The Volta Review, Volume 117(1.2)

A DESCRIPTIVE ANALYSIS OF NOISE IN CLASSROOMS ACROSS THE U.S. AND CANADA FOR CHILDREN WHO ARE DEAF AND HARD OF HEARING

Michelle A. Gremp, Ph.D., CED, and Susan R. Easterbrooks, Ed.D.

Sound levels and acoustic characteristic information was obtained in classrooms serving children who are deaf and hard of hearing (DHH) in grades K-2 in a variety of settings across the United States and Canada. Sound levels were easily measured using iPads, and acoustic characteristics were documented. Noise levels exceeded the American National Standards Institute standard for all 38 unoccupied classrooms. Classrooms in general education settings were significantly quieter than classrooms where children who are DHH received separate instruction, although significant differences did not emerge for occupied classrooms. Remote microphone technologies (such as personal-worn FM/DM systems or classroom sound field systems) were used significantly more in general education than separate instruction classrooms. Results indicated an unfavorable environment for children who are DHH to successfully access spoken language communication. This information about classroom noise levels, combined with knowledge of standards, acoustic characteristics, and sound abatement strategies is essential for parents, teachers, and administrators to secure acoustically favorable classrooms for children who are DHH.

INTRODUCTION

Being able to hear and understand what is said in the classroom is a key factor in the ability to benefit from instruction and meaningful

---

Michelle A. Gremp, Ph.D., CED, is an Assistant Professor in the Department of Special Education and Coordinator of the Education of the Deaf and Hard of Hearing Program at Eastern Kentucky University. Susan R. Easterbrooks, Ed.D., is Professor Emeritus and Co-Private Investigator at the Center on Literacy and Deafness at Georgia State University. Correspondence concerning this manuscript may be submitted to Dr. Gremp at michelle.gremp@eku.edu.

DOI: 10.17955/tvr.117.1.2.781

interactions for children who use spoken language to communicate. Classroom noise can adversely influence numerous aspects associated with both teaching and learning, including speech intelligibility, behavior, attention, memory, and motivation, as well as reading, mathematics, and spelling ability and test scores (American Speech-Language-Hearing Association, n.d. a; DiSarno, Schowalter, & Grassa, 2002; Iglehart, 2016; Mills, 1975; Neuman, Wróblewski, Hajicek, & Rubinstein, 2010; Shield & Dockrell, 2008; Stinson & Antia, 1999). All these factors can therefore potentially impact overall academic success.

While an appropriate listening environment is necessary in order for people of all ages to comprehend spoken language, it is especially important for children who are developing mature language, a phenomenon that continues until about age 15 (Nelson, Soli, & Seltz, 2002; Wróblewski, Lewis, Valente, & Stelmachowicz, 2012). Children are less experienced listeners than adults; they have less knowledge of language and fewer listening experiences and, therefore, are less able to rely on the redundancy of speech signals to fill in missing words or phrases whose clarity is reduced by competing signals in noisy environments (Mills, 1975; Nelson et al., 2002; Neuman et al., 2010). For example, Klatte, Lachmann, and Meis (2010) revealed increased difficulty in speech perception and comprehension in the presence of background noise for children with typical hearing in first and third grade compared to adults, with comprehension more adversely affected for first-grade students. Moreover, students were not able to accurately predict the impact of noise, rating disturbances as low compared to the actual measurement obtained in the study (Klatte, Lachmann, et al., 2010).

The problem posed by classroom noise has been documented for quite some time. As far back as 2002, the American National Standards Institute (ANSI), along with the Acoustical Society of America and the U.S. Access Board, set forth the first classroom standard (ANSI S12.60-2002), known as the *Acoustical Performance Criteria, Design Requirements and Guidelines for Schools Standard*, with the recommendation that the level of noise in unoccupied classrooms up to 20,000 cubic feet in size should not exceed 35 dBA. The A-weighted sound level (dBA) indicated in the ANSI measurement represents sounds which fall within the frequency range of human hearing and are important for speech, namely 20–20,000 Hz. In 2010, the recommendation was revised to reduce the classroom volume size and the present ANSI standard for noise in an unoccupied classroom is currently set at 35 dB for a classroom 10,000 cubic feet in size. The standard also designates that reverberation time (the measurement of how quickly sound decays in a room) be no greater than 0.6 seconds (American Acoustical Society, 2010). Additionally, the American Speech-Language-Hearing Association (ASHA) recommends a signal-to-noise ratio (SNR; the ratio between the sound level of a speaker's voice and the sound level of background noise) of +15 dB or greater (American Speech-Language-Hearing Association, n.d. a).

Standards are only as good as the processes and procedures set forth to monitor them. And while many states have incorporated the 35 dB standard into their construction and renovation requirements, few states' department of education have developed practices to monitor implementation. The U.S. Access Board previously identified just 6 entities that had adopted the original ANSI/ASA S12.60-2010 American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, but has since removed that section from their website due to an inability to maintain current data (D. Yanchulis, personal communication, July 20, 2015). Without mandatory compliance to the standard, it is plausible to conclude that many classrooms are exceeding noise levels proposed by ANSI and as a consequence are immersing children in noisy learning environments, which impacts speech intelligibility and academic performance. This assumption is supported by a number of studies over the years. Crandell and Smaldino (1994) looked at 32 classrooms and found none that met the noise criteria recommended at that time. Among 32 classrooms in public schools in central Ohio, only four were found to have unoccupied sound levels lower than the 35 dB requirement (Knecht, Nelson, Whitelaw, & Feth, 2002). Both private and public schools in Hawaii revealed even poorer results, with sound levels of greater than 35 dB in all 79 first, second, and third grade classrooms that were screened (Pugh, Miura, & Asahara, 2006).

Classroom noise can come from any number of sources including background noise generated by heating and cooling (HVAC) systems, lighting fixtures, computers, and projectors; external noise from hallways or outdoor traffic; and of course the children themselves.

