Acoustic Conditions in Classrooms for the Hearing Impaired in Nicaragua

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Acoustic conditions in 18 Nicaraguan classrooms for children with hearing impairments were examined to determine whether they met published recommendations regarding overall noise levels, reverberations, and signal-to-noise ratios. The classrooms were constructed of hard, reflective surfaces with little absorptive material. Both unoccupied and occupied noise levels exceeded published recommendations. Reverberation times were longer than those recommended and were not consistent across frequencies. Only 18% of the classrooms had signal-to-noise levels within the limits recommended for children with hearing impairments. Children wearing hearing aids would be expected to have difficulty understanding acoustic stimuli in these classrooms.

Although an individual's ability to perceive sound through the ears is obviously the basis for aural learning, the acoustic conditions in which that learning takes place determine whether maximal use of the auditory sense is possible. In spaces designated as classrooms, it is imperative that the design and composition of the rooms maximize speech intelligibility and that these spaces provide an atmosphere in which concentrated mental activity can take place.

Speech intelligibility is a measure of how understandable or decodable a par-

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A particular segment of speech is within a certain context. Intelligibility is influenced by language factors, the speaker’s production, and the acoustic conditions in which the message is received (Berg, 1993; Peutz, 1971). Acoustic factors include the amount and configuration of reflected sounds or absorption present, as well as the noise level in the environment. The overall noise level is important, but the noise spectrum and signal-to-noise (SNR) ratio also influence intelligibility.

In classrooms, language factors are usually known and controlled. Teachers commonly adapt the sentence length, vocabulary, and grammatical complexity of their language to the group with which they are working (Stilman & Wilkins, 1991). Individual speech characteristics are accessible to modification. Acoustic factors, however, are rarely amenable to change by teachers, yet their impact upon the intelligibility of the teacher’s speech is profound.

Beyond concern about how well or how poorly the speech used within a classroom is received, attention must be given to ensuring that the classroom provides an atmosphere in which concentrated mental activity can take place. Unlike vision, which can be voluntarily interrupted by the closing of the eyes, audition is “on” and processing input at all times, even when a person is asleep. A noisy acoustic environment in a classroom disrupts mental concentration and makes the development of habits of mental concentration difficult. Where mental concentration is absent, little learning will take place (Berg, 1993).

The acoustic needs mentioned above relate to all students in all classrooms. However, people with compromised hearing require even better acoustic conditions than do those with normal hearing if they are to decode acoustic input (Crandell, Smaldino, & Flexer, 1995). To derive meaning from speech in a classroom, children with hearing impairments need to be listening within the direct sound field, face-to-face, and in conditions with a higher SNR ratio and lower reverberation time than is necessary for their normally-hearing classmates (Crandell & Smaldino, 1994). It has been shown for adults (Nabelek & Pickett, 1974) and for children (Pinheiro-Heber & Tillman, 1978) that, when ambient noise and reverberation are increased, the combination causes even greater deterioration than is found under a single condition.

**CONDITIONS IN NICARAGUA**

**Environment**

While the need to maximize acoustic learning environments has received increasing attention in the literature (e.g., American Speech-Language Hearing Association [ASHA], 1995; Berg, 1993; Berg, Blair, & Benson, 1996; Crandell & Smaldino, 1994; Crandell et al., 1995, etc.), to date, little attention has been paid to these needs in the construction and maintenance of classrooms in Nicaragua. In three papers written recently about the recommended architectural standards
and needs of classrooms in Nicaragua, acoustic considerations were not mentioned at all (see Arcuello Carazo, 1994a, 1996a; Pacheco Pilón, 1996b). In a fourth paper, the need to search for sites with low traffic noise was noted, but acoustic factors internal to the classroom (internal noise, SN ratio, reverberation) were not included (see Pacheco Pilón, 1996a).

Though the need for a good acoustic environment remains the same whether one is in North America, Europe, or Latin America, the recommendations made for design and modifications of classrooms in North America and Europe are often not applicable to conditions found in countries such as Nicaragua. Climatic conditions and social interaction differ to an extent that conclusions reached about classrooms in other countries cannot be applied indiscriminately to conditions in countries such as Nicaragua. The purpose of this study was to describe the acoustic conditions in classrooms for children with hearing impairments in Nicaragua as a preliminary step toward formulating appropriate solutions and modifications for classrooms in countries with similar circumstances.

