A Comparison of Lecture and Problem-Based Instructional Formats for FM Inservices

Susan Naeve-Velguth
Deepa Hariprasad, and Mark E. Lehman
Department of Communication Disorders
Central Michigan University

This study compared the pedagogical approaches of traditional lecture and problem-based learning (PBL) for professional inservice instruction on classroom FM systems. Participants attended either a lecture or PBL instructional session, and each completed a pretest, immediate post-test, and one-week post-test examination of his or her knowledge of three FM systems (Phonic Ear Personal Easy Listener, Phonic Ear FreeEar, Phonak MicroLink). The findings indicated that the PBL group's post-instruction scores were significantly higher than those of the lecture group. These data and other findings are discussed in terms of the potential effectiveness of PBL as an instructional model for FM inservices.

Introduction

Restricted access to auditory information in the classroom may impair a student's ability to recognize and understand speech, which may negatively affect his or her ability to learn (Flexer, 1995). Students with hearing impairment are especially disadvantaged in that their ability to understand speech in noisy and reverberant classrooms is significantly poorer than that observed for their normal hearing peers (Finitzo-Hieber & Tillman, 1978). Personal FM systems provide listening benefits to students with hearing impairment over hearing aids alone by improving the signal-to-noise ratio at the listener's ear, typically in the range of 15-20 dB (Hawkins, 1984). To ensure maximum benefit to the student, it is important that FM systems are consistently in good working order. One role of the educational audiologist is to provide inservice training to school personnel on these classroom amplification units (ASHA, 2002b). The purpose of the present study is to compare the pedagogical approaches of problem-based (Gijselaers, 1996) and lecture-style instructional formats for professional inservices on personal FM systems.

The Classroom Listening Environment

A quality classroom listening environment is essential to a child's ability to learn (Flexer, 1995; Johnson, 2000; Nelson & Soli, 2000). The development of verbal skills, reading and writing, and academic progress are all dependent upon a child's ability to acquire auditory information (assuming the acquisition of an oral language; Davis, Elfenbein, Schum & Bentler, 1986; Holte, 1993; Quigley & Paul, 1984). Because auditory comprehension is necessarily based on the more basic processes of accurate speech detection and recognition, learning through listening requires that a student has full auditory access to his or her teacher's spoken utterances. Restricted access to auditory information in the educational setting can occur when the teacher's voice is of low intensity (e.g., the student is not seated near the teacher), when it is masked by a non-target auditory signal (e.g., classroom noise is louder than the teacher's voice creating a poor signal-to-noise ratio), and/or when it is interfered with by reverberant speech energy (i.e., the classroom reverberation time is high). A student's speech recognition abilities, and thus learning through listening, can be negatively affected under each of these conditions (Nabelek & Pickett, 1974a,b; Neuman & Hochberg, 1983).

Classroom Listening and the Need for FM Systems

Students with hearing loss are at a particular disadvantage when listening in such classroom environments because the ability of individuals with hearing impairment to recognize speech is more negatively affected by poor signal-to-noise ratio (SNR) and high reverberation time (RT), as compared to normal-hearing listeners (Dirks, Morgan & Dubno, 1982; Finitzo-Hieber & Tillman, 1978; Keith & Tallis, 1972; Nabelek & Pickett, 1974a,b; Suter, 1985). For example, Finitzo-Hieber and Tillman (1978) reported that when listening under classroom-like SNR and RT conditions, monosyllabic word recognition for normal-hearing listeners ranged from 30 to 71% correct, while (aided) scores for the students with hearing loss were much poorer, ranging from 11 – 52% correct (SNR: 0 - +6 dB, RT: 0.4 -1.2 sec; for reports of typical classroom noise levels, SNRs, and RTs see Bess, Sinclair & Riggs, 1984; Bradley, 1986; Crandell & Smaldino, 1994; Sanders, 1965). These and other findings have led to recommendations that classroom listening environments should meet or exceed a minimum SNR of +15 dB and a maximum RT of 0.4 – 0.7 sec (ANSI, 2002; ASHA, 1995; Crandell, Smaldino & Flexer, 1995; Crandell, Smaldino, 2000; Picard & Bradley, 2001).

Although children with hearing impairment are typically fitted with personal amplification, hearing aids alone are often not enough to help these students understand their teacher in a noisy and reverberant classroom (ASHA, 2002b; Duquesnoy & Plomp, 1983; Finitzo-Hieber & Tillman, 1978; Killion, 1997; Van Tasell, 1993). Current hearing aid technology, including wide dynamic range compression, digital noise-reduction, and directional microphones, cannot reliably improve SNR for all young listeners to the degree required for effective classroom communication (Johnson, 2000; Smaldino & Crandell, 2000). In addition, because the intensity of a target signal at the listener's ear is reduced with increased speaker-to-listener distance, hearing aids alone cannot overcome the negative effects of listening in an environment where the distance between a teacher and a student is not always constant or predictable. For these children, the negative effects of noise, distance, and reverberation are best addressed by the use of a personal assistive listening device, such as an FM system, used either alone or in conjunction with the student's hearing aids (Bentler, 2000; English, 1995; Smaldino & Crandell, 2000; Johnson, 2000). Personal FM systems enhance speech recognition by way of improving SNR, typically in the range of 15-20 dB (Hawkins, 1984).

