Teaching Hearing Conservation to School Children: Comparing the Outcomes and Efficacy of Two Pedagogical Approaches

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Rousseau said, "Teach by doing whenever you can, and only fall back on words when doing is out of the question" (in Frager, 1986, p. 175). Currently, many health-related issues are taught "by doing," that is, by using a pedagogical approach called problem-based learning (PBL). Problem-based learning organizes knowledge around problems rather than disciplines. Research has indicated superior outcomes using problem-based learning in comparison with traditional lecture-style instruction. Hearing conservation, however, typically is taught using a lecture approach. This study compares the effectiveness of both teaching approaches for a hearing conservation program designed for second grade children. The PBL approach resulted in higher immediate and 2-week post-test scores compared to the lecture approach. In addition, children's exposure to noise and use of hearing protection were examined.

Introduction

Approximately 1 % of the school age population (or more than 400,000 children) may have NIHL (Blair, Benson, & Hardegree, 1996), and NIHL has been detected in children as young as nine years old (Peppard & Peppard, 1992). Over the past thirty years, research has indicated an increase in high frequency hearing loss in several age groups, even in children as young as second grade students (Chermak & Peters-McCarthy, 1991; Woodford & O'Farrell, 1983). Montgomery and Fujikawa (1992) studied the prevalence of high frequency hearing loss in second, eighth, and twelfth grade students, and found a 2.8% increase in hearing loss among second graders and a 4% increase among eighth graders, compared to data collected ten years prior. Bess, Dodd-Murphy, and Parker (1998) indicated a 14% prevalence rate for hearing loss among ninth graders, and 21% among third graders when applying the criteria used by Montgomery and Fujikawa (1992). These authors indicated that inclusion of conductive loss and regional differences may account for discrepancies found among third graders.

Noise exposure attributed to cap-guns, go-carts, personal cassette players and other activities has been suggested as the cause for this increase (Chermak & Peters-McCarthy, 1991; Clark, 1991; Mills, 1975). For example, a personal cassette player has been shown to have outputs that exceed 115 to 124 dBA (Clark, 1991; Katz, Gerstman, Sanderson & Buhanan, 1982; Wood & Lipscomb, 1972). Bess and Poynor (1972) noted that snowmobiles can range from 105 to 136 dBA. Unfortunately, children exposed to a notable amount of noise at increased levels may sufer a high-frequency sensorineural hearing loss. These students are at risk for language, academic, and social/emotional difficulties (Bess et al., 1998). Students exposed to these levels of noise would benefit from hearing conservation programs at an early age to help reduce these risks.

Need for Hearing Conservation Programs at the Elementary School Level

The prevalence of noise induced hearing loss at the elementary school level warrants the need for hearing conservation programs. Florentine (1990), Anderson (1991), and Blair et al. (1996) support this need. Florentine (1990) stresses the need for basic information to be taught to children before they are exposed to harmful noise; however, there is little information in health textbooks regarding hearing loss and prevention (Axelsson, 1990; Frager & Kahn, 1988). In Anderson's 1991 article, "Hearing Conversation in the Public Schools Revisited," she states that education in hearing conservation is a critical area that needs to be addressed, and that only early and repeated education of hearing conservation skills may reduce exposure to harmful noise and permanent hearing loss. Blair et al. (1996) reported that 97% of third grade students evaluated in their study (N = 273) were exposed to potentially harmful noise.