When sound is transmitted around a room, it can experience absorption (part of the sound energy is converted to heat in an absorbing material rather than being transmitted), reflection (sound waves are bounced off a surface), and diffusion (sound waves hit an irregular surface sending the energy in many different directions). As sound waves are reflected off hard surfaces such as walls or high ceilings, sounds persist even after the sound source has stopped. Such sound persistence is referred to as reverberation, a characteristic that further affects the clarity of the speech signal because sounds overlap rather than being perceived as distinct components of words and sentences (Boothroyd, 2012). Excessive noise in the classroom creates a poor listening environment for all children because noise interferes with reception of the intended acoustic signal by drowning out the source sound, whether this is a teacher, an audio-video presentation, or a fellow student. Lower background noise in a classroom leads to a greater/better SNR because the desired sound source has less competing noise to overcome. Subsequently, the child's ability to distinguish a speaker's voice increases, potentially resulting in better speech comprehension. Therefore, the level of background noise and the SNR relationship must be addressed in schools if students are to receive adequate access to instruction, which historically has relied on teachers' spoken communication for a majority of the instructional content (Dahlquist, 1998). Indeed, even in classrooms where lively discussion takes place, students who cannot hear the teacher and other students are at a disadvantage (Klatte, Hellbrück, Seidel, & Leistner, 2010; Murphy, Wilkinson, Soter, Hennessey, & Alexander, 2009).

In order to create a clear listening and communication environment, a classroom should be free from acoustical barriers and the features that cause sound level measurements to exceed the ANSI standard. Sound measurement set forth for unoccupied rooms provides important information in assessing the acoustical environment. Thus it is problematic when unoccupied classrooms exceed the recommended dB level for a number of reasons. First of all, when dB levels in unoccupied rooms fail to meet the specified acoustical criteria, it is likely that sound is not being absorbed adequately but, rather, is being reflected off hard surfaces. This reflection may also lead to an increased reverberation time, with sounds lingering and overlapping one another. As a teacher and children occupy an already noisy room, the additional sound they generate will also be reflected around the room, causing the overall dB level to increase. In situations where overall sound levels exceed 70 dB, all conversations become difficult to hear (Nelson et al., 2002), so it logically follows those classrooms that are loud when unoccupied will reach or exceed 70 dB more quickly than quieter rooms when they are occupied by students and teacher(s). Additionally, the resulting SNR in these classrooms will be low/poor. In these circumstances, a teacher would need to struggle to project her voice at a volume sufficient to achieve and maintain a level 15 dB above the background noise in order to ensure the students' ability to hear the intended signal. Further impacting the SNR is the fact that as sound travels it loses 6 dB for every doubling of distance from the source. This distance effect, called the inverse square law, means that students seated further away from the teacher, or source of instruction, are at a disadvantage when it comes to understanding speech (The Institute for Enhanced Classroom Hearing, n.d.).

While important for all learners, classroom acoustics are critically important for classrooms serving children who are deaf or hard of hearing (DHH) because these children enter the process with compromised listening ability and generally lower language abilities (Iglehart, 2016; Nelson et al., 2002). The auditory signal that children with sensorineural hearing loss receive is not only decreased in acoustic intensity, it also has reduced clarity. Hearing aids or other amplification devices are unable to fully correct for a distorted auditory signal, making the acoustic characteristics of the classroom even more crucial. Consequently, a sound level of 30 dB has been recommended for unoccupied classrooms of students who are DHH (Crandell & Smaldino, 2000; Vaughn, 2010), a level stricter than the ANSI standard set for all children. In addition, it is recommended that the SNR be equal to or greater than +15dB (Crandell & Smaldino, 2000; Welling & Ukstins, 2015).

A significant number of children with hearing loss are now accessing some or all of their information through the auditory channel. According to the Regional and National Survey conducted by the Gallaudet Research Institute (2009-2010), approximately 70% of surveyed students who were DHH used spoken language in the classroom either solely or concomitantly with signs and/or cues. In 2015, Lederberg, Schick, and Webb reported that 60% of children who were DHH receiving instruction through pull-out services or in separate classrooms used spoken language either solely or concomitantly with signs. These learners need full and clear access to the teacher's voice or other relevant sound sources, which does not occur in noisy classrooms.

Noise abatement is a strategy known to reduce acoustical barriers in the environment resulting from emissions noise or vibrations from a sound source, thus decreasing the amount of noise present in an environment. Noise abatement strategies recommended for classrooms range from complex solutions, such as the reduction of noise generated by HVAC systems, acoustic treatment of external walls to minimize exterior noise, and installation of acoustic walls between adjacent noisy classrooms, to simple solutions, including placement of rugs or carpet, installation of window treatments, and application of soft materials such as fabric, corkboard, or felt on classroom walls (American Speech-Hearing-Association, n.d. b; Brown & Crouse, 2012). For a more complete explanation of managing classroom acoustics, see Easterbrooks and Estes (2007), Smaldino and Flexer (2012), and Seep, Glosemeyer, Hulce, Linn, and Aytay (2000).

When specified acoustical criteria are not met, persons with hearing loss are obliged to expend a great amount of energy, resulting in fatigue while listening to a message and sometimes impacting the ability to understand the meaning of the message itself (Bess, Gustafson, & Hornsby, 2014; Crandell & Smaldino, 2000; McCreery, 2015). However, despite overall agreement regarding the negative impact of noise in the classroom, compliance with the ANSI standard at the time of this study was voluntary. Furthermore, little has been reported about the state or variability of noise in classrooms serving children who are DHH. This study reports on the conditions of a large sample of classrooms from which the following data was collected: unoccupied classroom sound levels, occupied classroom sound levels, classroom setting, instructional mode of communication used in the classroom, and classroom acoustical characteristics.

The Center on Literacy and Deafness (CLAD) gathered language and literacy data from approximately 100 classrooms of children who are DHH in kindergarten through 2nd grade as part of a large grant from the Institute on Education Sciences (grant # R24C12001). When classroom observations were underway, CLAD researchers identified the need to provide a basic overview of the sound environment of the classrooms where these children were being served. Therefore, sound level measurement was introduced into the observation protocol, resulting in the subset of total classrooms presented in the current study. The purpose of the present study was to provide a picture of the acoustic environment of classrooms where children who are DHH were receiving services. The overall CLAD protocol gathered data on noise only, not on reverberation. Therefore, this study was restricted to an examination of noise level. The following specific research questions were addressed:

1. What were the sound levels in unoccupied and occupied classrooms serving children who are DHH?
2. Did sound levels of classrooms differ based upon classroom setting or classroom instructional mode?
3. What noise abatement strategies (e.g., acoustic tiles, carpeting) were employed in classrooms serving children who are DHH?
4. Did noise abatement strategies differ based upon classroom setting?