The Nicaraguan Special Education System

Although schooling for children with hearing losses has been available in Nicaragua since 1946, it was not until the mid-1970s that special education became available outside of Managua, the capital. In 1979, the Sandinista Revolutionary philosophy advocating universal education resulted in a policy decision to place at least one special education school in each of the 15 departamentos (states). Thus the number of schools offering special education increased from 7 in 1979 to 22 by 1982 (Convenio MED-CONESCAL, 1980). Special education schools serve children with mental, vision, hearing, and motoric handicaps with classrooms grouped according to disability. When there is more than one classroom for a given disability, groups are according to grades.

Not all schools have classrooms for all disabilities. Classrooms for children with mental retardation are the most common (75% of the total), followed by those for children with hearing impairments (20% of the total), with relatively few classrooms for children with vision or motoric impairments. In 1997, there were 1,904 children enrolled in all special education classrooms throughout the Republic of Nicaragua (Ministerio de Educación, 1997b). Five hundred of these students were enrolled in 55 classrooms for children with hearing impairments (aulas de audición) in 18 schools (Ministerio de Educación, 1997a). Fifteen of the schools with audición classrooms are in the Pacific zone, one is in the Central zone (Juigalpa), and two are on the Atlantic Coast (Bluefields and Puerto Cabezas).

Class size in special education classrooms is small, averaging fewer than 10 students to a teacher, a significant difference from the regular public education classes in Nicaragua in which primary classes of 50-60 students per teacher are common. Children with mild hearing impairments rarely are included in audi-
ción classrooms. Analysis of audiograms of the children enrolled in Escuela Melanía Mordas in Managua, where 206 of the 508 students enrolled it audiograms were acquired, revealed no audiograms with pure-tone averages better than 60 dB HL in either ear. Fifteen percent of the children had PTAs1 in the better ear between 60 and 80 dB HL. 26% had PTAs of 80-100 dB HL. 32% had PTAs between 100 and 109 dB HL. 27% had profound losses with PTAs exceeding 110 dB HL.

Hearing Aid Use

In general, fewer than 16% of those enrolled in classrooms for children with hearing impairments use hearing aids during classroom instruction. A survey of hearing aid use among the 150 audiograms students present on June 10, 1997 at the Escuela Melanía Mordas revealed only 3% of the children were wearing hearing aids, and less than 1% had functioning hearing aids. According to the teachers, the hearing aid use for that day was typical, with one preschool teacher stating that she discouraged parents from sending their children to her class wearing hearing aids because "when the children play, the aid might get broken, and then the parents would blame me." This same pattern of hearing aid use was found throughout this study at all the other schools with classrooms for children with hearing impairments. Since 1991, the Centro de Asesoramiento Auditivo has been a part of the Escuela de Audición. In 1992, the association of parents of handicapped children has begun an early language stimulation program (for children 0-3 years old), in which the use of bilateral amplification for children with hearing impairments is emphasized. It is possible that with their influence, use of hearing aids in special education classes will increase in the future, as the children served in that preschool program enter the elementary grades.

Architecture

Traditional architectural patterns, climatic needs, and geologic considerations have influenced how Nicaraguan schools have been built and thus have influenced the acoustical conditions in the resulting classrooms. Most schools in Nicaragua are built in a "pavilion" style in which multiple classrooms are placed side by side in rows. These rows are either placed parallel to each other or in a square around a courtyard or plaza circular. This form of construction provides acoustically sealed rooms for noise to pass from one classroom to another, either through the common walls or through the open windows and doors. The Escuela Hogar de Ciudadanos in Managua has been one of the few special education schools not built in a pavilion style but rather in a "cluster" style. Unfortunately, the doors of all of the classrooms open onto a common area, and all of its classrooms

1 Pure-tone averages are calculated at the average thresholds for the frequencies 500, 1000, 2000, and 4000 Hz. A lack of response at the limits of the audimeter was assigned a value of 155 dB HL, for purposes of calculation.
are united by a system of corridors that add reverberation. The resulting amplified sound is directed back into each of the classrooms through the windows opened for ventilation.