Effectiveness of Hearing Conservation Programs at the Elementary School-Aged Level

Few studies have evaluated the effectiveness of hearing conservation programs. Chermak and Peters-McCarthy (1991) studied the effectiveness of a hearing conservation program at the elementary level. A pre-program questionnaire revealed that 44% of the students frequently used a personal stereo system ("walkman"). Forty three percent of the students reported listening to stereo or television at a loud volume. Of those students who participated in high noise exposure activities, such as the use of firearms or attending auto races (approximately 30%), only 5.5% reported the use of ear protection. Two weeks after the hearing conservation program, answers to the post-program questionnaire indicated a statistically significant

increase in the knowledge of noise exposure. Blair et al. (1996) and Chermak, Curtis, and Seikel (1996) also found a significant increase in knowledge at the elementary level following in-class activities on noise, noise induced hearing loss, and hearing protection. Blair et al. (1996) also reported strong intentions among students to protect their hearing after participating in a hearing conservation program. The results of these studies demonstrate some effectiveness of a hearing conservation program at the elementary school level.

Teaching Hearing Conservation

All of the studies cited above used a traditional lecture format to deliver the instructional content. However, educational research is showing that students should be actively rather than passively engaged to acquire and master knowledge (Glaser, 1991). To develop an integrated and generative knowledge base, the student also should build upon prior knowledge (Dochy, Segers, & Moerkerke, 1996; Dolmans, Snellen-Balendong, Wolfgang, & Van Der Vleuten, 1997). Modern cognitive theories state one of the key features of memory is its associative ability, rather than repetition and rehearsal (Bruer, 1993; Brunning, Schraw, & Ronning, 1995). The need to activate existing knowledge to facilitate processing of new knowledge, self-monitoring or goal-setting skills, and use of knowledge are three key principles of modern cognitive theory (Gijselaers, 1996).

Problem-based learning (PBL) is a pedagogical approach based on these theories. It is designed to increase interest, motivate, and engage the students, and build on prior knowledge. PBL has five assumptions: 1) learning begins with a problem; 2) the problem is one that students are apt to face in the future; 3) the knowledge students are expected to gain is organized around the problem rather than disciplines; 4) students, individually and collectively, assume responsibility for their own learning; and 5) most of the learning occurs within small group discussion other than lecture. By organizing knowledge around problems rather than disciplines, PBL stimulates higher level thinking skills, guides students to construct meaning from their own activities, and provides a bridge between theory and practice (Sheiman, Whittaker, & Dell, 1989). The instructor serves as an observer, a resource, and a facilitator, instead of a lecturer (Barrows, 1983; Bransford, Franks, Vye, & Sherwood, 1989; Cordeiro, 1998; English, 1996, 1998; Pearson, 1996; Posnar & Pudnitsky, 1994). These practices are consistent with Piaget's concrete operation stage theory, which describes children from ages 7-12 as having the ability of concrete thought, conservation, classification, and ordering objects by attributes and relation (Lefrancois, 1988). Abstract concepts, such as loudness and noise, therefore need to be experienced by the child in a problem-solving manner in order to apply them to real world situations.

The following study was designed to compare the learning outcomes of a hearing conservation program presented through two different approaches (lecture and PBL). In addition, this study collected information about children's exposure to noise and use of hearing protection.

Methods

Subjects

One hundred and twenty-six children (males = 71, females = 55) enrolled in eight regular education classrooms participated in the study. All subjects were second graders (ages 7-9 years), of middle class socioeconomic status, residing in a mid-sized metropolitan city in Michigan. Five classes were taught hearing conservation material with the lecture approach (N = 69 children), and three classes were taught with the PBL approach (N = 57).

Instruments

Two questionnaires were developed by the Department of Communication Disorders, based on materials from the House Ear Institute and the National Institute for the Deaf. They were both piloted with a separate cohort of 91 second graders. The first questionnaire ("Can You Guess," Appendix A) consisted of seven questions that identify risk, awareness, and hearing conservation skills. The second questionnaire ("Noise and You," Appendix B) assessed students' exposure to noisy environments and the use of hearing protection. Five teachers reviewed both instruments and verified them to be appropriate for second grade reading levels.