FM Inservices

Because FM systems have the potential to enhance learning by improving SNR, it is important that these systems are used properly to ensure maximum benefit for the student. Unfortunately, this is not always the case. Bess et al. (1984) found approximately 50% of teacher FM transmitter-microphone and student FM receiver units failed at least one of a 27-point physical condition checklist. Similarly, Johnson (1998) found only 56.8% of prescribed amplification (hearing aid(s) and/or FM units) to be in satisfactory working condition upon inspection. These findings suggest the need for improved inservice training of educational staff on student hearing aids and FM systems used in the classroom.

One role of the educational audiologist is to provide teachers and school staff with inservice training on how to use and maintain classroom FM systems (ASHA, 2002a,b). A traditional form of pedagogy is to provide learners with new information by way of lecture-based instruction. Within such an FM inservice, the primary focus is the presentation of oral and written materials, and the demonstration of FM systems by an audiologist to educational staff. Although hands-on experience with classroom amplification systems would be an expected part of such FM inservices (English, 1995; Johnson, 2000), within a traditional lecture-style presentation, hands-on activities would not lead or dominate instructional time.

Problem-Based Learning

In recent years, many training programs in the health professions have begun to include instruction where students learn by "discovering" and "doing" rather than by teachers "explaining" and "showing" (Beard, Robinson, & Smout, 2002; Curtis, Indyk & Taylor, 2001; Fincham & Shuler, 2001; Scheiman, Whittaker, & Dell, 1989; Williams, 2001). This form of instruction is called problem-based learning (Barrows, 1983; Gijselaers, 1996). Problem-based learning (PBL) is a pedagogical approach where learners acquire new information by actively working through problems embedded within hands-on activities, clinical cases, and realistic scenarios (Jonassen & Hernandez-Serrano, 2002; Ram, 1999). Within problem-based learning, a student plays an active role in determining what he or she needs to learn, students are encouraged to work collaboratively, and there is a focus on the relationship between theoretical knowledge and its practical application (Cooke & Moyle, 2002). Within this model, the instructor does not lecture, but observes the problem-solving efforts of students and facilitates their thinking (Savery & Duffy, 1995).

Research suggests that PBL has been successfully implemented in nursing and medical schools, teaching training programs, and education in the allied health fields, and is associated with higher examination scores, as compared to instruction provided via lecture (Aaron, Crocket, Morrish, Basualdo, Kovithavongs, Mielke & Cook 1998; Bennett & English, 1999). Aaron et al. (1998) evaluated examination scores for a class of medical students enrolled in a single problem-based learning course, with all of their other courses taught by lecture. The results indicated that the students' examination scores were higher for the PBL-content areas than for the material related to their other courses. In a study of the application of problem-based learning to hearing conservation instruction for children, Bennett and English (1999) found that PBL participants had significantly higher immediate and one week post-test scores on a 10-point examination than did children who attended a lecture covering equivalent content.

In addition to improved exam performance, research suggests that PBL is also associated with greater levels of student motivation and time spent on learning (Ozuah, Curtis & Stein, 2001), enhanced clinical communication skills (Bernstein, Tipping, Bercovitz & Skinner, 1995), and enhanced ability to apply information to a new context or problem (Cockrell, Caplow & Donaldson, 2000). Ozuah et al. (2001) assessed self-directed learning behaviors in medical students receiving PBL instruction as compared to those receiving lecture-style instruction and found PBL students spent more out-of-class time learning course material, performed more computer literature searches, and formed more discussion and study groups than those students who attended lectures. Bernstein et al. (1995) surveyed a class of medical students before and after a 5-week long problem-based clinical experiences course and found the majority of students felt that PBL helped them develop better peer-to-peer and doctor-patient communication skills. These students also reported that the discussion component of the PBL format increased their ability to remember what they learned, as well as allowed them to actively think about the material instead of just memorizing information. Similarly, Cockrell et al. (2000) investigated the perceptions of graduate students enrolled in two PBL courses and found that the students reported that they had good information recall, that they were confident with the material they were learning, and that they were able to apply the information acquired in the problem-based learning sessions to other problems and environments.

Purpose of the Present Study

To date, there are no studies that have examined problem-based learning as an instructional format for FM inservices.