Climate

Climatic conditions in Nicaragua are such that ventilation and the free circulation of air are crucial considerations. During the academic year (March to November), the climate of Nicaragua is hot and humid. Ventilation is provided by opening windows and doors for cross-ventilation. In some schools the walls between classrooms are not built to meet the roof, but instead a space is left for air to circulate. When those classrooms are in use, isolation between classrooms is minimal because the airborne noise from one classroom is transmitted through the gap between the wall and the roof directly into the adjacent classroom. Classroom windows and doors are closed only when not in use. The incidence of broken window panes is high, and in many instances there are no doors to the classrooms, only metal bars for security. Beyond allowing the sounds from neighboring classrooms to enter as ambient noise, these ventilation systems provide entrance for noise from corridors and courtyards within the schools, and for environmental noise such as traffic or loud radio music.

In a climate in which water is scarce for much of the year and expensive year-round, little use has been made of the special education schools of the sound isolative effects of landscaping. While most schools have a few ornamental plants, there is no special education school with a planned use of trees and shrubbery to provide acoustics absorption of playground or traffic noise. Unfortunately, on the sides of the schools most affected by traffic noise, there is no space left to place the shrubbery which could act as insulators for the traffic noise.

The fact that the climate of Nicaragua has two main divisions, the dry season (November to May) and the rainy season (May to October), means that building materials must be resistant to water damage and dust. Carpet, for example, which is likely to be ruined both by water damage and excessive dust, is never found as an absorptive material in Nicaraguan audición classrooms. Further, the desperate economic situation of the country results in imported materials (acoustic tile) rarely being used and locally-produced materials (concrete floor tiles, concrete blocks) are preferred.

Geology

Nicaragua lies within an earthquake belt, and every year experiences many minor seismic shocks, as well as having a history of major earthquakes (e.g., 1931, 1972). Architectural standards thus require use of materials and construction forms that best withstand seismic eruptions. Some form of reinforced walls (poured reinforced concrete blocks) are typical, with hard tile floors and galvanized metal roofs being usual.
RECOMMENDED ACOUSTIC CONDITIONS IN CLASSROOMS FOR CHILDREN WITH HEARING LOSS

Unoccupied and Occupied Noise Levels

The average level of sound in classrooms is typically measured under two conditions: while unoccupied and while the students and teacher are present (Berg, 1993). In other published studies, unoccupied noise levels included noise generated by heating or air conditioning systems, but no special education school in Nicaragua has heating or air conditioning in its classrooms. More intrusive in Nicaragua is the noise generated outside of the classroom which enters and becomes ambient noise during the teaching sessions. Occupied noise levels include the noise measured in unoccupied levels with the addition of noise generated by the persons within the room. In classrooms this is typically students talking, whispering, shouting, dropping books, scraping feet, and moving chairs and desks.

Although adults can tolerate noise levels of 50 dBA, children should have quieter conditions when engaged in mental activity requiring concentration (Pfeifer, 1993, p. 63). Webster and Snell (1983) found that the speech recognition scores of normally-hearing children appeared to be minimally affected by noise levels under 65 dBA, but children with mild hearing losses showed detrimental effects when the noise level exceeded 55 dBA, and children with moderate to severe hearing losses showed significant interference when noise levels exceeded 50 dBA.

Because all of the children in the audítorio classrooms have at least a moderate hearing loss, the desirable target chosen for this study was an occupied level of 50 dBA in an occupied room. To meet an occupied noise level of 50 dBA, it is necessary to have an unoccupied level at least 10 dB quieter (Berg, 1993).²

Reverberation Time

Reverberation is the prolonged or repeated reflection of sound, which can be quantified as RT (reverberation time), defined as the time it takes for a sound to decay 60 dB from its original intensity (Nabelek & Mason, 1981). The RT depends upon the absorption characteristics of a particular room. When RTs are high, the vowels of speech, which tend to have higher energy, mask the low intensity consonants and thus degrade speech intelligibility.

