Clearly, in these cases efficacy must be carefully evaluated. Unfortunately, the present investigation did not query respondents on whether or not efficacy was measured for individual populations of children. Another potentially concerning finding in this area was the rather low percentage of audiologists recommending sound field FM amplification for children for whom English is a second language (16%), children with learning disabilities (26%), children with reading disabilities (10%), and children with developmental delays (19%). Certainly, prior investigations have demonstrated that such populations exhibit significant perceptual difficulties when placed in classroom environments (see Crandell et al., 1995 for a review of past investigations).

Results from the survey also indicated that almost three-fourths (72%) of audiologists observed the classroom environment prior to installing sound field FM amplification. This is an extremely positive finding as it is well recognized that careful observation of teaching style, classroom-seating arrangement throughout the school day, and student listening needs are imperative for an appropriate sound field installation. Conversely, it was somewhat disappointing that only 32% of the audiologists attempted to conduct acoustical modifications in the classroom prior to sound field installation. Once again, it is well recognized that acoustical modifications (to reduce ambient noise and reverberation levels) should be attempted prior to sound field placement. Of course, it is reasonable to assume that these data may indicate the unavailability of funds for acoustical modifications available for many classrooms today (Crandell et al., 1995). Finally, approximately 60% of the respondents indicated that they had primarily learned about sound field FM technology "on the job." An additional 27% of the respondents learned about sound field technology from professional and company conferences/in-services. Only 9% learned about such technology in university settings. It is hoped that future studies are able to report a greater number of audiologists learning about such technologies in university classes and/or pratica. It is also hoped that more state, national, and international symposia will be available for this fast growing, well recognized technology.

Conclusions

These survey results suggest that educational audiologists are firmly embracing sound reinforcement technologies into their scope of practice. This is extremely encouraging news, because there is no professional better positioned or educated to deal with the complex issues of classroom acoustics. As the scope of practice for audiologists expands, so must the knowledge base of the professional and the acute awareness of the need to establish efficacy for interventions designed to remove the barriers to listening and learning in the classroom. While the data from this investigation strongly suggest that audiologists are doing an excellent job in most areas regarding classroom sound reinforcement technologies, there are several areas where audiologists may feel challenged to do a better job in the future. Hopefully, subsequent investigations will continue to demonstrate the effectiveness of audiologists in the improvement of educational strategies in the United States.

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Table 1. Responses (in percentage) to the question "Do you dispense (sell) or recommend sound-field FM units?" (N=239)

Recommend Only	73%
Dispense (sell) and Recommend	16%
Dispense (sell) Only	3%
None of the above	8%

Table 2. Responses (in percentage) to the question "Who generally recommends where the loudspeaker(s) be placed in the classroom?" (N=240)

I Make That Recommendation	83%
Company Representative	8%
School Personnel	2%
Other	7%

Table 3. Responses (in percentage) to the question "Who generally recommends the number of loudspeakers to be used in the classroom?" (N=240)

I Make That Recommendation	79%
Company Representative	14%
School Personnel	2%
Other	5%

Table 4. Responses (in percentage) to the question "Who generally physically installs the sound-field FM unit in the classroom?" (N=238)

I Physically Install the Sound Field System	65%
School Personnel	17%
Company Representative	7%
Other	11%

Table 5. Responses (in percentage) to the question "Do you consider the Q factor of the loudspeaker when selecting the loudspeaker(s) for a room?" (N=221)

Yes	14%
No	86%

Table 6. Responses (in percentage) to the question "What type of microphone do you generally prefer to have the teacher use in the classroom?" (N=241)

Boom	56%
Lapel	21%
Collar	18%
Other	5%

Table 7. Responses (in percentage) to the question "How do you primarily evaluate the teacher's perception of the sound-field FM amplification?" (N=213)

I Personally Speak to Them	62%
I Provide Questionnaires such as the SIFTER or LIFE	25%
I Do Not	6%
Other	7%

Table 8. Responses (in percentage) to the question"How do you primarily evaluate the parents' perception of the sound-field FM amplification?" (N=216)

I Personally Speak to Them	58%
I Provide Questionnaires such as the SIFTER or LIFE	1%
I Do Not	38%
Other	3%

Table 9. Responses (in percentage) to the question "How do you primarily evaluate the students' perception of the sound-field FM amplification?" (N=221)

I Personally Speak to Them	61%
I Provide Questionnaires such as the SIFTER or LIFE	13%
I Do Not	17%
Other	9%

Table 10. Responses (in percentage) to the question "What populations do you typically recommend for sound-field amplification (check all that apply)?" (N=241)