Procedures

Lecture approach. The lecture-style hearing conservation program described the basic anatomy and function of the ear; hearing loss; a description of noise; the causes, early warning signs, and prevention of a noise-induced hearing loss; and the importance of regular hearing evaluations. The program was approximately one hour in length. The information was presented by the use of lecture, videos, and a visual presentation of amplification systems. A follow-along activity packet was provided to the students. Ear protection and verbal instructions regarding proper use were provided at the end of the session.

Problem Based Learning approach. The problem-based learning (PBL) approach focused on the same content as the lecture approach. The PBL hearing conservation program posed the following three problems to students: (1) How loud is our environment? (2) Can loud be too loud? and (3) How does sound travel through the ear? Students rotated through monitored work centers in the classroom, spending 15 minutes at each center, to discover for themselves about anatomy and function of the ear, environmental noise, and the risks and consequence of exposure to excessive noise levels. A follow-along packet was provided to the students. The program was approximately one hour in length.

To address the first problem ("How loud is our environment?"), students were asked to identify sound sources in their school setting, and learned how to measure sound with a calibrated Radio Shack digital sound level meter (Cat. No. 33-2055). They were divided into teams to collect samples and to record their data on a chart ranging from 0 to 120 dB.

The second problem ("Can loud be too loud?") was addressed as students discovered for themselves that there was a level where excessive loudness caused a risk, and the conse-

quences can be a permanent hearing loss. Games, materials, and discussion were used, and the investigator moderated the discussion to ensure that the information learned was accurate and complete.

To address the third problem ("How does sound travel through the ear?"), students viewed the anatomy and function of the ear on "The Ultimate Human Body: A Multimedia Guide to the Body and How it Works" CD ROM on a Macintosh PowerBook 1400c/166 laptop computer. The students followed along on a worksheet and identified the structures of the ear. The pathway of sound was discussed in a group format. When the students finished rotating through the stations, they were encouraged to teach an adult or family member what they learned during the presentation. As with the lecture approach, ear protection and verbal instructions regarding proper use were provided at the end of the program.

Data Collection

The questionnaire "Can You Guess" was administered three times: one day prior, immediately following, and two weeks following the hearing conservation programs to assess the subjects' knowledge of hearing conservation. The "Noise and You" questionnaire assessed students' exposure to noisy environments and the steps they took to protect their hearing. This questionnaire was administered during the 2-week post-test session. A teacher evaluation form was also administered following the immediate post-test session. Comments about the two teaching approaches were solicited and analyzed.

Data Analysis

A general linear model statistical analysis was performed to determine a significant difference between teaching models. This analysis was chosen over an analysis of variance (ANOVA) due to the difference between group sizes. A *t*-test was used to determine if the students developed and maintained hearing conservation skills. Interactions between the groups are identified using post hoc procedures. A difference in proportions analysis was performed for the "Noise and You" questionnaire to determine gender bias.

Results

Table 1 provides mean test scores across approaches, collected as pretests, immediate post-tests, and 2-week post-tests. Comparison of the two approaches shows no difference in pre-test scores, and statistically significant higher scores for PBL compared to the lecture format both immediately and 2 weeks after the programs, suggesting that PBL was more effective in helping children understand, retain, and recall hearing conservation information.

Noise Questionnaire

Forty-nine percent (N = 35) of the males indicated noise exposure , compared to approximately 30% (N = 17) of the females. Of the males exposed to noise, only 34% use ear protection, whereas 46% of the females indicated using ear protection. See Appendix B for responses by item.

An item-by-item comparison of the "Noise and You" questionnaire comparing male to female with a 2 sided *t*-test for a difference in proportions was conducted. Significant gender differences were noted for questions 2, 3, 4, and 5, with a larger proportion for males. Questions 1, 6, 7, 8, 9, and 10 did not show significant difference for males or females.