Given the importance of classroom FM systems to learning for children with hearing loss and the rate at which classroom amplification may exhibit unsatisfactory performance, it is reasonable to consider whether school personnel may benefit from a PBL approach to FM inservice instruction. The purpose of the present study was to compare learning outcomes using a lecture style format versus a problem-based learning approach in the delivery of instructional content on three personal FM systems used in the public schools with children who have hearing loss.

Method

Participants

Thirty-four adults enrolled in a university course on communication disorders in school-age children participated in the study (females = 27, males = 7). The university course from which participants were drawn was open to individuals pursuing degrees in communication disorders, regular education, special education, and other related undergraduate and graduate programs. All participants were adults living in or near the location of the university, a mid-sized city in Michigan. Participant sex, ethnic background, and age (over 18 years) were not controlled. Participation in the study was voluntary.

Procedure

Prior to their participation, the study was explained and participants signed a university Internal Review Board approved consent form. One week later, each participant was randomly assigned to and attended either a 25-minute lecture presentation (N = 16) or a 25-minute interactive problem-based workshop (N = 18) on three FM systems used for school-aged children with hearing loss. The lecture and PBL sessions were conducted on the same day by the same two instructors, and covered equivalent content. All participants first completed a 15-point written examination on the three FM systems included in the study. This pretest evaluation took approximately 10 minutes to complete. An independent sample t-test of the problem-based and lecture instructional method pretest means revealed no significant difference in pretest scores (Problem-Based pretest mean = 6.89, sd = 2.30; Lecture pretest mean = 6.63, sd = 2.00; p= .725). The lecture and PBL instructional sessions were conducted following the pretest: immediately, in the case of the lecture group, and approximately 35 minutes following the pretest for the PBL group. Because the lecture and PBL sessions were conducted on the same day by the same two instructors, the sessions could not occur simultaneously. While not attending their research instructional session (i.e., lecture or PBL workshop) study participants attended a discussion held by their course instructor on a topic unrelated to FM systems. The sequence for the lecture group was pretest, FM lecture, course instructor discussion session. The sequence for the PBL group was pretest, course instructor discussion session, PBL workshop.

Immediately following the conclusion of the PBL or lecture FM instructional session and before he or she moved on to any other activity, each participant completed a 15-point post-test examination. This exam represented the immediate post-test evaluation, took about 10 minutes to complete, and was identical to the pretest except for the randomization of items. The total amount of time participants spent completing the pretest exam, instructional session, and post-test exam was approximately 45 minutes. One week following the lecture and PBL sessions, study participants completed a third randomization of the 15-item examination, which represented the 1-week post-test evaluation and took approximately 10 minutes to complete.

The written exam used for the pre-, immediate-post, and one-week post-tests was developed by the authors for the purposes of the present study (Appendix A). The exam items were reviewed by three audiologists prior to their use, who verified their appropriateness for the project. In addition, five individuals who were not familiar with FM systems and who were not associated with the study were asked to complete the examination to confirm that the correct multiple choice answers were not intuitively obvious to respondents.

Lecture format The lecture-based session consisted of a 25-minute description of the component parts and basic operation of three different FM systems: 1) the Easy Listener by Phonic Ear Corporation (model PE 300), 2) the MicroLink by Phonak Corporation (model ML5S); 3) and the FreeEar by Phonic Ear Corporation (model PE 700). The goals of the presentation were, for each system, to explain: 1) how to identify, assemble, and use the parts of the system used by the teacher; 2) how to identify, assemble, and use the parts of the system used by the student; 3) how to turn the system on and off; and 4) how to recharge the system. These goals were accomplished by way of an oral presentation, supplemented by a video-projected visual presentation of a lecture outline and example FM systems. The final five minutes of the 25 minute session were reserved for questions. This period consisted of the instructors responding to participant questions.

Problem-based learning format The 25-minute PBL session consisted of hands-on, small-group experiences with the Easy Listener, MicroLink and FreeEar systems listed above. The goals of the PBL session were identical to those of the lecture, with the exception that they were to be met by way of participant discovery and self-directed learning. This was accomplished by providing participants access to functioning FM units and, for each system, a 1-2 page set of guidelines. The guidelines included a simple description of the FM system; diagram(s) of the unit, illustrating the system's parts and how they go together; an outline of the session's instructional goals; and problems and questions designed to encourage student activity and interaction. To illustrate, the FM system description from the Easy Listener's workstation guidelines read: "This system is called an Easy Listener and is used to help children with mild hearing losses hear their teacher's voice better in the classroom. The purpose of this exercise is to help you become more familiar with the Easy Listener. Please work through the following questions, using the materials provided." One of the goals for the Easy Listener from the workstation guidelines read: "Goal: Understanding how to set-up the teacher microphone and transmitter." One of the problems for the Easy Listener from its guidelines read: "When using the Easy Listener, the teacher must wear something that will pick up his/her voice and transmit it to the student, so that it can be heard. Which part(s) are worn by the teacher and how do they go together?"