METHOD

Participants

As part of the ongoing CLAD study gathering language and literacy data over a 2 year period, the leadership team began investigating the sound level characteristics of participating classrooms located throughout the United States and British Columbia, Canada. Sound measurements for both unoccupied and occupied conditions were obtained in 19 schools and 42 classrooms where children with typical hearing and those identified as DHH were served. Noise abatement strategies were documented by research assistants and reported for 38 of these classrooms. Classrooms were located in a variety of educational environments including day/charter schools for the deaf, residential schools for the deaf, private oral schools for the deaf, local school districts with designated buildings or classrooms for students who are DHH, and neighborhood schools in the child’s local school system.

For the purpose of investigating classroom noise levels, classrooms were classified according to two different distinguishing factors. First, classrooms were identified by the instructional setting where children who are DHH were being served. The key factor for determining classroom setting was whether or not the children who are DHH received instruction alongside children with typical hearing, or in environments separate from the general education classroom. Based upon the classroom setting, the authors designated two categories of classrooms: separate instruction classroom and general education classrooms. Separate instruction classrooms included all types of classroom settings where only students who are DHH received instruction and included classrooms commonly referred to as resource or self-contained, as well as those in schools for the deaf. Conversely, the classification of general education referred to classrooms in which one or more children who are DHH received instruction in a classroom alongside children with typical hearing. Nearly 70% of the classrooms in this study were classified as separate instruction, which is slightly higher than the approximately 60% of combined special or center schools, self-contained classrooms, and resource rooms listed on the Gallaudet Regional and National Survey (2009-2010). This was a natural and not unexpected outcome of the CLAD recruitment procedures, which sought to include schools serving multiple children who are DHH; greater concentrations of these children tend to be found in settings other than the general education classroom.

Next, classrooms were classified according to the mode of communication used for instruction. This was identified at the school level as the primary mode of instruction used by teachers and was classified as sign language, spoken language, or some combination of signed and spoken language. All variety of schools mentioned previously were represented in the current study, and although the primary mode of instruction was identified for each classroom, research assistants discovered that within the two types of classroom settings, individual children used a range of communication modes, sometimes with more than one mode being used by children within the same classroom setting.

Of the more than 300 students in the total number of classrooms included here, 122 of the children were DHH. One hundred ten students were in separate instruction classrooms and 12 were in general education classrooms. All of the students in general education classrooms used some form of spoken language. In the separate education classrooms, 54 out the 110 students used spoken language, with or without some type of sign support.

Apparatus

A measure of noise in occupied and unoccupied classrooms was gathered. CLAD research assistants observing classroom instruction were provided with an iPad on which the Studio Six Digital *Real Time Analyzer*© application had been installed ("Smith," n.d.). This program conforms to ANSI and International Electrotechnical Commission (IEC) specifications for all electronic related technologies. An initial iPad was calibrated in a sound booth according to Studio Six Digital instructions. First, the audiometer presented white noise at 75 dBSPL into the sound booth. Then, inside the booth with a calibrated Sound Pressure Level (SPL) meter serving as the reference, the dB level for the microphone input on the iPad was set to match the dB level on the SPL meter. Subsequent iPads were calibrated in a similar manner, with researchers adjusting the settings and matching each iPad output level to that of the SPL meter. Final comparisons of the four iPads used in this study revealed that sound level measurements differed by no more than 2 dB among the iPads. The iPads were shipped for use at the various sites, and upon completion of the testing, subsequent comparisons revealed similar results among the sound level readings, thus providing assurance that the sound measurement devices had functioned properly. In addition to calibrating the internal microphones on the iPads, the following measurement features were selected as part of the Real Time Analyzer set-up process provided by Studio Six Digital: A-weighting measurement (dB), 1/3 octave band, and average decay (performs a continuous equal-weighted average).

Classroom acoustic information, including data related to noise abatement strategies present in the classrooms, was also gathered. Many authors, agencies, and organizations have developed and published processes and procedures for managing noise in the classroom (Crandell & Smaldino, 2001; Easterbrooks & Estes, 2007; Seep et al., 2000; Smaldino & Flexer, 2012). The Classroom Acoustic Inventory (Appendix), which became the primary observation tool for this study, was created as a compilation and refinement of these resources, and as a means of outlining characteristics of classrooms recognized to impact the overall acoustic environment in a format that was easy for research assistants to complete.

Procedure

To obtain sound measurements of unoccupied classrooms, each research assistant waited until no children were in the classroom or nearby hallways. The iPad was placed on a solid surface in a central location of the classroom and sound levels were recorded for approximately 2–3 minutes. To obtain sound measurements of classrooms occupied during language arts instructional time, each research assistant placed the iPad at desk height in a location that would be, on average, equidistant among the children and the teacher or instructional sound source and allowed the recording to continue throughout the entire class period, no matter whether the students remained in their seats or moved around. Data obtained from each recording included date and time of the recording, the octave and decay selections made on the Real Time Analyzer application, and the average, minimum, and maximum dB levels at 30 different frequencies ranging from 25 Hz through 20,000 Hz. The overall dB average was also displayed, and this value was used in the analyses presented here.

Research assistants were provided with written instructions for collecting sound measurements when the classroom was empty and again while language arts instruction was taking place in the classroom. Upon completion of the recording, data were automatically stored in the Real Time Analyzer program in an Excel spreadsheet format. Each file was sent by research assistants via email to the first author and entered into a master Excel spreadsheet.

To obtain classroom acoustic information, research assistants visually surveyed the room and completed the Classroom Acoustic Inventory. This provided information related to the number of students in the room, teacher gender, the type of school and instructional setting (general education, self-contained, or pull-out), use of remote microphone (RM) technology (e.g., personal-worn FM/DM systems, or classroom audio distribution systems [CADS]), the type of floor covering, the presence of windows and window coverings, and the presence of ceiling tiles. While RM technology traditionally may not be considered as a noise abatement strategy, it does represent a strategy to improve listening conditions and was therefore included in this category for the purpose of this study. Research assistants completed inventory sheets, and results were either scanned and emailed or sent by ground mail delivery to the first author for data entry.

Research assistants self-reported their ability to follow the specified procedures. Only those observations where all data was collected (unoccupied and occupied classrooms as well as the Classroom Acoustic Inventory) were included for the purpose of data analysis.

RESULTS

Sound Level

Descriptive data were obtained for 42 classrooms where sound level measurements were recorded. For the classrooms measured, the mean intensity level of unoccupied classrooms was 48.18 dB with a minimum or quietest level of 37.2 dB and a maximum or loudest level of 66.20 dB. The mean intensity for all occupied classrooms was 63.77 dB with minimums and maximums of 44.20 and 76.40, respectively. All unoccupied classrooms exceeded the recommended 35 dB level for all children and the recommended 30 dB level for children who are DHH.

