Original Article

Classroom Listening Conditions in Indian Primary Schools: A Survey of Four Schools

Gayathri Sundaravadhanan[1], Heramba G. Selvarajan[1], Bradley McPherson[2]

[1]Department of Speech, Language & Hearing Sciences, Sri Ramachandra University, Chennai, Tamil Nadu, India, [2]Division of Speech and Hearing Sciences, The University of Hong Kong, Hong Kong, China

Abstract

Introduction: Background noise affects the listening environment inside classrooms, especially for younger children. High background noise level adversely affects not only student speech perception but also teacher vocal hygiene. The current study aimed to give an overview of the classroom listening conditions in selected government primary schools in India. **Materials and Methods:** Noise measurements were taken in 23 classrooms of four government primary schools in southern India, using a type 2 sound level meter. In each classroom measurements were taken in occupied and unoccupied conditions. Teacher voice level was measured in the same classrooms. In addition, the classroom acoustical conditions were observed and the reverberation time for each classroom was calculated. **Results:** The mean occupied noise level was 62.1 dBA and 65.6 dBC, and the mean unoccupied level was 62.2 dBA and 65 dBC. The mean unamplified teacher speech-to-noise ratio was 10.6 dBA. Both the occupied and unoccupied noise levels exceeded national and international recommended levels and the teacher speech-to-noise ratio was also found to be inadequate in most classrooms. The estimated reverberation time in all classrooms was greater than 2.6 seconds, which is almost double the duration of accepted standards. In addition, observation of classrooms revealed insufficient acoustical treatment to effectively reduce internal and external noise and minimize reverberation. **Conclusion:** The results of this study point out the need to improve the listening environment for children in government primary schools in India.

Keywords: Classroom noise, India, noise levels, primary school, reverberation, speech levels, teacher vocal health

Introduction

Noise is an environmental stressor and nuisance. Schools and colleges are often at risk of high levels of noise exposure. Noise in schools can be classified into two broad types: internal (such as students talking) and external (such as road traffic noise). These internal and external noises together constitute background noise in a classroom setting. Classroom background noise is aggravated by factors such as poor quality or absent acoustic ceiling tiles, lack of acoustically modified furniture, absence of carpets and absence of double-glazed windows.[1] Excessive reverberation also impacts on classroom acoustic environments. Increased reverberation, in addition to background noise, may severely affect listening conditions in classrooms.

Adequate speech recognition by students is essential for learning. Younger children are the most vulnerable population, more affected by unfavourable listening environments because of their developing auditory and linguistic systems.[2] In addition, children with conductive or sensorineural hearing loss (unilateral or bilateral), speech and language disorders, reading disorder, learning difficulties, central auditory processing deficits, developmental delays or attention deficits exhibit more perceptual difficulties in typical classroom environments than other children.[2,3] The importance of classroom listening conditions has been explored for the past four decades, and it was reported that a good listening environment facilitated improved speech perception in normal hearing children as well as in children with central auditory processing disorder, attention deficit, unilateral hearing loss and mild hearing loss. A less noisy environment helps in mainstreaming children using hearing aids and cochlear implants by providing them with a good

Address for correspondence: Dr. Heramba Ganapathy Selvarajan, Associate Professor, Department of Speech, Language & Hearing Sciences, Sri Ramachandra University, Porur, Chennai 600116, Tamil Nadu, India.
E-mail: hega@sriramachandra.edu.in

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speech-to-noise ratio (SNR). It also helps teachers to use their voice at comfortable loudness levels.

The presence of poor classroom acoustics not only affects student learning, but may also affect teachers. It may cause several health issues in teachers including poor hearing status, stress-related factors and annoyance.[4] Teachers have also reported issues related to vocal health that included hoarseness, fatigue, discomfort when using their voice for speaking or singing, difficulty in projecting their voice, vocal monotony, effortful speaking, chronic throat dryness and soreness, frequent throat clearing and swallowing difficulties.[5] These issues are commonly attributed to increased vocal loudness when conversing in the presence of a background noise.

To control background noise and reverberation in classrooms, several organisations[6-8] have developed standards for permissible acoustic levels. To achieve these standards in classrooms, several strategies such as improved acoustical treatment and maintaining heating and ventilation systems can be implemented. Use of classroom amplification systems also aids better understanding of teacher speech. The other factors that influence good listening environment are distance between teacher and students, classroom style, teaching style and seating arrangements.