Using these materials, participants worked in groups of 2-3 individuals at each of three FM-system workstations. Six work stations were prepared for the PBL session: two stations with an Easy Listener system each, two stations with a MicroLink system each, and two with a FreeEar system each (see below for specific system components and settings). Each workstation included a set of guidelines as described above. Two identical work stations were available for each of the three FM systems in order to ensure participants were able to access each system in the time allotted. Participants were instructed to begin at a workstation of their choosing, learn about the FM system at each station by reading and following the guidelines, and to ask an instructor for assistance if they needed help. They were informed that they had a total of 20 minutes of hands-on time with the FM systems. The participants worked at their own pace, and rotated through the work stations as they finished with each FM system. The instructors walked among the students and made themselves available to respond to questions. The final five minutes of the 25 minute session were reserved for group discussion. This period consisted of the instructors listening to and facilitating participants' reporting of what they experienced during the session, and responding to any final participant questions.

Materials

The FM systems used in this study consisted of standard audiological equipment commonly used in the school setting. The performance of each system was consistent with manufacturer's descriptions and specifications (ASHA, 2002; ANSI, 1996).

Easy Listener The Easy Listener personal FM system consisted of an FM transmitter (Phonic Ear, 300T), FM receiver (Phonic Ear, 300R), Sony walkman-style headphones (Phonic Ear, AT-541), a Phonic Ear lapel microphone, and a recharging cable (Phonic Ear, AT-534). The maximum output of this system is pre-set by the manufacturer and is approximately 120 dB SPL with the volume at its highest setting of 10. Participants were advised to begin listening with the system at its lowest volume control setting and to adjust the volume to a level no higher than was comfortable for them.

MicroLink The MicroLink personal FM system consisted of an FM transmitter (Phonak, TX2), a Phonak lapel microphone, an FM receiver (Phonak, ML5S), a hearing aid (Phonak, PicoForte3 PP-SC, direct audio input ready), and a recharging unit (Phonak, CH-1). In addition, a "dummy" FM receiver (Phonak, ML5S, no internal components) was included with each MicroLink workstation to allow participants to become comfortable with attaching and detaching the FM receiver to the hearing aid before working with the functional unit, if they so chose. The maximum output of the hearing aid was set to the minimum, which is approximately 108 dB SPL, according to manufacturer specifications. Participants were advised to begin listening with the hearing aid at its lowest volume control setting and to adjust the volume to a level no higher than was comfortable for them. Students listened to the MicroLink system with a listening stethoset and were advised to clean the eartips with disinfecting wipes after each use.

FreeEar The FreeEar personal FM system consisted of a hearing aid with a built-in FM receiver (Phonic Ear, 700R, moderate), an FM transmitter (Phonic Ear, 300T), a Phonic Ear lapel microphone, and a recharging cable (Phonic Ear, AT-534). The maximum output of this system was set to the minimum, which is approximately 105 dB SPL, according to manufacturer specifications. Participants were advised to begin listening with the system at its lowest volume control setting and to adjust the volume to a level no higher than was comfortable for them. Students listened to the FreeEar system with a listening stethoset and were advised to clean the eartips with disinfecting wipes after each use.

Results

Following the completion of the study, the pretest, immediate post-test, and one-week post-test exams were scored. An analysis of variance (ANOVA) with repeated measures was performed to test for differences in the between-subjects variable of Instructional Method (lecture, problem-based learning), and the within-subjects variables of Time (pretest, immediate post-test, one-week post-test) and Device (Easy Listener, FreeEar, MicroLink). The results of the analysis indicated that the main effect of Instructional Method was significant ($F_{1,32} = 4.89$, $p = .034$), with the problem-based group achieving a higher mean score than the group instructed by lecture (see Table 1).

The results of the ANOVA also indicated that main effects of Time and Device were significant (Time: $F_{2,64} = 42.8$, $p < .001$; Device: $F_{2,64} = 34.4$, $p < .001$), as was the interaction of Time x Device ($F_{4,128} = 8.8$, $p < .001$). Inspection of the Time variable means indicated that the mean score was the lowest for the pretest condition, the highest for the immediate post-test condition, and the one-week post-test score fell between the two (see Table 1). Post hoc comparisons indicated that the Time means were each significantly different from one another ($p < .01$).