It has been recommended that the RTavg (average of RTs measured at 500 Hz, 1000 Hz, and 2000 Hz) not exceed 0.5 s in classrooms for normally-hearing children or 0.3 s in classrooms for children with hearing impairments (Berg et al., 1996). The ASHA subcommittee's recommendation of RT no greater than 0.4 s

²The ASHA Subcommittee on Acoustics in Educational Settings recommends that unoccupied levels not exceed 35 dBA (ASHA, 1991). These levels were not used because, given previous knowledge of the conditions, they seemed unrealistically low.
(ASHA, 1995) is essentially a compromise between these two levels. Furthermore, RTs should be uniform across the spectrum. If the RTs at lower frequencies are greater than the RTs at higher frequencies, the masking of high-frequency consonants by the low-frequency vowels will occur (Nabelek, Letowski, & Tucker, 1989). The reverberation time for a given room were judged uniform if the RT at one frequency did not differ more than 0.1 s from the RT at adjacent frequencies.

S/N Ratio

The ratio (in dB) between the desired signal, which in classrooms is typically the teacher's voice, and the level of ambient noise is known as the S/N ratio. Normally-hearing children can tolerate low S/N ratios and still derive some understanding of the acoustic signal, but children with hearing impairments listening through hearing aids cannot (Nabelek & Mason, 1981). Desirable S/N ratios for children using hearing aids would be at least +15 dB (Finizio-Hieber, 1988). This is hard to attain, and other experts in classroom acoustics have recommended that classrooms for children with hearing impairments have occupied noise levels of 50 dBA or less, unoccupied levels less than 40 dBA, and that the S/N ratio be at least +10 (Berg, 1993). The acceptable target for this study was the less stringent +10 S/N ratio.

The first step in determining whether acoustical conditions in audición classrooms in Nicaragua provide an adequate environment for learning was to determine the present situation. Measurements were made in a representative classroom in each of the 18 schools in the Republic which have classes for children with hearing impairments. Those measurements were compared to the recommended norms.

**METHOD**

The 20 special education schools administered by the Ministry of Education in the Republic of Nicaragua were visited in February 1997 to obtain at least one classroom dedicated to the instruction of deaf or hard-of-hearing students were evaluated. The relevant classrooms in two schools were later found to have been closed. Thus, 18 sites were included in the present study. Because many of the schools had only one classroom for children with hearing impairments (e.g., Rivas, El Viejo, Matagalpa, Nagarote, and Ocotal) and the logistics of travel in Nicaragua meant that measurement time was limited, one classroom at each school was evaluated. When there was more than one classroom for audición students, the class with the youngest children was evaluated. Occupied classroom measurements were taken during normal classroom instruction, and unoccupied measurements were taken when the school was not in session.

The study consisted of two parts: (a) descriptive information about the physical conditions, obtained through observations and interviews, and (b) noise
measurements conducted on site. A questionnaire was used to obtain information about the state of the physical plant, the type of construction materials used, and the location of the school near noise sources. The measurements included room dimensions, and various acoustic measurements, which were taken with a hand-held Quest 2700 Impulse Sound Level Meter and a Goldline GL60 reverberation meter. Both occupied and unoccupied noise levels on the dBA scale and within-octave bands were measured, as was estimation of S/N ratio in the occupied classroom.

The data reported are averages of at least six individual measurements and usually of 26 measurements taken with the hand-held sound level meter, set first to the A scale, and then measured in octave bands. Occupied and unoccupied levels and S/N ratios were obtained by making six measurements at 10-s intervals in each of six different positions within the classrooms and averaging the results. The positions chosen were center of the room, position where the teacher normally stands, and positions approximately 1 m from the center of the room to the north, south, east, and west.

The levels used to calculate signal in the S/N ratio were obtained by having the teacher read a paragraph aloud with the sound level meter located at 0° azimuth at 1 m, with samples taken at 10-s intervals over a 2-min period. The samples were then averaged to obtain the average level of signal. This level was compared to the average occupied noise level of the classroom to obtain an approximation of the S/N ratio in the classroom.