Classroom listening environment international standards have been developed by the World Health Organization (WHO), American National Standards Association (ANSI) and the American Speech Language Hearing Association (ASHA), among others, with respect to background noise and reverberation time.[6-8] Similarly, the National Buildings Code (NBC) of India has given standards to be followed in schools to maintain good classroom acoustics. Although the necessity of a good listening environment is well acknowledged, there are no data on the current listening conditions of primary schools in India. Hence, this study analysed the current classroom listening conditions of government primary school classrooms in Kanchipuram, a semi-urban town in southern India, to give an initial appraisal of acoustic conditions. These findings provided an understanding of current classroom environments in India, allowed recommendations to be made regarding possible modifications to existing classrooms and might guide future school construction projects, so that more optimal classroom listening conditions are achieved.

Materials and Methods

Prior to the study, approval was obtained from the ethics committee of Sri Ramachandra University to conduct the research (reference: CSP/15/JAN/39/30). Permission was also obtained from the District Education Officer, Kanchipuram, to perform noise measurements and evaluate the speech levels of teachers in government primary schools. Twenty-three classrooms from four randomly selected government primary schools were chosen for the study. On the basis of their location, schools and classrooms were categorised as high, medium and low external noise exposure, as shown in Table 1.

The study consisted of the following three phases: (1) observation of features relevant to background noise and reverberation was made. The observations made use of an adapted version of the ANSI survey worksheet for classroom acoustical screening [Appendix 1]; (2) measurement of background noise levels and the teachers speech level in the same classrooms; and (3) estimation of reverberation time for each classroom using the Sabine equation.

A 3M Sound Examiner SE-402 sound level meter (SLM; St Paul, MN), with type II half-inch condenser microphone, was used for the study. The equipment was calibrated with reference to IEC 61672-1, ANSI S1.43 and ANSI S1.4-1983 standards.[9-11] Both noise and speech levels were measured using dBA and dBC scales in each classroom when the students were quiet, that is, during non-verbal activities such as silent reading and writing tasks.

Observational information

Classroom features related to background noise

Information concerning background noise sources was noted down using the survey sheet. This included items such as noise from heating, ventilation and air conditioning (HVAC) systems, noise from mechanical equipment in the classroom, playground noise, noise from road traffic, noise from air traffic and noise from other classrooms.

Classroom features related to reverberation

Information concerning use of any sound reflecting materials in floors and walls, use of acoustical ceiling tiles in the classroom and the height of the ceiling of each classroom were noted down to understand the reverberation qualities of the classroom.

Teacher-to-student distance

Information regarding the nearest and farthest distances between the teacher and the students in the classroom were noted.

Other observations

Information with respect to the following parameters was also noted in each classroom: student age range, grade, teacher-to-student distance, classroom type, style of instruction, seating arrangements and use of sound field amplification systems in each classroom.

Table 1: Location of schools and classrooms surveyed

Location	Number of schools	Number of classrooms
High external noise exposure (near to main traffic roads)	0	0
Medium external noise exposure (near to minor roads or in residential areas)	2	13
Lower external noise exposure in urban fringe areas)	2	10

Noise measurements

Noise levels

Occupied and unoccupied classroom noise levels were measured using an SLM with the dBA and dBC scales. The A-weighting scale gives equal emphasis to all but the lower frequency noise sources and speech levels as received by the listener, and the C-weighting scale gives approximately equal weighting to almost all sound frequency regions in the classroom. Measurements were recorded at the centre of the student's seating area in each classroom, as depicted in Figure 1. The noise levels were averaged over a 5-min period during school hours using $L_{\text{Aeq,5 min}}$ and $L_{\text{Ceq,5 min}}$. Occupied classroom noise measurements were obtained with students present in classrooms and doing silent reading or writing tasks. This condition was chosen to measure the exact noise interference from external sources without including noise generated by students and teacher inside a classroom. This condition was selected because active classroom activities tended to produce more noise compared to passive classroom activities, and the former situation made it difficult to measure the exact amount of noise interference deriving from external sources. An occupied condition was defined as being the classroom with students and teacher along with furniture and any ventilation system (such as fan) being utilised. The unoccupied condition signified the same classroom without students and teacher.