An inspection of the Device variable means revealed that the mean score was the highest for the Easy Listener, the next highest for the FreeEar, and the lowest for the MicroLink (see Table 1). Post hoc comparisons indicated that each Device mean was significantly different ($p <. 01$) from each of the others. A visual inspection of the Time x Device interaction means (see Figure 1) suggested that for both the FreeEar and MicroLink systems: 1) participant scores improved pretest to immediate post-test, 2) participant scores declined immediate post-test to one-week post-test conditions, and 3) one-week post-test scores were higher than pretest scores. In contrast, for the Easy Listener system, although participant scores improved between the pretest and immediate post-test conditions, and participant scores declined between the immediate post-test and one-week post-test conditions, the pretest and one-week post-test appeared equally high. Finally, a visual

Table 1. Mean (with maximum possible) and 95% confidence interval (CI) examination scores by Instructional Method, Time and Device

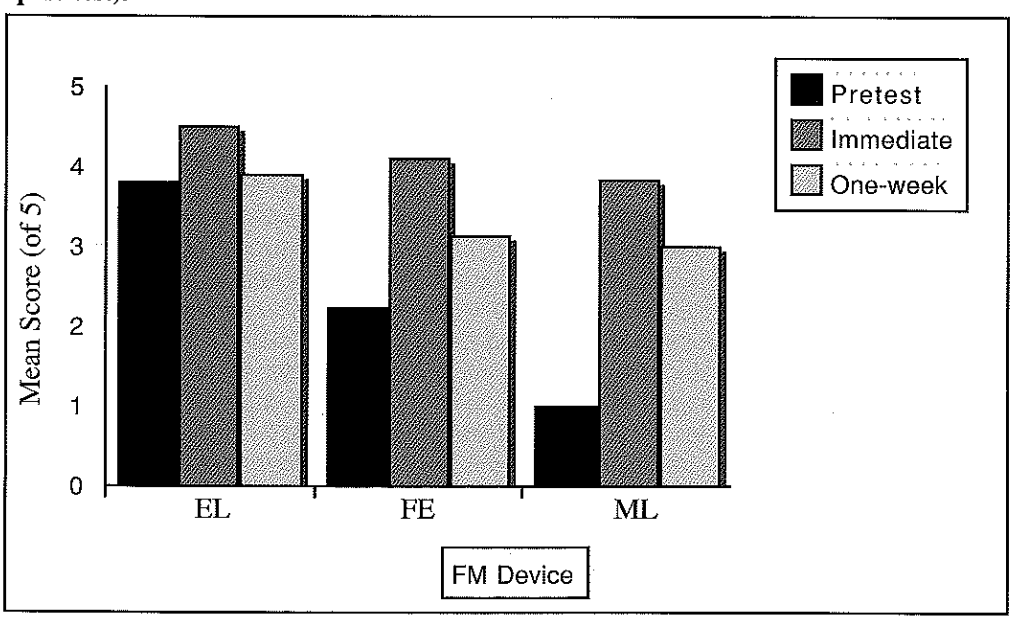
Variable	*Mean (maximum score)*	*95% CI Lower bound*	*95% CI Upper bound*
Instructional Method			
Problem-based	10.39 (15)	9.47	11.31
Lecture	8.94 (15)	7.97	9.91
Time			
Pretest	6.75 (15)	6.00	7.50
Immediate post-test	12.45 (15)	11.67	13.17
One-week post-test	9.72 (15)	8.49	11.13
Device			
Easy Listener	3.93 (5)	3.64	4.20
FreeEar	3.15 (5)	2.79	3.42
Microlink	2.63 (5)	2.37	2.84

comparison of the pretest means across FM systems suggested that the Easy Listener pretest mean was greater than that of the FreeEar and the MicroLink.

As a follow-up to the significant Time x Device interaction, a series of one-way ANOVAs with repeated measures was performed to test for differences in Time (i.e., pretest, immediate post-test, one-week post-test) for each of the three FM devices (i.e., Easy Listener, FreeEar, and MicroLink). The results indicated that with the exception of one comparison, each Time mean for a given FM system was significantly different ($p <= .01$) from each of the system's others. Thus, for example, in the case of the MicroLink, the pretest mean was significantly different from the immediate ($p < .001$) and one-week post-test ($p < .001$) means, which were significantly different from one another ($p = .001$). The single pair of means for which a significant difference was not found was for the Easy Listener pretest vs. one-week post-test comparison ($p = .69$).

The two-way interactions of Time x Learning ($F_{2,64} = 1.8$, $p = .17$) and Device x Learning ($F_{2,64} = 1.4$, $p = .26$) were not significant, nor was the three-way interaction of Time x Device x Learning ($F_{4,128} = .43$, $p = .79$). Despite a nonsignificant Time x Learning interaction, statistical comparisons of the problem-based and lecture immediate post-test and one-week post-test means were conducted in order to assess the effects of Instructional Method as a function of Time independent of the pretest data, separately assessed for pre-instructional group equivalence (see Methods, above). An independent sample t-test of the problem-based and lecture instructional method immediate post-test means revealed that the PBL and lecture scores were significantly different from one another immediately following instruction, with the PBL score higher than the mean score for the lecture group (see Figure 2; Problem-Based immediate post-test mean = 13.72, sd = 1.27; Lecture immediate post-test mean = 11.13, sd = 2.83; $p = .001$). An independent sample t-test of the problem-based and lecture instructional method one-week post-test means revealed that although the PBL score was higher than that of the lecture group at one week post-instruction (see Figure 2), this difference did not reach statistical significance (Problem-Based one-week post-test mean = 10.56, sd = 3.70; Lecture one-week post-test mean = 9.06, sd = 3.91; $p = .261$).