A subset of 38 classrooms (11 general education and 27 separate instruction) had completed Classroom Acoustic Inventory data, which was analyzed in the same manner. Ranges remained identical, and the means were very similar (unoccupied room: M = 48.33, range = 29.00, SD = 7.39; occupied room: M = 63.69, range = 32.20, SD = 8.57); hence the 4 classrooms eliminated due to lack of acoustic characteristics represented neither the quietest nor the loudest rooms. The average difference between unoccupied and occupied rooms was 15.35 dB. Specific sound level measurements for these 38 classrooms based upon setting and instructional mode are presented in Table 1.

Classroom setting (separate instruction or general education) was coded for each classroom (N = 38), and was also analyzed to compare levels in both unoccupied and occupied conditions. Noise levels in unoccupied general education classrooms ranged from 37.30 dB to 51.20 dB with a mean of 43.55 dB and SD of 4.89, while separate instruction classrooms had a range from 37.20 dB to 66.20 dB with a mean of 50.29 dB and SD of 7.42. For occupied classrooms, the ranges and means

Table 1. dB levels by classroom type and instructional mode in unoccupied and occupied classrooms.

General education classrooms				*Separate instruction classrooms*			
Spoken language		*Combined sign & spoken*		*Sign language*		*Combined sign & spoken*	
Unoccupied Classroom dB	*Occupied Classroom dB*	*Unoccupied Classroom dB*	*Occupied Classroom dB*	*Unoccupied Classroom dB*	*Occupied Classroom dB*	*Unoccupied Classroom dB*	*Occupied Classroom dB*
46.3	70.2	45.8	65.3	38.3	65.8	53.1	65.9
38.7	66.2	47.6	75.3	51.5	65.3	38.0	65.7
41.9	44.2	38.2	64.6	47.0	62.7	37.2	74.7
47.4	66.9	46.8	67.2	53.5	66.3	43.0	73.0
37.9	54.8	37.3	47.0	61.8	71.1	52.4	64.9
51.2	46.6			55.3	53.3	45.0	64.4
				51.0	55.6	45.3	73.1
				66.2	68.9	49.7	60.2
				61.4	68.7	54.1	44.2
				57.5	63.4	47.3	71.9
				44.2	55.4	51.5	66.3
				54.0	54.6	55.2	73.4
						52.5	62.7
						39.1	64.1
						52.7	76.4

were as follows: general education, *M* = 60.75 dB, range = 44.2–75.3 dB, *SD* = 10.70; and separate instruction, *M* = 64.89 dB, range 44.2–76.4 dB, *SD* = 7.44. Figure 1 depicts sound level ranges for occupied and unoccupied classrooms in general education and separate instruction settings. A 2 (classroom setting) x 2 (occupancy) repeated measures ANOVA revealed a significant main effect for occupancy, $F(1, 36) = 66.92$, $p = .000$, $\eta p2 = .650$. As expected, empty classrooms were quieter than occupied classrooms. There was also a significant main effect for classroom setting, $F(1, 36) = 7.82$, $p = .008$, $\eta p2 = .178$. General education classrooms were quieter on average by 5 dB than separate instruction

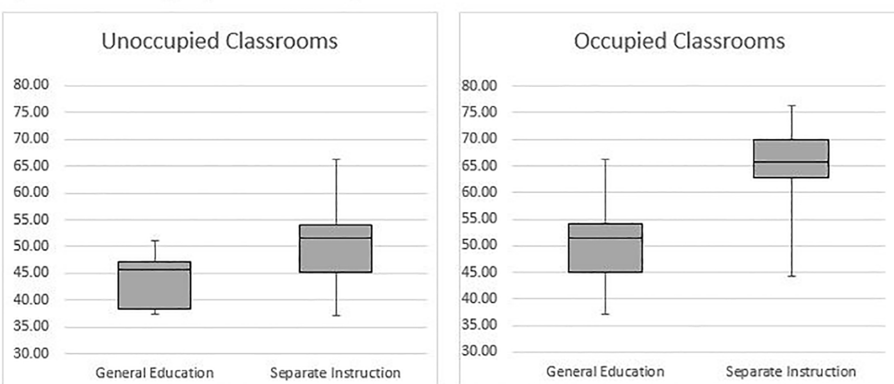

Figure 1. dB ranges in unoccupied and occupied classrooms by setting.

classrooms (M = 52.16, SD = 1.64; M = 57.59, SD = 1.05, respectively). The interaction was not significant, $F(1, 36) = 26.42$, $p = .447$.

Instructional communication mode (sign language only, spoken language only, or some combination of sign language and spoken language) was also coded for each classroom (N = 38). Means and ranges based upon this classification are presented in Table 2. A 3 (communication mode) x 2 (occupancy) repeated measures ANOVA showed a significant interaction between instructional communication mode and occupancy, $F(2, 35) = 3.41$, $p = .044$, ηp2 = .163. Instructional communication mode affected noise level in empty but not occupied classrooms. Follow-up Bonferroni comparisons showed that empty classrooms using only spoken language were significantly quieter (on average by 10 dB) than those that used sign only. These differences disappeared once the classroom was occupied. In fact, the noise level was the same across the three modalities when the classrooms were occupied.

Noise Abatement Strategies

Data were gathered on five noise abatement strategies: use and type of RM technology, floor coverings, wall type, windows, and ceiling tiles. See Tables 3 and 4 for results. The overall percent of use across both classroom settings was as follows: 42.1% of the classrooms used some type of RM technology; 89.5% of the classrooms were carpeted; 15.8% had acoustically treated walls; 73.7% of the classrooms had windows; and 92.1% of the classrooms had recognizable, though not necessarily acoustic, tiles on the ceiling. Noise abatement strategies for all classrooms were compiled and frequency of use was identified. Cross tabulation analyses were run on all five strategies. Pearson chi-

Table 2. Mean and range dB levels by instructional mode in unoccupied and occupied classrooms.

		Unoccupied Classroom dB		*Occupied Classroom dB*	
Instructional Mode	*Number of Classrooms*	*Mean*	*Range*	*Mean*	*Range*
Sign language only	12	53.5	38.3 – 66.2	62.6	55.3 – 71.1
Spoken language only	10	43.5	37.2 – 53.1	62.8	44.2 – 74.7
Combined sign and spoken language	16	47.5	37.3 – 55.2	65.1	44.2 – 75.3

Table 3. Remote microphone technology use and type by classroom setting.