Children with conductive hearing loss	69%
Children with central auditory processing difficulties	68%
Children with minimal degrees of SNHL	66%
Younger children (< 13 to 15 years old)	63%
Children with unilateral SNHL	56%
Children with mild degrees of SNHL	52%
Children with cochlear implants	47%
Children with attentional deficits	41%
Children with hearing aids	38%
Children with normal hearing/history of otitis media	35%
Children with learning disabilities	26%
Children with language disorders	20%
Children with moderate degrees of SNHL	19%
Children with developmental delays	19%
Children for whom English is a second language	16%
Children with reading disabilities	10%
Children with articulation disorders	8%
Children with severe-profound degrees of SNHL	8%
Other populations	8%

Table 11. Responses (in percentage) to the question "Do you generally conduct classroom observation prior to sound-field FM placement?" (N=237)

Yes	72%
No	28%

Table 12. Responses (in percentage) to the question "Do you generally implement physical classroom acoustical modifications (i.e., carpeting, ceiling tile, etc.) prior to sound-field FM placement?" (N=239)

Yes	32%
No	68%

Appendix A. Sound-field FM Questionnaire

1 What area of Audiology do you primarily work in?

Education	197
Hospital	7
Private Practice	12
University	17
ENT Office	5
Other	2

2 What area of the country do you work in?

Northeast	64
Southeast	39
Midwest	89
Southwest	10
West	39

3 If you work in Educational Audiology, approximately how many students are in your school district?

<5,000	21
5,000-10,000	33
10,000-25,000	66
25,000-50,000	43
50,000-100,000	38
>100,000	36

4 What percentage of classrooms in your school district has FM sound-field placements? 8.6%

5 Do you dispense (sell) sound-field FM units?

Dispense (sell)	7
Recommend	175
Dispense (sell) and recommend	38
None of the above	19

6 Approximately how many sound-field units do you dispense or recommend every month? 2.4

7 Who generally recommends the loudspeaker(s) to be placed in the classroom?

Company Representative	19
School personnel	5
I make that recommendation	199
Other	17

8 Who generally recommends the number of loudspeakers to be used in the classroom?

Company Representative	34
School personnel	5
I make that recommendation	189
Other	12

9 Who generally physically installs the sound-field FM unit in the classroom?

Company Representative	17
School personnel	40
I physically instll the sound-field system	155
Other	26

10 How many loudspeaker(s) do you generally prefer to use in the classroom?

1	12
2	22
3	22
4	94
I prefer to use a ceiling speaker placement	33
I prefer to use speakers located at the child's desk	17
Other	41

11 Do you consider the Q factor of the loudspeaker when selecting the loudspeaker(s) for a room?

Yes 31
No 190

12 What type of microphone do you generally prefer to have the teacher use in the classroom?

Boom	135
Lapel	51
Color	43
Other	12

13 Who primarily provides the teacher training of the sound-field unit?

Company Representative	10
School personnel	7
I provide teacher training	205
No one provides teacher training	2
Other	12

14 How do you primarily evaluate the teacher's perception of the sound-field FM amplification?

I do not measure efficacy	13
I provide questionnaires such as the SIFTER or LIFE	53
I personally speak to them	132
Other	15

15 How do you primarily evaluate the parent's perception of the sound-field FM amplification?

I do not measure efficacy	82
I provide questionnaires such as the SIFTER OR LIFE	2
I personally speak to them	125
Other	7

16 How do you primarily evaluate the students' perception of the sound-field FM amplification?

I do not measure efficacy	37
I provide questionnaires such as the SIFTER OR LIFE	29
I personally speak to them	135
Other	20

17 What populations do you typically recommend for sound-field amplification?

Younger children (<13 to 15 years old)	152
Children with conductive hearing loss	166
Children with articulation disorders	19
Children with language disorders	48
Children with learning disabilities	63
Children for whom English is a second language	39
Children with severe-profound degrees of SNHL	19
Children with developmental delays	46
Children with normal hearing/history of otitis media	84
Children with central auditory processing difficulties	164
Children with minimal degrees of SNHL	159
Children with mild degrees of SNHL	125
Children with moderate degrees of SNHL	46
Children with unilateral degrees of SNHL	135
Children with cochlear implants	113
Children with reading disabilities	24
Children with attentional deficits	99
Children with hearing aids	92
Other	19

18 Do you generally conduct classroom observation prior to sound-field FM placement?

Yes	171
No	66

19 Do you generally implement physical classroom acoustical modifications prior to sound-field FM placement?

Yes	76
No	163

20 Where did you primarily learn about FM sound-field technology?

University	22
Company course	17
Course at conference	24
On the job	144
In-service	24
Other (please specify)	10