Figure 1. Mean examination subscores for the Easy Listener (EL), FreeEar (FE), and MicroLink (ML) FM systems as a function of time (pretest, immediate, and one-week post-test).

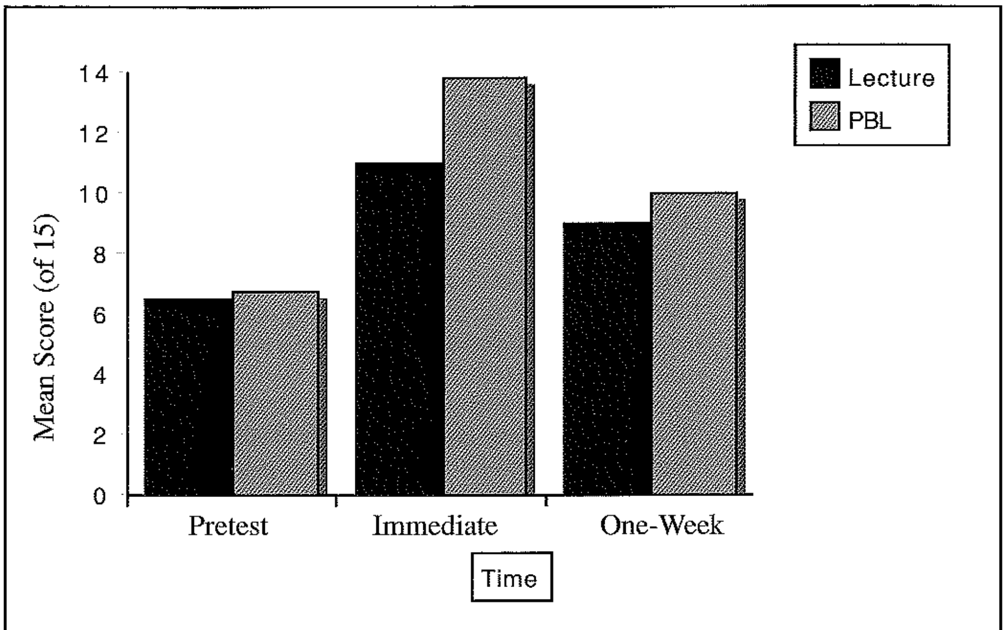


Discussion

Effect of Instructional Method

The findings of the present study suggest that problem-based learning may be a more effective instructional model for FM inservices than a traditional lecture style presentation. Although the PBL vs. Lecture one-week post-test comparison did not reach statistical significance, this may have been due to the large variance values found for these data, in combination with the study's restricted sample size. As reported above, the standard deviations for the one-week post-test data were 3.70 and 3.91, for the PBL and lecture groups, respectively. These standard deviations were outside the range of those found for the pretest and immediate post-test data (1.27 – 2.82). Because greater variance in a data set reduces the likelihood of a true difference in means reaching

Figure 2. Mean pretest, immediate, and one-week post-test scores for the lecture and problem-based learning instructional method groups.



Student learning may also be enhanced when it is self-directed and self-paced. In problem-based learning, students progress through activities in their own way and at their own pace and have greater personal control over their individual learning experience. With PBL, students may be better able to familiarize themselves with material and spend more time on specific concepts that they understand less well, as compared to students who listen to an instructor-paced and instructor-directed lecture. In addition, because learning is self-directed and self-paced, students may be better able to incorporate new information into their existing knowledge set, which may allow for enhanced critical thinking and self-evaluation of learning. More personalized learning experiences and greater familiarity and practice with new concepts may result in improved learning outcomes (Ericsson & Kintsch, 1995). For the present study, the PBL session's design, which allowed students to move through the work stations in the order in which they chose, to revisit work stations if they wished, and to complete activities at their own pace, may have personalized their learning experience and thus enhanced their ability to recall information that they learned.

statistical significance, especially if the underlying effect is small and the sample size is reduced (Howell, 1987), if the present study had included a greater number of participants, significance in the difference between the PBL and Lecture one-week post-test means may have been achieved. Together, the main effect of Instructional Method and the pretest, immediate post-test, and one-week post-test PBL vs. Lecture means comparisons provide support for the efficacy of problem-based learning as an instructional model for FM inservices.