The reverberation samples were taken in three positions: with the stimulus delivered at 0° azimuth 1 m from the reverberation meter set in the middle of the room, with the stimulus delivered at 1 m to the right of the original position, and at 1 m to the left of the original position. The three readings were averaged.

Measurements were taken for RT at 500, 1000, and 2000 Hz and then averaged to provide the $R_{T_{500}}$, which is the reported value. The stimulus was a blown-up balloon popped with a straight pin.

RESULTS

Physical Conditions

A summary of the physical condition of each school is shown in Table 1. Table 2 contains a summary of the acoustic measurements performed at each school. The 18 schools were given an overall rating of good, fair, or poor relative to their overall physical condition. Half of the schools were judged to be in good condition, while five (28%) were rated as fair and four (22%) were rated in poor condition. The schools judged to be in good condition had complete window panes, closeable doors, non-deteriorated ceiling panels, and complete floor tiles. Schools judged to be in fair condition showed some deterioration in windows, doors, ceiling, or floor, but the damage was not present in all categories. Schools
Table 1
Summary of the Physical Conditions Found at Each of the Schools

<table>
<thead>
<tr>
<th>Location</th>
<th>Condition</th>
<th>Walls</th>
<th>Roof</th>
<th>Ceiling</th>
<th>Floor</th>
<th>Windows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chinandega</td>
<td>good</td>
<td>brick</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>2. Ciudad Juárez</td>
<td>good</td>
<td>brick</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>3. El Vizco</td>
<td>good</td>
<td>concrete block</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>4. Carola</td>
<td>good</td>
<td>concrete block</td>
<td>Zinc</td>
<td>yes (plywood)</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>5. Farandía</td>
<td>good</td>
<td>brick</td>
<td>Zinc</td>
<td>yes (plywood)</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>6. Amantea</td>
<td>good</td>
<td>brick</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>7. Managua</td>
<td>good</td>
<td>brick</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>8. Puerto Cabezas</td>
<td>good</td>
<td>concrete block</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>decorative concrete block</td>
</tr>
<tr>
<td>9. Rio</td>
<td>good</td>
<td>brick</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>10. Bluefields</td>
<td>fair</td>
<td>concrete block</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>11. Javotte</td>
<td>fair</td>
<td>concrete block</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>windows with panes</td>
</tr>
<tr>
<td>12. Jagüel</td>
<td>fair</td>
<td>pre-fab concrete</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>13. León</td>
<td>fair</td>
<td>pre-fab concrete</td>
<td>N/A</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>14. Nagarote</td>
<td>average</td>
<td>brick</td>
<td>Zinc</td>
<td>n/a</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>15. Diriamba</td>
<td>poor</td>
<td>adobe</td>
<td>Top</td>
<td>n/a</td>
<td>concrete tile</td>
<td>setting only</td>
</tr>
<tr>
<td>16. Managua</td>
<td>poor</td>
<td>brick</td>
<td>Zinc</td>
<td>yes (plywood)</td>
<td>concrete tile</td>
<td>glass slats</td>
</tr>
<tr>
<td>17. Mantea</td>
<td>poor</td>
<td>concrete block</td>
<td>Zinc</td>
<td>n/a</td>
<td>poured concrete</td>
<td>setting only</td>
</tr>
<tr>
<td>18. Oxital</td>
<td>poor</td>
<td>concrete block</td>
<td>Zinc</td>
<td>n/a</td>
<td>poured concrete</td>
<td>glass slats</td>
</tr>
</tbody>
</table>