Speech levels

The teachers were asked to speak in their usual manner – as they would in a regular teaching–learning environment. All the teachers who participated in the study had completed a course in education at the bachelor's level. There were totally 19 female teachers and three male teachers. The teachers' experience ranged from 2 to 15 years. None of them exhibited any voice disorder symptoms during the study period. The distance between the teacher and the SLM was kept at 2 m, as it had been reported that the average gap between teacher and students in a classroom setting was approximately 2 m.[12] The speech levels were obtained when teachers were giving instructions in a formal lesson and when students were listening to teachers speaking quietly. The SLM measurements were recorded for 10 min using the dBA-weighting scale.

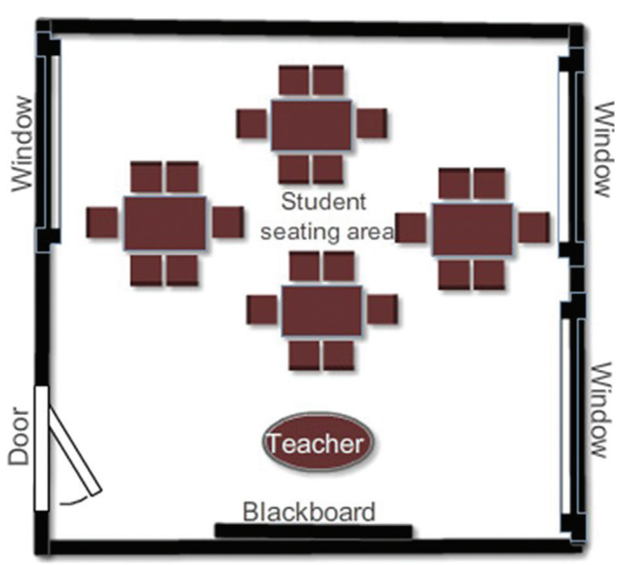

Figure 1: Typical layout for both furnished and unfurnished classrooms

Speech-to-noise ratio

SNR was obtained by subtracting the teacher's speech levels from occupied noise levels (dBA scale) in the same classroom. The background noise was measured within 10 min of the speech level measurement to minimise possible changes in acoustic conditions.

Test–retest reliability

To check for test–retest reliability, the acoustic measurement procedures were repeated for a sample of occupied classrooms. Measurements were taken again in one of the four schools, 1 week after the first visit. The differences between the measurements taken on both occasions were compared. The mean difference was checked to determine whether it was within the measurement error tolerance level as given by IEC 61672-1, ANSI S1.43 and ANSI S1.4-1983.[9-11]

Estimating reverberation time

Reverberation time (RT-60) was estimated using the Sabine equation. The Sabine equation for calculating reverberation time is RT-60 = 0.049 × volume/surface area × average absorption. Volume was calculated by multiplying length, width and height of the classrooms in meters (volume = length of room × width of room × height of room). The surface area of the classrooms was calculated using the area of the floor, ceiling and side walls. The absorption coefficients of the floor, ceiling and side walls were based on the types of materials noted on the classroom survey sheet using ANSI and Acoustical Society of America figures.[13]

Results

The findings for noise measurements and teacher speech levels conducted in 23 classrooms, across four government primary schools in these southern Indian schools, are presented herewith.

Observational information

Twenty-three 1st to 5th grade classrooms from four government schools were randomly selected for this study. Students ranged between 5 and 11 years of age. The student enrolment of each class was from 25 to 30 students.

Classroom features related to background noise

All classrooms had audible noise interference from other classrooms, hallways or learning spaces when the ventilation system was switched off. All classrooms used ceiling fans for ventilation. However, audible noise interference from these fans was observed in only nine of 23 classrooms. None of the classrooms used heating or air-conditioning systems or other mechanical equipment. Nineteen classrooms had noise interference from a playground, and 13 classrooms were exposed to road traffic noise. None of the classrooms were exposed to air traffic noise. The sources for background noise are depicted in Figure 2.

Classroom features related to reverberation

None of the classrooms had acoustically modified furniture nor acoustically treated walls and floors. All 23 classrooms had hard surfaced ceilings without acoustic ceiling tiles and did not have sound reflective materials over walls and floors. Two classrooms were of open style, in which there were partial brick walls on the sides with a common roof. Another two classrooms were separated using wooden and brick wall partitions. Features of the 23 classrooms with respect to reverberation are depicted in Figure 3.