The finding that problem-based learning is a more effective instructional model for FM inservices than a traditional lecture is consistent with previous reports of more positive outcomes for problem-based instruction, reflected in higher examination scores (Aaron et al., 1998; Bennett & English, 1999), greater levels of student motivation and time spent on learning (Ozuah et al., 2001), enhanced clinical communication skills (Bernstein et al., 1995), and enhanced ability to apply information to a new context or problem (Cockrell et al., 2000). Problem-based instruction may benefit learners because it centers on group-based problem solving and utilizes hands-on activities, clinical cases, and realistic scenarios. Providing learners with questions to consider, relevant issues to investigate, and realistic problems to solve—rather than requiring them to passively listen to a lecture—may generate higher levels of student interest and involvement which, in turn, may result in better learning (Glaser, 1991). For the PBL session of the present study, the personal experience of listening to an FM system, the challenges of discovering how the parts of the system must be assembled to create a working unit, and the inherent teamwork required to allow for successful resolution of the workstation problems may have enhanced student learning.

Educational audiologists may enhance classroom teachers' learning about FM systems by incorporating problem-based learning into their inservices. This may be accomplished by centering the inservice on self-discovery and problem-solving activities rather than on an oral, lecture-style presentation. For example, as for the present study, the educational audiologist may provide teachers with working FM units (either those assigned to students or units on an educational-purpose loan from a manufacturer) and, by way of prepared and goal-directed problems and guidance materials, encourage them to discover how the systems work, what they sound like when they are working and when they are in need of service, and how to handle them appropriately. Educational audiologists may also incorporate problem-based learning into FM inservices by organizing small group rather than large-group or one-on-one instructional session. For example, the educational audiologist may consider coordinating several (e.g., 4-6) individual FM inservices so that they may be conducted at the same time, even if the FM systems used by the teachers' respective students are not the same. By conducting inservices for small groups, teachers may interact with their colleagues and learn from each other, as well as develop strategies for using one another as a resource for when the audiologist is not available.

The Variables of Time and Device

The Time, Device, and Time x Device interaction data of the present study suggest that participants were able to learn about each of the FM systems by way of instruction (i.e., for each FM system, immediate post-test scores were significantly higher than pretest scores). The findings also suggest that for the MicroLink and FreeEar systems, participants were able to retain some, but not all, of what they had learned by one week post-instruction (i.e., one-week post-test means were significantly lower that immediate post-test means but still significantly higher than pretest means). One-week post-test means may have been lower than the immediate post-test means for these FM systems because study participants did not have an opportunity to apply, practice, or review the target material between the immediate and one-week post-tests (Ericsson and Kintsch, 1995). Unlike classroom teachers, who would begin to use an FM system following an inservice, participants of the present study did not have the opportunity to apply, reinforce, or practice the information they had learned between the time of instruction and the evaluation of their knowledge one week later.

The Time, Device, and Time x Device interaction data of the present study also suggest that participants came to the present study with greater prior knowledge of the Easy Listener system than for the MicroLink or FreeEar. Specifically, as described above, a visual comparison of the pretest means across FM systems suggested that the Easy Listener pretest mean was greater than that of the FreeEar and the MicroLink, and the Easy Listener one-week post-test mean was as equally high as the pretest mean. Participants' prior knowledge of the Easy Listener system may have been due to its use at the university where the study was conducted and at local elementary and secondary schools. In addition, individuals who enrolled in the course from which the study participants were drawn included students of Speech-Language Pathology and Teacher Education programs. These individuals may have learned about mild-gain personal FM systems, such as the Easy Listener, for use with children who have temporary conductive or fluctuating hearing loss, auditory processing disorders, speech and language problems, and/or learning disabilities. This background information and training was less likely to have occurred for the MicroLink and FreeEar systems due to their more narrow application of use. A limitation of the present study was a lack of test sensitivity for such potential differences in experience across the FM systems studied.

Non-Instructional Learning

Regardless of the particular FM system or pedagogical approach used for inservice instruction, the learning outcomes observed for the present study may also have been influenced by incidental learning, the integration of conceptual themes across categorically-related content areas, and/or the transfer of prior knowledge to a target area of instruction (Kaplan & Murphy, 2000; Wattenmaker, 1999). For example, participants may have perceived similarities or differences in pre- and post-instruction examination questions that influenced their responses, outside of the material they acquired directly via instruction. In addition, participants may have transferred previous or newly acquired knowledge about a particular FM system to their knowledge set about a second FM system, and then applied that knowledge when answering examination questions, apart from what they had actually learned about the second FM system during instruction. For the present study, each FM system had a similar set of multiple choice examination questions and each FM system included a similar teacher microphone unit. It is possible that participants in both the lecture and PBL groups acquired information about a given FM system by observing similarities and differences between examination questions, between the FM systems of instruction, or between an instructional FM system and one with which they had had previous experience. Although such effects are not undesirable or unexpected, it is important to note that learning in the present study may have occurred not only by way of direct instruction.