Remote microphone technology	*General education classrooms*	*Separate instruction classrooms*	*Sound abatement feature*	*Pearson Chi-square* χ^2	*df*	*p value*
Whole room RM sound field system	0	3	RM system use	10.02	1	.002**
Teacher/student personal-worn RM System	9	5				
No RM system used	2	19	RM system type	4.09	1	.043*

Table 4. Comparison of noise abatement features by classroom setting.

Noise abatement feature	*Pearson Chi-square* χ^2	*df*	*p value*	*Noise abatement details*	*General education classrooms*	*Separate instruction classrooms*
Presence of windows	6.36	1	.012*	No windows in classroom	6	4
				Draperies	1	1
				Shades	0	4
				Blinds	3	13
				No window covering	1	5
Presence of carpeting	0.96	1	.326	Carpet	9	25
				Tile only- no special treatment	2	2
Wall type	7.10	3	.069	Acoustic material/fabric	4	2
				Concrete or plaster/dry wall	7	24
Ceiling type	1.32	1	.249	Acoustic ceiling tiles	7	7
				Non-acoustic ceiling tiles	1	5
				Undetermined type of ceiling tile	3	12
				No ceiling tiles present	0	3

square analyses were conducted to examine the relation between noise abatement strategies and classroom setting. Significant differences were revealed in the areas of RM technology use, χ^2 (1, $N = 38$) = 10.02, $p = .002$, type of RM technology use, χ^2 (1, $N = 17$) = 4.10, $p = .043$, and the presence of windows, χ^2 (1, $N = 38$) = 6.36, $p = .012$. No significant differences between general education and separate instruction classrooms were found in the remaining noise abatement strategies listed on the survey (floor covering, wall type, and ceiling tile).

Remote microphone (RM) technology use and type.

Classroom Acoustic Inventories indicated that some kind of RM technology was being used in 9 of the 11 general education classrooms. All 9 of these RM systems were use of the student's personal-worn RM technology; none of the general education classrooms reported use of a whole classroom RM system. In 8 of the 27 separate instruction classrooms, RM technologies were in use; 3 of these used a whole classroom RM sound field system, while the remaining 5 classrooms utilized the child's personal-worn RM technology.

Classroom characteristics.

The remaining noise abatement strategies reported on the Classroom Acoustics Inventory reflected physical characteristics of the classrooms. With regard to floor coverings, carpeting was present as a noise abatement strategy in all but 2 general education and 2 separate instruction classrooms. These exceptions had tile flooring coverings. Data on types of walls revealed that 4 of the 11 general education classrooms had noise abatements materials (e.g., acoustic tiles or fabric) on the walls. In the separate instruction classrooms, 2 of the 27 had noise abatement materials on the walls. The general education classrooms were approximately equally divided regarding the absence or presence of windows; 5 of the classrooms had windows and 6 did not. In the separate instruction classrooms, 23 of 27 (85%) of the classrooms had windows. However, most of the windows had coverings. Overwhelmingly the window treatments were blinds; only 6 of the classrooms used drapery or soft-fabric shades to cover the windows. Information reported for the final characteristic revealed that all but 3 of the combined classrooms had ceiling tiles; however, research assistants were generally unable to discern visually or from inquiring of school personnel whether tiles were acoustic or not.

DISCUSSION

As previously stated, this study sought to answer four specific questions. With regard to the first question, 'What were the sound levels in unoccupied and occupied classrooms serving children who are DHH?', Figure 1 displays the results of sound level measurements based upon occupancy and classroom setting and indicates that none of the classrooms, whether general education or separate instruction, met the general ANSI standard of 35 dB for unoccupied classrooms or the stricter recommendation of 30 dB for sound levels of unoccupied classrooms where students who are DHH received instruction. This poor compliance with the ANSI standard is concerning for a number of reasons. First of all, other studies support the importance of ANSI standard compliance for unoccupied classrooms because noisy classrooms not only impact the ability to recognize speech, but the impact is greater for younger children, such as those included in this study (Iglehart, 2016). In addition, noisy classrooms can also affect children's concentration and attention, and can contribute to student and teacher fatigue (Crandell & Smaldino, 2000). When background noise levels exceed the recommended standard, without RM technology support it is difficult for a teacher to maintain a voice level loud enough to create a SNR sufficient for a child to access the acoustic signal containing instructional information. Thus, it appears that none of the classrooms in this study provided a condition in which spoken language could be adequately accessed, either for children with typical hearing or for children who are DHH.

The second research question investigated whether sound levels varied based upon classroom setting and instructional mode of communication. For unoccupied classrooms, the analysis revealed a difference based upon classroom setting, with the general education classroom settings being significantly less noisy than the separate instruction classrooms, a result that initially may be somewhat surprising. The logical assumption when a child who is DHH receives instruction in a separate setting is that effective instruction will result. Children in separate instruction settings generally enjoy a more favorable student-teacher ratio, which may also carry with it the presumption of a favorable acoustic environment. However, data from this study revealed that separate instruction classrooms were in fact louder in their unoccupied state than the typically larger general education classrooms. Precise reasons for this are speculative, but it is possible that general education classrooms have prescribed and preplanned locations within a school, while separate instruction classrooms are procured on an as-needed basis and are thereby impacted by space limitations within a school. For example, there are many instances of separate instruction classrooms being located in large closets, the back rooms of auditoriums, or trailers. Whatever the reason, an unfavorable acoustic environment can have the same negative impact upon students even if instruction takes place in a more individualized setting. Educators and parents, therefore, need to acknowledge that atypical class locations may be a problem relative to noise abatement and should consider noise levels and noise abatement strategies when the location of a separate instruction classroom is being decided.

Further consideration of research question two with regard to unoccupied classrooms again revealed a difference, this time based upon instructional mode of communication. Unoccupied spoken language classrooms were quieter than unoccupied sign language classrooms, with combined sign and spoken language classrooms falling somewhere in the middle and not significantly different from the other two. While it may seem somewhat encouraging that unoccupied classrooms where children received spoken language instruction were quieter than signing only classrooms, it must be noted that these levels still exceeded the recommended standard so that any spoken instruction provided by the teacher was taking place in an unfavorable acoustical environment. In addition, because no difference was revealed when classrooms were occupied, any perceived advantage to this 'quieter' environment disappeared when instruction was taking place.