Teacher-to-student distance

The average nearest teacher-to-student distance was 0.46 m, and the average farthest distance was 1.6 m.

Classroom type

Twenty-one classrooms had traditional style closed rooms, and two classrooms had an open plan.

Primary instruction style

The main instruction style in all classrooms was small-group teaching.

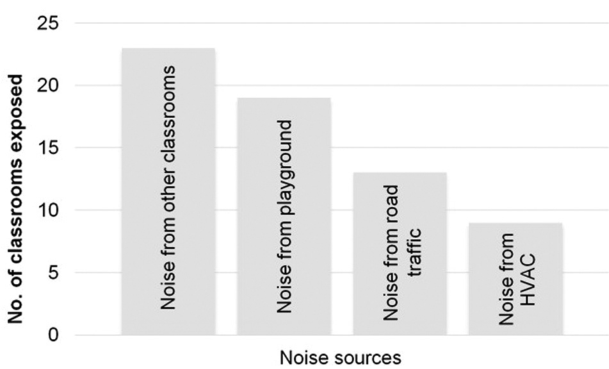

Figure 2: Noise sources surveyed in the classrooms, $n = 23$

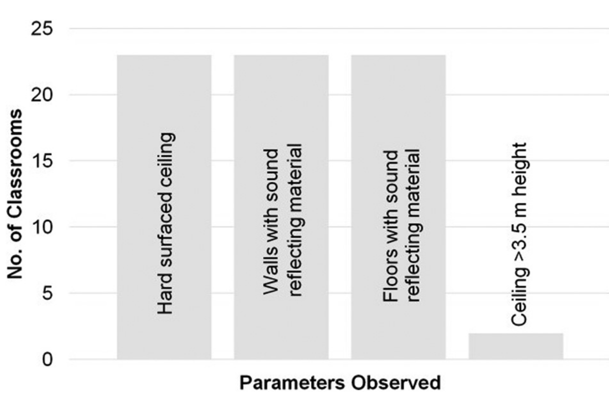

Figure 3: Classroom features observed with respect to reverberation, $n = 23$ classrooms

Seating arrangement

Clustered seating arrangements were used in all 23 classrooms. Among all the classrooms, only 11 were furnished with student sitting/writing desks and teacher tables/chairs. In the remaining 12 classrooms, the students were seated on a floor mat in the same clustered arrangement.

Noise measurements

Background noise levels

All classroom noise levels were higher than the recommended noise levels given by WHO,[6] ANSI[7] and NBC.[8] The dBA and dBC noise levels measured in occupied and unoccupied classrooms are shown in Figures 4 and 5, respectively.

Occupied classroom noise levels measured using dBA and dBC scales were 62.1 (SD = 3.18, range = 57.0–68.2) and 65.6 (SD = 4.01, range = 60.3–79.7), respectively. The noise levels measured in unoccupied classrooms using dBA and dBC were 62.2 (SD = 3, range = 57.1–68.7) and 65 (SD = 2.68, range = 60.1–70.8), respectively. The difference between noise levels of occupied and unoccupied classrooms using dBA ($t = 0.48$; $P > 0.05$) and dBC ($t = 0.25$; $P > 0.05$) scales was not statistically significant. The noise levels measured using the dBC scale were higher than the dBA scale measures for both occupied and unoccupied classrooms.

Test–retest reliability

The noise levels measured initially were compared to measurements taken 1 week later in one of the four schools. The measures were observed not to exceed the error tolerance level ±1.4 dB for a type 2 SLM as given by IEC 61672-1, ANSI S1.43 and ANSI S1.4-1983.[9-11]

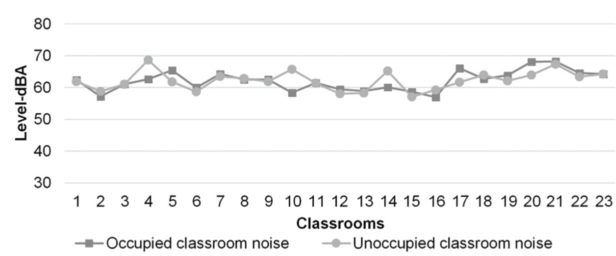

Figure 4: Occupied and unoccupied classroom noise levels using A-frequency weighting