*Although commonly referred to as "Zinc", these are actually sheets of galvanized steel.  
\(^a\) Brand name for sheets of a prefabricated fiber-concrete mixture.  
\(^b\) Another brand name for pre-fab sheets of fiber-concrete (different fiber content).
<table>
<thead>
<tr>
<th>Location</th>
<th>Overall</th>
<th>Summary of ABR Stimulation Measures at Each School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unoccupied</td>
<td>E9 (%)</td>
</tr>
<tr>
<td>1.</td>
<td>46.9</td>
<td>72.6</td>
</tr>
<tr>
<td>2.</td>
<td>48.7</td>
<td>85.5</td>
</tr>
<tr>
<td>3.</td>
<td>50.1</td>
<td>90.0</td>
</tr>
<tr>
<td>4.</td>
<td>52.6</td>
<td>86.9</td>
</tr>
<tr>
<td>5.</td>
<td>55.1</td>
<td>85.9</td>
</tr>
<tr>
<td>6.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>7.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>8.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>9.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>10.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>11.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>12.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>13.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>14.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>15.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
<tr>
<td>16.</td>
<td>55.1</td>
<td>84.7</td>
</tr>
</tbody>
</table>

Note: Results listed in bold are the measurement on the recommended level.
in poor condition had a significant number or all of the window panes missing, no closeable door, water-damaged ceiling panels, and broken floor tiles.

Materials

All of the schools had classrooms with hard, flat surfaces on at least five of six surfaces. Seven out of 18 schools (39%) had walls bar of bricks, while eight (44%) had concrete block walls. Two (11%) had pre-fabricated concrete slabs for walls, and one (6%) had walls made of adobe. Thirteen (72%) had a finishing applied to the walls, and 15 (83%) had painted walls. Fifteen (83%) had concrete tiles as flooring, and three (17%) had poured concrete floors. Galvanized steel was the typical roofing material in nine cases (50%), while eight (44%) had a concrete fiberboard roof. One (Doriambo), the oldest school, had a roof made of clay tiles. Only six schools (33%) had ceilings, and all of these consisted of wooden panels which were hard and flat. No absorptive treatment of walls or floors was observed. The decoration on the walls all tended to be smooth and flat, which contributed minimally to any absorption in the room.

Within the classroom, significant portions of at least two walls were taken up with large blackboards made from either concrete or plywood surfaces that were flat and hard. Windows were mostly movable glass panes. Two schools only had metal netting over the windows, to keep out thieves. In these last cases there was no external noise attenuation possible. Ventilation was generally provided by open windows and doors, and in addition, a few schools had walls that did not reach to the roof, allowing circulation of air in the breach between walls and roof.

Location in the Community

While some special education schools were located in more isolated sites, away from city traffic, two (11%) were located next to busy market areas, five (28%) at bus stops, six (33%) on main streets, five (28%) next to churches, and four (22%) next to restaurants. All of these provided significant levels of external noise for the schools.

Unoccupied Noise Levels

Only two schools (Izalcal and Ocosal) were able to meet unoccupied levels of 40 dBA or less. Eight of the schools (44%) had unoccupied levels between 40 and 50 dBA, while another 33% had unoccupied levels in excess of 50 dBA. The one outlier, Najacar, missed the goal by 28 dB, but the results in this case are explained by the constant presence of loud music from the Evangelical church which was played all day, both when school was in session and out of session. No city or town in Nicaragua seems to have any municipal regulation of acceptable noise levels or acceptable times of transmission for amplified church music, ambient publicity1, or use of bens/truck horns. Machinery noise from factories
or small business workshops is also unregulated. These forms of acoustic stimuli provide external noise to school classrooms in Nicaragua, and their impact upon the learning capacity of Nicaraguan children with hearing loss is of concern.

**Occupied Noise Levels**

None of the schools studied were able to meet the recommended occupied noise level of 50 dBA or less. The occupied levels exceeded the recommended levels by 6.5 to 25 dB. It is disturbing to note that the occupied levels for Nagorz do not occupy the extreme end of the range, as would be expected as Nagorz was at the extreme end of the scale for unoccupied levels. This school, which had constant external loud music, was exceeded in occupied levels by eight schools. A significant portion of occupied noise levels may have been provided by the children themselves. Children’s spontaneous speech, moving of chairs, tapping of feet, and dropping of books appeared to be major sources of occupied noise levels.