Analyses of occupied rooms showed no difference in sound levels based upon classroom setting or instructional mode. For all occupied classrooms combined, the median sound level was 63.69 dB. While this indicates that sound levels for the majority of all classrooms fell below the 70 dB level at which speech becomes difficult to understand, it is important to note that the sound level measurements of nine, or 24%, of all occupied classrooms were at or above 70 dB. All children in these rooms, then, would experience difficulty understanding speech signals. These levels were found in just 1 of the 12 sign language only, 3 of the 10 spoken language only, and 5 of the 16 combined sign and spoken language classrooms. This result clearly revealed too many instances in which the overall sound level in the classroom adversely impacted the ability to gain information from a speech signal for children who were learning via spoken language either alone or in combination with visual cues or signs.

Research questions three and four sought to identify the type of noise abatement strategies being employed in classrooms serving children who are DHH and whether differences in these strategies existed based upon classroom setting. These findings are considered together for each strategy included on the Classroom Acoustic Inventory. Some type of RM technology was observed in 42% of all classrooms, indicating that fewer than half of all classrooms were utilizing RM technology specifically designed to offset the noise levels in classrooms and provide optimal listening and communication environments for children who are DHH. When differences in use based upon setting were explored, RM systems were found to be used significantly more frequently in general education settings compared to separate instruction settings, (χ^2 (1, N = 38) = 10.02, p = .002).

As with the difference reported in sound levels of unoccupied rooms across classroom settings, here again one possible explanation for the lower use of RM technology in separate instruction classrooms seemed plausible. Separate instruction often takes place with smaller group size and in a smaller space than a general education classroom. Therefore a logical expectation would be that this setting would create a more favorable acoustic environment, but analyses here have shown otherwise. This assumption could readily lead teachers to disregard the need for the added acoustical enhancement that RM systems provide. In order to provide the most optimal learning environment for all students, the acoustic environment must be taken into consideration and teachers, administrators, and parents should be aware that oftentimes rooms selected for separate instruction are not necessarily quieter. Furthermore, and because of this finding, teachers should be committed to using RM technology for all students during instructional time and in all settings.

In addition to the difference between general education and separate instruction classrooms with regard to RM technology use, a difference in RM system type was also revealed (χ^2 (1, N = 17) = 4.10, p = .043), with personal-worn RM systems being used more than whole room sound field systems. When any RM system is being used, input from the microphone (typically the teacher's voice) is heard at a more favorable SNR. However, because the sound must be picked up by the microphone, this means that comments from other classmates or sound from other audio equipment would not be transmitted with the same favorable SNR, thus excluding a student who is DHH from access to potentially relevant auditory information. Therefore, specific direction and training in techniques for sharing the microphone, use of a second pass-around microphone, or use of a conference microphone would be necessary so that children who are DHH have access to instructional interactions between and among classmates in the classroom. It should be noted that personal-worn RM systems provide the greatest improvement in SNR for the child who is DHH (Schafer & Kleineck, 2009; Wolfe et al., 2013).

The final area of difference which emerged on the Classroom Acoustic Inventory was the presence of windows (χ^2 (1, N = 38) = 6.36, p = .012), with windows being present in the majority of separate instruction classrooms. While there is nothing inherently positive or negative about this finding, considerations with regard to optimal learning for children who are DHH are essential. Windows can often introduce outside noise when open and, if not properly insulated, when they are closed as well. Additionally, windows have the potential to create glare on whiteboards, the teacher, or interpreters, thus compromising a student's ability to access information that is presented visually and potentially leading to eye strain and fatigue (Millett, 2009).

Findings for the remaining noise abatement strategies, while not statistically significant, still merit consideration. Of the 85% of classrooms that had windows, only 27% had window coverings that could be considered sound-absorbing (i.e. draperies). Most windows were either not covered or had blinds or shades, which generally reflect sound, thereby contributing to an increased overall sound level in a room. While most of the classrooms were carpeted, 2 classrooms in each setting had tile floors, which can result in scuffing of feet and scraping of chairs, again potentially adding to the overall noise level. Another feature that stood out in this study was the minimal use of noise abatement materials on the walls. Hard wall surfaces such as concrete blocks and plaster generate excessive reverberation, which contribute to overall classroom noise. Finally, while nearly all of the classrooms had some type of ceiling tile, the information gathered was insufficient to determine if the material was designed to reduce reverberation.

Taken together, the major findings of this study revealed that no unoccupied classrooms met the ANSI sound level standard and that the general education classrooms were quieter and used RM technology more frequently than separate instruction classrooms. These results highlight the need for overall increased attention to the acoustic characteristics of the learning environment for all children, but especially for children who are DHH. The first step in improving the acoustic environment for learning is to make all parties involved aware of the importance of quiet classrooms. For decades studies have provided evidence of the negative effects of classroom noise on speech perception, attention, and learning (Klatte, Hellbrück, et al., 2010; Klatte, Lachmann, et al., 2010; Mills, 1975; Murphy et al., 2009; Nelson et al., 2002, Neuman et al., 2010; Shield & Dockrell, 2008; Stinson & Antia, 1999). This information must become known to all stakeholders in the field of education so that classroom acoustics become a priority. Teachers, speech-language pathologists, administrators, and parents must be committed to including careful inspection of the acoustic characteristics of a room in the selection of instructional spaces. Placement within a school should consider sources of outdoor noise such as traffic and playgrounds; noise from nearby rooms such as cafeterias, band rooms, or gymnasiums; and noise-emitting objects within a room such as HVAC equipment, lighting fixtures, and electronic equipment.

In addition, possible noise-reducing modifications to ensure appropriate classroom selection should be included on the Individual Education Program (IEP) and/or 504 Plan of every child who is DHH. Numerous resources related to improving classroom acoustics are available, and many strategies are easy to implement (American Speech-Language-Hearing Association, n.d. a, n.d. b; Brown & Crouse, 2012; Easterbrooks & Estes, 2007; Seep et al., 2000). A number of practical and inexpensive modifications could be implemented to address the noise abatement problems revealed in this study. For instance, when classrooms have tile floors, carpet or carpet samples (often available for free or at reduced prices at carpet stores) can be spread about. Latex-free soft tips can be placed on chair and desk legs. (Though widely popular, the practice of placing tennis balls on desk and chair legs to mitigate noise is no longer recommended because of the potential release of latex allergens from and/or mold growth in the tennis balls.) A number of options to compensate for high ceilings and/or hard surface walls are possible as well. While the installation of flame-retardant acoustic tiles on classroom ceilings and walls would be ideal, banners, flags, or student artwork can help to absorb sound as well. The National Fire Protection Association provides specific information as to the permissible amount of such material in classrooms (Carson, 2012). In addition, cork, felt, or flannel bulletin boards, dividing panels, and even the placement of bookshelves and furniture at angles can help to reduce reverberation. Adding flame-retardant draperies or acoustically treated blinds to windows, checking the seal around windows and doors, and keeping them closed can also help to reduce noise.