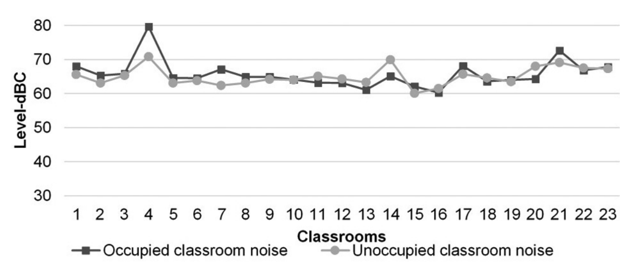

Figure 5: Occupied and unoccupied classroom levels using C-frequency weighting

Speech-to-noise ratio

The average teacher speech level was 72.5 dBA (SD = 3.21, range = 68–78.7), and mean teacher SNR was 10.6 dBA (SD = 3.28, range = 4.5–15.1). SNRs for individual teachers are shown in Figure 6.

Estimation of reverberation time

Five different classroom sizes were observed across the four schools. Two classrooms with open plan arrangements had length and width of 6 m each, and their height was greater than 3.4 m. Among the traditional style classrooms, two classrooms had length of 12.2 m, width of 4.6 m and height of 3.04 m. One traditional style classroom had length of 4.6 m, width of 6.1 m and height of 3.04 m. Another traditional style classroom had length of 7.6 m, width of 6.1 m and height of 3.04 m. The remaining 17 traditional style classrooms had length of 6.1 m and width and height of 3.04 m, respectively. The estimated reverberation times in all classrooms were greater than 2.6 s, which exceeded the recommended duration time of 1.25 s for optimal speech perception.[8]

Discussion

This study investigated the classroom acoustics in four sampled government primary schools in a semi-urban area of southern India. In addition, internal and external sources contributing to background noise in classrooms, the acoustic treatment of the classrooms and classroom types were documented. All measurements were made during school hours. The measured background noise levels in all classrooms exceeded the ANSI[7] recommended maximum noise levels of 50 dBA for occupied classrooms. Noise levels ranged from 58 to 68.2 dBA, which indicated that the background noise level was high even when students were engaged in quiet tasks in the classroom. The measured background noise levels in all classrooms also exceeded the recommended maximum noise levels of 35 dBA given by ANSI and NBC of India for unoccupied classrooms.[7,8] The noise levels ranged from 57.1 to 68.7 dBA, indicating that, in general, there was poor classroom acoustical treatment. The presence of increased background noise has a great impact on a teaching and learning environment. Comparison of measurements made using dBA and dBC scales indicated that low-frequency noise was high in both occupied and unoccupied classrooms. Low-frequency noise is important because of upward spreading of masking, by which high levels of low-frequency noise can mask higher frequency speech.[1] Because most of the external noise was low frequency in nature, it was important to assess the degree of low-frequency noise.

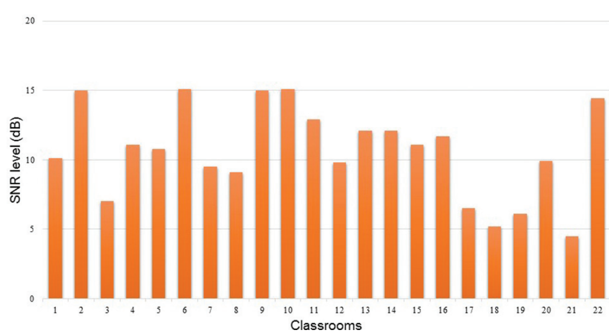

Figure 6: Speech-to-noise ratio (SNR) for teachers' voice in occupied classrooms

The average unamplified speech level of teachers was 72.5 dBA, and the SNR for teachers was 10.6 dB. The recommended +15 dB ratio was not met.[14] The average SNR value in this study was found to be about 4 dB less than the recommended SNR value for classrooms. Only four classrooms met the +15 dB SNR level. In addition, all classrooms had noise interference from at least four sources, which included noise from neighbouring classrooms, playground noise, road traffic noise and fan noise. None of the classrooms used any acoustic modifications like sound insulation or sound absorption material on walls or floors for noise reduction. A limitation of the study was that only a single speech sample for each teacher was obtained. Teacher voice intensity might have been affected by their awareness of the SLM recording, either in a positive or negative manner. However, a long duration (10 min) recording was made in each case, and it was considered that this provided a relatively representative sampling of individual teacher speech output.