Table 1. Pre- and post-test results by lecture and PBL approaches from "Can You Guess" evaluation

Approach	Pre-test scores	Immediate Post-test scores	2-week Post-test scores
Lecture	5.63	6.01*	6.08*
PBL	5.69	6.56*	6.40*

*$P < 0.05$

Teachers Surveys

A teacher evaluation was administered and subjectively analyzed. Teachers were asked to comment on the interest, age-appropriateness, and effectiveness of the approach utilized in their classroom. The majority of teacher evaluations indicated that the hearing conservation program activities in both formats were age-appropriate, interesting, and effective. A comparison between formats could not be made since teachers observed only the approach used in their classroom.

Discussion

The purposes of this study were to 1) determine the effectiveness of a hearing conservation program, 2) compare the effectiveness of the lecture and problem-based learning (PBL) approaches for teaching hearing conservation skills, and 3) determine the exposure to noise and use of hearing protection in this population of second grade children. Several studies suggested an elevation in NIHL in school-aged population and the need for an effective hearing conservation program at the elementary school level. Educational and modern cognitive psychology research indicates the use of an active or problem-based learning approach to increase and maintain knowledge. Many health-related issues are successfully taught in a problem-based manner. This study indicated the effectiveness of a hearing conservation program at the elementary school-aged level, with a significant improvement in acquiring and maintaining knowledge for the groups involved in problem-based learning. Although the lecture approach resulted in an increase in the subjects' knowledge base regarding hearing health, the PBL approach resulted in significantly higher test scores, suggesting that PBL was more effective in helping children understand, retain, and recall hearing conservation information.

This study also described some types of noise risks and a general lack of use of ear protection among subjects. The majority of second grade students reported being exposed to a notable amount of noise and were not using hearing protection.

Anecdotally, carryover was observed as well among children participating in the PBL programs: several teachers reported their second grade students from the PBL groups taught

the third grade students about the ear and hearing protection during their science lesson regarding the five senses. The teachers further indicated that this activity was initiated by the students and facilitated by the teacher. This follow-up was not reported by teachers of students who participated in the lecture approach.

A limitation of this study included the absence of test-retest reliability of either questionnaire; this needs to be investigated since children may likely have high variability in responses. Additional studies also are needed to determine if either or both approaches affect changes in practices in hearing conservation: for example, does a hearing conservation program result in an increased use of ear protection or reduction of volume levels from headphones? Ultimately, the purpose of any program is to persuade children to take active steps in protecting their hearing health.

In conclusion, this study suggests that a problem-based approach is more effective than a lecture approach in hearing conservation programming, as measured by student learning outcomes.

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Appendix A
"Can You Guess"

Please answer all of the questions by answering True or False.

1. Noise I like can hurt me.
2. A hearing test is fun for me.
3. Cap guns and fire crackers are noisy.
4. Noise never makes people mad.
5. I can do something about noise.
6. Loud music is good for me.
7. Good hearing is a gift.

Appendix B
"Noise and You"

Do you listen to the radio, tapes, or CDs really loud?

Male	Female
Yes 27%	Yes 25%
No 73%	No 75%

Do you mow the lawn?

Male	Female
Yes 47%	Yes 18%
No 53%	No 82%

Do you use ear plugs when you mow the lawn?

Male	Female
Yes 40%	Yes 15%
No 60%	No 85%

Do you shoot guns?

Male	Female
Yes 54%	Yes 22%
No 46%	No 78%

Have you been standing or sitting next to someone who shoots guns?

Male	Female
Yes 61%	Yes 39%
No 39%	No 61%

Do you use ear plugs when you or someone near you shoots guns?

Male	Female
Yes 45%	Yes 50%
No 55%	No 50%

Do you go to "monster truck" races?

Male	Female
Yes 44%	Yes 28%
No 56%	No 72%

Do you use ear plugs at the races?

Male	Female
Yes 27%	Yes 25%
No 73%	No 75%

Do you ride on snow mobiles?

Male	Female
Yes 62%	Yes 47%
No 38%	No 53%

Do you use ear plugs while riding on snow mobiles?

Male	Female
Yes 27%	Yes 25%
No 73%	No 75%