By far the most effective method for lessoning the impact of background noise levels and improving access to spoken language in a classroom comes from the use of RM technology. These can range from sound field RM systems that provide amplification to the entire room, to personal-worn RM systems connected to children's personal hearing devices. It is important to note that while these RM systems are helpful, they cannot totally negate the effects of poor acoustics in the classroom and teachers must be trained in their proper use.

Limitations

There are a number of limitations to this study that should be considered when interpreting the results. First of all, although sound level measurements were obtained using the same software and with devices that had been carefully calibrated, researchers were not able to calculate reverberation times in the classrooms, nor were they able to determine precise SNRs. This would have required additional equipment as well as a level of expertise beyond the qualifications of the research assistants who were trained to make video recordings of classrooms and write notes about instructional materials. Additionally, researchers were unable to collect sound level measurements from every classroom that participated in the larger CLAD study; the decision to gather this data was made after a number of classroom observations had been completed, research assistants failed to obtain both empty and occupied classroom sound levels for some classrooms, or difficulty was encountered when recording, saving, and/or sending the sound level data.

Future research

The study presented here could be expanded to include additional classrooms to verify the findings about the sound levels in classrooms serving children who are DHH. Calculation of reverberation times and true SNR information would provide valuable information as well. Finally some of the noise abatement strategies suggested here should be implemented in actual noisy classrooms to determine their effectiveness on sound level reduction.

Implications

It is apparent from the data presented here, representing a variety of classroom settings throughout the U.S. and Canada, that the ANSI recommendations for classroom environments are not being followed, either for children with typical hearing or for children who are DHH. The U.S. Access Board is currently working on a supplement to the Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines to address acoustics in classrooms (United States Access Board, n.d.), but without follow-up and enforcement by states' departments of education the condition of noise is not likely to improve, either in general education or in separate instructional classrooms, whether in local or separate school buildings. The findings in this study further indicate the need for parents, teachers, speech-language pathologists, and administrators to be educated regarding the ANSI recommendations, to understand the sources of noise that impact the acoustical environment of a classroom, and to be trained and equipped to perform a classroom sound assessment. Moreover, the results of this study suggest that classroom acoustics vary across classroom setting. Therefore, personnel should consider the range of listening environments that children encounter throughout the day in order to obtain optimal listening environments in each setting (Cruckley, Scollie, & Parsa, 2011).

This study illustrated that iPads and sound level apps such as the Studio Six Digital Real Time Analyzer provided an easy and relatively inexpensive way to measure the acoustic properties of classrooms to determine if standards set by ANSI were being met and whether sound abatement was needed. Other apps are currently available for use with cell phones as well. With little or no cost, it is now possible to obtain relatively accurate measures of sound levels in classrooms. If unoccupied classroom sound levels exceed the 35 dB standard for all children or the preferred 30 dB recommendation for children who are DHH, then parents, teachers, and administrators must understand and implement strategies for effective sound abatement in an effort to create a more acoustically favorable learning environment. The authors strongly encourage policy makers to add appropriate acoustic environment specifications to the IDEA regulations and that assessment of the classroom acoustic environment, along with plans for any needed noise abatement modifications, be included in the IEP or 504 Plans of all children who are DHH. A favorable listening environment is important for all children, but it is even more essential for children who are DHH, so it is important to act now.

ACKNOWLEDGEMENTS

This research was supported by grant # R24C12001 from the Institute of Education Sciences as part of the research of the Center on Literacy and Deafness (CLAD).

REFERENCES

Acoustical Society of America. (2010). *American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools*, (pp. 1–46). Melville, New York: Acoustical Society of America.

American Speech-Language-Hearing Association. (n.d. a). Classroom acoustics. Retrieved from http://www.asha.org/PRPSpecificTopic.aspx?folderid=8589935320&section=Key_Issues

American Speech-Language-Hearing Association. (n.d. b). Tips for creating good listening environment in the classroom. Retrieved from http://www.asha.org/public/hearing/Creating-a-Good-Listening-Environment-in-the-Classroom

Bess, F. H., Gustafson, S. J., & Hornsby, B. (2014). How hard can it be to listen? Fatigue in school-age children with hearing loss. *Journal of Educational Audiology*, 20, 34–46.

Boothroyd, A. (2012). Speech perception in the classroom. In J. Smaldino and C. Flexer (Eds.), *Handbook of Acoustic Accessibility*, (pp. 18–33). New York: Thieme Medical Publishers.

Brown, P., & Crouse, M. (2012). Ongoing developments in classroom acoustic theory and practice in 2012, and reports on efforts to implement good classroom acoustics. *Acoustical Society of America. 132*(3), 2036. https://doi.org/10.1121/1.4755522

Carson, C. (2012). In compliance. NFPA code requirements. NFPA Journal. Retrieved from http://www.nfpa.org/news-and-research/publications/nfpa-journal/2012/september-october-2012/the-experts/in-compliance

Crandell, C., & Smaldino, J. (1994). An update of classroom acoustics for children with hearing impairment. *The Volta Review, 96*(4), 291–306.

Crandell, C., & Smaldino, J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. *Language, Speech, and Hearing Services in Schools, 31*, 362–370. https://doi.org/10.1044/0161-1461.3104.362

Crandell, C., & Smaldino, J. (2001). An update on classroom acoustics. *The ASHA Leader, 6*(10), 5–20. https://doi.org/10.1044/leader.FTR2.06102001.5

Cruckley, J., Scollie, S., & Parsa, V. (2011). An exploration of non-quiet listening at school. *Journal of Educational Audiology, 17*, 23–35.

Dahlquist, L. H. (1998). Classroom amplification: Not just for hearing impaired anymore. Paper presented at the CSUN 1998 Conference. Los Angeles, CA, March 1998.