Audiological implications and recommendations that can be derived from this study

High background noise levels and effects on students

Background noise levels of both occupied and unoccupied classrooms were high when compared to the recommended noise levels of 50 dBA for occupied classrooms[7] and 35 dBA for unoccupied classrooms.[6-8,13] In occupied classrooms, the average noise level was 12.1 dB higher than the recommended level. In unoccupied classrooms, it was 27.2 dB higher than the recommended level. None of the classrooms met the international or national standards of permissible noise levels. The findings of this study were similar to studies conducted in developed countries, as shown in Table 2.

Table 2: Comparison of noise levels (dBA) between findings of this study and Western literature

	Current study (India)	Shield and Dockrell[15] (London)	Sato and Bradley[16] (Canada)	Rosenberg *et al.*[17] (Florida)
Occupied noise level	62.17	56.3	44.4	62.63
Unoccupied noise level	62.21	47	42.2	47.48

The unoccupied classroom noise level was high in this study because of noise inference from outside and noise generated inside the classroom. In India, classes receive much noise from external sources through large, open windows and the classroom door, which is open during teaching time. Classrooms in this study had at least three open windows and one open door for ventilation and lighting, which is very important for schools located in a tropical region. On the other hand, these open windows and doors allowed noise from neighbouring classrooms and playgrounds. In addition, the windows of 13 classrooms faced the roadside and were exposed to traffic noise. However, there were low traffic conditions, as all schools were located in residential areas. The source for noise inside unoccupied classrooms in this study was typically ceiling fans, which were audibly perceived in nine classrooms.

The average noise level in occupied classrooms in this study was similar when compared to unoccupied classrooms. This might be because of children being involved in quiet activities and being seated in korai mats (similar to bamboo mat) on the floor, which did not create much noise in the classroom even with some student movement. This is the most prevailing passive learning situation in day-to-day classroom activity in Indian schools. Sato and Bradley[16] stated that sound absorption increased with an increasing number of students in a classroom. However, in this study, sound absorption might be less of a factor because there were less than 30 students in each classroom.

Poor acoustic environments were found in this study, which resulted from excessive ambient noise in the classrooms. As mentioned earlier, excessive ambient noise levels affect speech perception, learning, attention/concentration, processing and the effective participation of students in the classroom, especially for young children. In addition, there are an increasing number of students with special educational needs (e.g. students with hearing loss and central auditory processing disorder) enrolled in ordinary primary schools. This emphasises the need for a good acoustic environment in classrooms, as these children perform comparatively poorer in the presence of excessive background noise.[18]

Low-frequency noise in classrooms

Findings of this study suggested that the level of low-frequency noise was slightly greater than high-frequency noise. The mean noise levels measured in occupied and unoccupied classrooms using the dBC scale were 65.6 and 65, respectively, with a maximum level of 79.7 in occupied and 70.8 in unoccupied classrooms. The average noise level was 3.5 dB higher than measured in the dBA scale for occupied classrooms and 2.8 dB higher for unoccupied classrooms. Low-frequency noise can effectively mask teacher speech because of upward spreading of masking, thereby leading to poor speech perception in students in the classroom.[1] Hence, the presence of low-frequency noise might affect speech intelligibility in the classrooms. Priority should be given to reducing low-frequency noise, as the energy levels in this region were higher than at other frequencies.

Prolonged excessive voice use by teachers

Normal conversational level for speakers is around 60 dBA.[19] In this study, the teacher speech level was at least 8 dB above this mark. The average speech levels of teachers were 12 dB higher than the normal conversational level. Increased teacher voice level was attributed to the need to maintain a good SNR for students in the classroom. Poor classroom acoustics highly correlates with voice symptoms in school teachers.[20] The background noise in the classroom increases the teachers' tendency to raise their voice level. Consequently, this also tends to increase the risk of developing voice problems.

Unfavourable speech-to-noise ratios for students

In this study, the average SNR obtained for teacher speech level was 10.6 dB. Teacher speech levels were adequately audible in most of the classrooms, as 13 of the unamplified teacher SNRs met the minimum recommended level of + 10 dB level for normal hearing children.[21] However, ASHA's recommendation of +15 dB SNR was achieved only for four (18.1%) classrooms without amplification.