As previously noted, the use of amplification by children with hearing impairments in Nicaragua is rare. One result of this practice is that children with severe-to-profound hearing losses have no auditory feedback about their own voices or about any noise that they cause in a classroom. Many of the children, however, are aware that voicing gains people’s attention, and thus, in many classrooms, there is a significant amount of internal noise that is attributable to children screaming to gain the teacher’s attention, protesting vociferously the transgressions of their neighbors, and scraping metal and wooden chairs across concrete floor tiles. Actions that produce transient increases in noise levels to 80-109 dBA. If more children with hearing impairments were using formal amplification consistently, it is possible that they would monitor their voice levels more and reduce the amount of chair-scraping. Discipline also modifies the amount of internal noise in a classroom. In general, the children in the classrooms observed were quite noisy (not necessarily verbally) and teachers made little effort to reduce the level of spontaneous vocalization.

**Reverberation**

None of the classrooms met the reverberation goal of an $RT_{avg}$ of 0.5 s, which is the goal for classrooms for normally-hearing children, and much less that of 0.3 s, which is the recommended goal for classrooms for children with hearing impairments. The lowest $RT_{avg}$ were 0.7 s in Chirrasal and El Viejo, with val-

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1 This is a common means used to broadcast paid announcements and advertisements throughout a community on short notice. A powerful speaker is mounted on the back of a truck, and the truck circulates slowly up and down the streets as the message (which can be either pre-recorded or broadcast spontaneously into a microphone) is amplified to a level estimated to be heard within the bounds along the route. Daily notices with announcements about formal arrangements for common material in the market, police, and announcements about electricity or water repairs, political announcements, and advertisements for various products are also typically heard.
uses under 1.0 s for Esteli, and Naganote. At the other end of the range, RT10% was 2.3 s in Diriamba and 1.7 s in Matagalpa. In addition to low RT10%, it is also rec-
mended that the RT1 measured across frequencies be consistent (Naheleak et al., 1989). When a criterion of no more than 0.1 s difference between adjacent frequencies was applied, none of the classrooms met the criterion of consistency.

S/N Ratio

The S/N ratio was measured within the occupied classroom, and three (16%) classrooms met the levels recommended for listeners with hearing impairments (+10 S/N ratio). Seven other classrooms (39%) had S/N ratios between 0 and +9.9 dB, levels considered acceptable for normally-hearing listeners. Unfor-
nately, eight (44%) had levels with negative S/N ratios. Even normally-hearing 
children experience speech degradation under such circumstances. Teachers 
were able to improve the S/N levels by forcing their voices, but this practice can-
not be recommended on a long-term basis because it leads to excessive fatigue 
for the teacher and probable vocal abuse (Choe & Johnson, 1991).

SUMMARY AND DISCUSSION

When classroom construction was considered, all of the special education 
schools examined were found to have nearly no absorbive materials and be 
mainly made of hard, reflective surfaces. Many schools are located close to 
Sources of external noise, such as main street arterials, buses, churches, mar-
tks, and restaurants. Only two schools met the goal of 40 dBA or less for un-
occupied classrooms, and none met the occupied classroom goal (less than 50 
dBA). All average reverberation times exceeded the goal of 0.3 s for children 
with hearing impairments, and in fact, none were able to meet the more generous 
level of 0.5 s recommended for normally-hearing children. Reverberation times 
were not consistent across frequencies. Only 16% of the classrooms had accept-
able S/N levels for children with hearing impairments, and 50% could not meet 
the recommended levels for normally-hearing children.

Some manner of increasing absorption within these classrooms is needed. Use 
of carpeting and acoustic tile are not realistic given the climate and econo-
mic situation of the country. It is possible that some form of braided sisal, now used in 
floor mats woven mainly for the tourist market, could be manufactured in a form 
that could be hung on the walls to increase sound absorption. Gluing felt to the 
metal feet of chairs and desks or placing slip tennis balls over the metal feet 
would decrease the transient noises caused by dragging chairs and desks across 
the tile floors. Increasing the use of shrubbery to act as acoustic barriers should 
be investigated. It is clear that the present acoustic conditions in Nicaraguan 
classrooms for the hearing impaired are not ideal, not even adequate. Creative 
and attainable solutions are needed to improve these conditions.
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