DiSarno, N. J., Schowalter, M., & Grassa, P. (2002). Classroom amplification to enhance student performance. *Teaching Exceptional Children, 34*, 20–26. https://doi.org/10.1177/004005990203400603

Gallaudet University. (2009-2010). Regional and national survey. Retrieved from http://research.gallaudet.edu/Demographics/2010_National_Summary.pdf

Iglehart, F. (2016). Speech perception in classroom acoustics by children with cochlear implants and with typical hearing. *American Journal of Audiology, 45*, 100-019. https://doi.org/10.1044/2016_AJA-15-0064

Klatte, M., Hellbrück, J., Seidel, J., & Leistner, P. (2010). Effects of classroom acoustics on performance and well-being in elementary school children: A field study. *Environment and Behavior. 42*, 659–692. https://doi.org/10.1177/0013916509336813

Klatte, M., Lachmann, T., & Meis, M. (2010). Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. *Noise & Health, 12*, 270–282. https://doi.org/10.4103/1463-1741.70506

Knecht, H. A., Nelson, P. B., Whitelaw, G. M., & Feth, L. L. (2002). Background noise levels and reverberation time in unoccupied classrooms: Predictions and measurements. *American Journal of Audiology, 11*, 65–71. https://doi.org/10.1044/1059-0889(2002/009)

Lederberg, A. R., Schick, B., Webb, M., Antia, S., Easterbrooks, S., Kushnalagar, P., et al. (2015). Development of language, reading, and phonological awareness in deaf and hard of hearing children. Paper presented at the annual conference of the Society for Research in Child Development, Philadelphia, PA.

McCreery, R. (2015). For children with hearing loss, listening can be exhausting work. *Hearing Journal, 68*, 26–28. https://doi.org/10.1097/01.HJ.0000465741.63770.2a

Millett, P. (2009). Accommodating student with hearing loss in a teacher of the deaf/hard of hearing education program. *Journal of Educational Audiology. 15*, 84–90.

Mills, J. H. (1975). Noise and children: A review of literature. Journal of the *Acoustic Society of America, 58*, 767–779. https://doi.org/10.1121/1.380748

Murphy, P. K., Wilkinson, I. A. G., Soter, A. O., Hennessey, M. N., & Alexander, J. F. (2009). Examining the effects of classroom discussion on students' comprehension of text: A meta-analysis. *Journal of Educational Psychology, 101*(3), 740–764. https://doi.org/10.1037/a0015576

Nelson, P. B., Soli, S. D., & Seltz, A. (2002). Acoustical barriers to learning: Classroom acoustics II. *Acoustical Society of America, Melville, New York*, 1–13.

Neuman, A. C., Wróblewski, M., Hajicek, J., & Rubinstein, A. (2010). Combined effects of noise and reverberation on speech recognition performance of normal-hearing children and adults. *Ear and Hearing, 31*, 336–344. https://doi.org/10.1097/AUD.0b013e3181d3d514

Pugh, K. C., Miura, C. A., & Asahara, L. L. Y. (2006). Noise levels among first, second and third grade elementary school classrooms in Hawaii. *Journal of Educational Audiology, 13*, 32–38.

Schafer, E. C., & Kleineck, M. P. (2009). Improvements in speech-recognition performance using cochlear implants and three types of FM systems: A meta-analytic approach. *Journal of the Educational Audiology Association, 15*, 4–14.

Seep, B., Glosemeyer, R., Hulce, E., Linn, M., & Aytar, P. (2000). *Classroom acoustics: A resource for creating environments with desirable listening conditions.* Melville, NY: Acoustical Society of America.

Shield, B., & Dockrell, J. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *The Journal of the Acoustical Society of America, 123*, 133–144. https://doi.org/10.1121/1.2812596

Smaldino, J., & Flexer, C. (2012). *Handbook of acoustic accessibility: Best practices for listening, learning, and literacy in the classroom*. New York: Thieme Medical Publishers, Inc.

Smith, A. (n.d.). Studio Six Digital Real Time Analyzer [mobile application software]. Retrieved from http://itunes.apple.com

Stinson, M. S., & Antia, S. D. (1999). Considerations in education deaf and hard-of-hearing students in inclusive settings. *Journal of Deaf*

Education and Deaf Studies, *4*, 163–175. https://doi.org/10.1093/deafed/4.3.163

The Institute for Enhanced Classroom Hearing. (n.d.). Poor acoustics. Retrieved from http://www.classroomhearing.org/acoustics.html

United States Access Board. (n.d.). About the classroom acoustics rulemaking. Retrieved from https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/classroom-acoustics

Vaughn, R. (2010). Acoustics and deaf children: Understanding the essential concepts. Scottish Sensory Centre. University of Edinburgh. Retrieved from http://www.ssc.education.ed.ac.uk.courses/deaf/dmay10ii.html

Welling, D., & Ukstins, C. (2015). *Fundamentals of audiology for the speech-language pathologist.* Burlington, MA: Jones & Bartlett Learning.

Wolfe, J., Morais, M., Neumann, S., Schafer, E., Mulder, H. E., Wells, N., et al.(2013). Evaluation of speech recognition with personal FM and classroom audio distribution systems. *Journal of Educational Audiology, 19*, 65–79.

Wróblewski, M., Lewis, D. E., Valente, D. L., & Stelmachowicz, P. G. (2012). Effects of reverberation on speech recognition in stationary and modulated noise by school-aged children and young adults. *Ear and Hearing*, *33*, 731–744. https://doi.org/10.1097/AUD.0b013e31825aecad

Appendix A. Classroom accoustic inventory.

Videographer: ___________________________________ Date: ____

School: ____ Teacher ID: ___________________________________

Number of students: ______________________________ Teacher gender: _________male _________female

Subject: ____ Approximate Time: ______________________ minutes

Empty Room Sound level reading: __________________

Please circle when empty classroom reading was gathered: before, during, after school

Instructional Setting: ☐ General Education/Inclusion classroom ☐ Self-contained ☐ Pull-out ☐ Other	Sound System: ☐ Yes • Whole room sound system • Teacher and student personal FM • Other _________________________________ ☐ No
Floor covering: ☐ Carpet ☐ Tile ☐ Other ____________________________________	Walls: ☐ Concrete block ☐ Plaster/dry wall ☐ Acoustic tile/fabric ☐ Other ____________________________________
Windows: ☐ Yes ☐ No Window coverings: ☐ Yes • Draperies • Shades • Blinds • Other ☐ No	Ceiling Tiles: ☐ Yes • Acoustic • Nonacoustic • Unsure ☐ No Please note any other sound absorbing features. What other noise sources are in the room? (fans, A/C, another group working, other adults)

Please draw a basic diagram indicating where the IPad was placed while the sound sample was being taken.