None of the classrooms used an amplification system, which further suggested that the teachers had to raise their voice level to counteract the background noise. It is important to remember that these measurements were taken from a single location of 2 m from the teacher. Therefore, students seated beyond this distance might have a poorer SNR than the measured values. Both ANSI and ASHA have recommended +15 dB SNR to be present throughout the classroom, which includes classes for normal children and children with special needs.[7,14] Therefore, it could be inferred that classrooms selected in this study were more likely to have a poorer SNR at the rear of the classrooms.

Inadequate acoustical treatments for noise reduction in classrooms

In this study, observations revealed that none of the classrooms used any acoustical modifications. Use of acoustic modifications is uncommon in primary schools across India. Among 23 classrooms, only 11 classrooms were furnished with writing desks and benches. Others had mats for student seating. Nineteen classrooms had complete brick walls on four sides. Two classrooms had partial brick partitions on one side, and two had both brick and wooden partitions on one side. None of the classrooms used acoustically modified furniture, partitions, drapes or acoustically treated venetian blinds, acoustic ceiling tiles, or carpeting items which are most effective in noise reduction.[22]

Reverberation time estimation

In this study, the reverberation time was estimated using the Sabine equation. There were totally five different types of classroom dimensions noted. The estimated reverberation time in all classrooms was greater than 2.6 s, which was almost double the recommended time of 1.25 s in Indian standards for good speech perception.[8] This indicated that all classrooms had a poor speech perception environment. Increased reverberation time might be attributed to the absence of sound absorption materials in walls, ceilings and floors. As per the Sabine equation used in this study, the estimate of reverberation time increased with higher room size, less absorption materials and the directionality of the signal. Most of the classrooms were not furnished, and teachers had to stand in front of the class when teaching. This indicated that there was little absorption material in classrooms and the signal directly reflected from the walls, which increased the reverberation time. It is also important to note that reverberation was not only present for teachers' voice, but also for noise. Therefore, when the noise level increases, it will also result in increased noise reverberation, and in turn this will adversely affect speech intelligibility. High reverberation along with background noise affects the concentration of the speaker (teacher) and may also cause teachers to increase their voice further.[23] None of the classrooms used any acoustic modification to reduce reverberation.

Use of classroom amplification systems

In this study, SNRs obtained for unamplified teachers' speech levels were not adequate for children who were seated more than 2 m away from the teacher. This indicated that the teachers should raise their speech levels to achieve adequate listening levels of all the students. To provide adequate SNR, several modifications might be suggested. Many schools in western countries use amplification systems to overcome this issue. Studies have reported that children's academic performance and communication between teacher and students improved after the use of amplification systems.[24,25] Hence, it is suggested that a fixed/portable sound field system be used to improve SNRs for students throughout the classroom. This will also reduce the teacher's risk of over-using their voice. In India, to set up a sound field amplification system in a classroom, the estimated cost is around Rs. 10,000–12,000 (USD 150–180), which is more cost-effective than providing acoustic treatments for the same classroom. However, amplification is possible only with closed doors and windows to avoid sound spillover from one classroom to other and this is problematic in tropical environments. In addition, minimal classroom sound treatment is necessary before installing an amplification system to ensure the system is effective.[18]

Possible alterations to improve classroom acoustics

The results of this study indicated that external noise was more predominant than internal noise. External noise interference can be minimised in several ways. A simple way to reduce noise interference from adjacent classrooms is by closing only the windows and doors near neighbouring classrooms or by constructing doors and windows away from neighbouring classrooms. Arranging classroom learning and teaching spaces away from open windows and doors might help in reducing noise interference from adjacent classrooms. Increasing the distance between classrooms will also reduce some noise interference from adjacent classrooms. In future, school construction projects should avoid having windows and doors facing roads and playgrounds, and this will reduce interference from external noise inside classrooms. Constructing high compound walls around schools will also help reduce external noise interference.

Likewise, internal noise can be reduced by relatively simple alterations. Increased background noise arising within classrooms was mostly from HVAC systems. In this study, ceiling fans were observed to be the major contributor to internal noise. Fans can be kept in good working condition by periodic repairs and replacements to reduce their noise output.

To prevent teachers from overuse of their voice, the following suggestions are offered. Initially, counselling can be provided to teachers about the risk of developing voice problems and how to avoid these disorders. Awareness can be created about how the voice can be used effectively for teaching. Likewise, creating awareness about the importance of good classroom acoustics will help in effective voice use. Tips can also be provided to help teachers monitor for increase in background noise and reverberation in classrooms. In addition, advice to use strategies such as changing to subjects wherein less verbal communication is required in the classroom during periods of increased background noise, to prevent overuse of teacher's voice and to provide an improved learning environment in classroom would be useful.