Future Research

The limited sensitivity in the examination items to differences in participants' prior knowledge of FM systems, and the lack of assessment of their prior experience with these devices represent limitations of the present study. In addition to addressing these concerns, future research might include studies that more closely replicate the experience of classroom teachers, such as providing participants with opportunities to use and practice newly acquired information following an inservice, and assessing participant learning following instruction over a period of time that is similar to a school term. Additional research topics might include assessing participant learning by evaluating teachers' actual use of and trouble shooting abilities with FM systems in their classrooms, and examining pre- and post-instruction failure rates of classroom FM units following a PBL inservice. Finally, future research might examine the feasibility and cost effectiveness of PBL for FM and other educational inservices given the fiscal and scheduling constraints of teachers, school administrators, and educational audiologists.

Summary and Conclusions

These results of the present study indicate that the main effect of instructional method was significant, with the problem-based group achieving an overall higher mean score than the group instructed by lecture. This finding, in conjunction with the pretest, immediate post-test, and one-week post-test PBL vs. lecture means comparisons, suggests that problem-based learning may be an effective instructional model for inservices on classroom FM systems. By incorporating problem-based learning into FM inservices, educational audiologists may better equip classroom teachers with the skills necessary for ensuring a better listening environment for their deaf and hard-of-hearing students.

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Appendix

1. How can you turn off the teacher's voice with the Easy Listener system?
   a. turn off the transmitter
   b. turn off the FM boot
   c. turn off the antenna
   d. turn off the hearing aid

2. Which of the following belong together for the Easy Listener system?
   a. hearing aid for the student; FM boot and antenna for the teacher
   b. FM boot for the student; antenna and transmitter for the teacher
   c. hearing aid and FM boot for the student; transmitter and receiver for the teacher
   d. receiver and headphones for the student; transmitter and microphone for the teacher

3. Which of the following is recharged for the Easy Listener system?
   a. only the student's equipment
   b. only the teacher's equipment
   c. both the student's and the teacher's equipment
   d. neither the student's nor the teacher's equipment is recharged

4. The Easy Listener system includes which of the following?
   a. transmitter, receiver, headphones, microphone
   b. hearing aid, telecoil, transmitter
   c. antenna, amplifier, headphones, receiver
   d. FM boot, antenna, microphone

5. How can you adjust the loudness of the teacher's voice with the Easy Listener system?
   a. adjust the volume control on the transmitter
   b. adjust the volume control on the receiver
   c. adjust the volume control on the FM boot
   d. adjust the volume control on the hearing aid

6. How can you turn off the teacher's voice with the Free Ear system?
   a. turn off the hearing aid
   b. turn off the amplifier
   c. turn off the telecoil
   d. turn off the receiver

7. The Free Ear system includes which of the following?
   a. FM boot, transmitter, antenna
   b. amplifier, antenna, transmitter, direct-audio-input
   c. receiver, headphones, transmitter, microphone
   d. hearing aid with built-in FM, transmitter, microphone

8. Which of the following belong together for the Free Ear system?
   a. hearing aid with built-in FM for the student; transmitter and microphone for the teacher
   b. FM boot and headphones for the student; microphone and FM boot for the teacher
   c. hearing aid and transmitter for the student; transmitter and antenna for the teacher
   d. FM boot for the student; microphone and receiver for the teacher

9. Which of the following is recharged for the Free Ear system?
   a. only the student's equipment
   b. only the teacher's equipment
   c. both the student's and the teacher's equipment
   d. neither the student's nor the teacher's equipment is recharged

10. How can you adjust the loudness of the teacher's voice with the Free Ear system?
   a. adjust the volume control on the FM boot
   b. adjust the volume control on the hearing aid
   c. adjust the volume control on the telecoil
   d. adjust the volume control on the antenna

11. How can you adjust the loudness of the teacher's voice with the MicroLink system?
   a. adjust the volume control on the telecoil
   b. adjust the volume control on the transmitter
   c. adjust the volume control on the antenna
   d. adjust the volume control on the hearing aid

12. How can you turn off the teacher's voice with the MicroLink system?
   a. turn off the receiver
   b. turn off the FM boot
   c. turn off the telecoil
   d. turn off the transmitter

13. Which of the following belong together for the MicroLink system?
   a. transmitter and headphones for the student; receiver and FM boot for the teacher
   b. hearing aid with built-in FM for the student; transmitter and antenna for the teacher
   c. FM boot and hearing aid for the student; microphone and transmitter for the teacher
   d. hearing aid for the student; FM boot and microphone for the teacher

14. The MicroLink system includes which of the following?
   a. microphone, receiver, hearing aid with built-in FM
   b. headphones, receiver, antenna, telecoil
   c. hearing aid, microphone, FM boot, transmitter
   d. direct-audio-input, headphones, transmitter

15. Which of the following is recharged for the MicroLink system?
   a. only the student's equipment
   b. only the teacher's equipment
   c. both the student's and the teacher's equipment
   d. neither the student's nor the teacher's equipment is recharged