To reduce reverberation in classrooms, a commonly recommended option is using sound absorption materials on the walls, carpet on the floor and acoustically treated tiles on the ceiling. However, classrooms with acoustical treatment are rare in India. An alternate way to reduce reverberation is by using three-dimensional furnishings such as bookshelves placed around a classroom room to reduce sound reflection. This also provides a cost-effective solution that can also be implemented easily. In future, classrooms could be constructed with acoustical ceiling treatment and three-dimensional furnishings to provide more optimal reverberation for speech perception.

Conclusion

Studies from a number of developed countries have shown that high classroom background noise levels and poor SNRs are common. This suggested that achieving a good classroom acoustic environment was a challenging task in all school administrations. This study's results were in line with international studies and indicated that the southern Indian primary schools did not meet national or international standards for noise levels and reverberation time. The excessive noise levels in classrooms in this study were because of poor acoustic environments. A good listening and teaching environment can be achieved by using sound field amplification and sound absorption materials in classroom, as well as considering noise issues when designing schools. Further study of the acoustic environment of schools in different regions of India, and ways to improve this environment, is necessary.

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Conflicts of interest

There are no conflicts of interest.

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Appendix 1

CLASSROOM ACOUSTICAL SCREENING SURVEY WORKSHEET

Date_________________ **Audiologist/Surveyor**___________________________________

School____

Student age range___________________**Grade**___________________________________

1. OBSERVATION INFORMATION

Background Noise

Listen in the classroom and check for the following; a "yes" is an indicator of potentially excessive levels of noise

Classroom Features	Yes	No
Ventilation system is audible		
Mechanical equipment must be turned off during important lessons		
Noise from playground is audible		
Noise from automobile traffic is audible		
Noise from air traffic is audible		
With heating and ventilation system turned off, sounds from other classrooms, learning spaces or hallway are audible		

Reverberation

Classroom Features	Yes	No
A hard surface, flat ceiling without acoustical ceiling tiles		
Ceiling height is over 3.3 meter		
Acoustical ceiling tiles have been painted		
Walls are constructed of sound reflective materials (e.g., plasterboard, concrete, wood panelling)		
Floors are constructed of sound reflective materials (e.g. concrete, tiles, wood)		

Teacher to Listener Distance: Nearest ____m Farthest ____ m

Classroom Style: □ Traditional □ Open □ Portable/Relocatable

Primary Instruction Style: □Lecture □Large Group □Small Group □Individual □ Other____

Seating Arrangement: □ Clusters □ Rows □ U-shape or Circle □Other

2. NOISE MEASUREMENTS

Classroom Schematic Diagram: see attached

Sound Level Meter: Make/Model____

Method Used: _______

<table>
<tr><th></th><th colspan="4">Ambient Noise Levels (dBA, dBC)
Unoccupied and Occupied Classroom</th><th colspan="2">Teacher Voice Levels (dBA):
Occupied Classroom</th></tr>
<tr><td>Condition</td><td colspan="4">1. Unoccupied, HVAC on;
2. Occupied, HVAC on</td><td colspan="2">With Classroom ADS
☐ Hon ☐ Hoff</td></tr>
<tr><td rowspan="2">Weighting</td><td colspan="2">dB A</td><td colspan="2">dB C</td><td rowspan="2">Level</td><td rowspan="2">SNR</td></tr>
<tr><td>1</td><td>2</td><td>1</td><td>2</td></tr>
<tr><td>Measurement locations</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

3. REVERBERATION TIME

Room Volume (V) =____________________ cubic feet

Area Floor_____________ x ABS. Coef._______________ = A Floor __________________

Area Ceiling ___________ x ABS. Coef._______________ = A Ceiling_________________

Area Side Wall 1________ x ABS. Coef.______________ = A Wall 1__________________

Area Side Wall 2________ x ABS. Coef.______________ = A Wall 2 __________________

Area End Wall 1_________ x ABS. Coef.______________ = A End 1__________________

Area End Wall 2 _________x ABS. Coef.______________ = A End 2 __________________

Total A=_________________________

Estimated Average RT of Classroom = .049 x _______ (V) / ________ (A) = ______seconds