SETTING UP A CLASSROOM FOR THE HEARING - IMPAIRED

REg. No. M. 9305

An independent Project work submitted in partfulfilment for First Year M.Sc. (Speech and Hearing) to the University of Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE-670 006

MAY 1994

Dedicated to

My Cousins:

Baljinder Mohan and Subhash Chander

and

The Hearing Impaired Population

DECLARATION

I hereby declare that this Independent project entitled: **"Setting up a classroom for the Hearing Impaired"** is the result of my own study undertaken under the guidance of **Dr.(Miss) S. Nikam,** Prof, and Head of the Department of Audiology, and Director, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore,
May 1994.

Reg.No. M 9305.

CERTIFICATE

This is to certify that the Independent Project entitled: **"Setting up a classroom for the Hearing Impaired"** is the bonafide work done in part fulfilment for first year M.Sc.(Speech and Hearing) of the student with Reg.No. M 9305.

Mysore,
May 1994.

Director,
All India Institute of Speech & Hearing, Mysore-570006.

CERTIFICATE

This is to certify that this Independent project entitled **"Setting up a Classroom for the Hearing Impaired",** has been prepared under my supervision and guidance.

Mysore,
May 1994.

Dr. (Miss) S. Nikam,
GUIDE.

ACKNOWLEDGEMENTS

I extend my gratitude and thanks to Dr.(Miss) S. Nikam, Prof, and HOD Audiology, for her invaluable guidance. Thanks to the Director, **Dr.(Miss) S. Nikam,** AIISH for giving me an opportunity to take up this project.

Ms. Asha Yathiraj for her guidance and invaluable suggestions.

Ms. Manjula for her timely guidance and support throughout the study.

Library Staff, for helping me with the references.

My Dear friends, for their encouragement and moral support.

My family, for being with me throughout.

Dr.Devraj and Mrs.Jayalata Acharya for their invaluable guidance and support.

Dr.Shetty, Mr.Kiran and Ms.Sree Divya for their finishing touches and their invaluable help.

TABLE OF CONTENTS

INTRODUCTION

Communication plays a vital role in the extent to which a person can relate to and influence his or her environment, interact with friends and family, and derive enjoyment from day-to-day activities. Any impediment to this process can limit a person's potential to receive and interpret vital information and maintain relationships necessary to achieve the greatest potential for quality of life. This can be seen in individuals with a hearing impairment.

In 1937, the committee on Nomenclature of the conference of Executives of American schools for the Deaf recognized the importance of the ability to be able to speak, the ability to hear (as showen by their use of the word "functional") and time of onset in proposing the following classifications and definitions:

l.The Deaf: Those in whom the sense of hearing is non-functional for the ordinary purposes of life. They are further classified as: Congenitally deaf and Adventitiously deaf.

2.The Hard Of Hearing:- Those in whom the sense of hearing, although defective, is functional with or without a hearing aid.

For the deaf and the hard of hearing, special care needs to be taken to teach them to be self sufficient and be independent. In the rehabilitation process, the first step involves prescribing an appropriate hearing aid after the audiological evaluations. The second step is to give proper education to the individual depending upon the language abilities of the child, the child can be put into a regular school or a special school. Just putting the child in a school and making him wear the hearing aid does not suffice. It does not ensure proper education because of a number of factors.

Classrooms are auditory-verbal environments (Simon, 1985). That is, information is presented through speech with the underlying assumption that students can indeed hear the teacher. Children spend atleast 45% of the school day engaged in listening activities **(Berg, 1987)**.

Because hearing loss is invisible (an invisible acoustic filter); the results of hearing loss are ambiguous and difficult to appreciate **(Ling, 1986)**. This ambiguous nature of hearing loss is compounded by the tendency to categorize hearing loss into dichotomous groupings: normally hearing or deaf **(Ross & Calvert, 1984)**. When a child with a mild-moderate hearing loss is obviously not "deaf", the hearing loss is often thought to be of minimal consequence to classroom function **(Bess, 1985, Davis, 1977)**. Approximately 92-94% of the total hearing-impaired population is functionally "hard-of hearing "and not deaf". Preferential seating is not enough; even properly functioning hearing aids are not enough **(Flexer et al, 1989)**.

The literature suggests that the major acoustic problems a child faces in educational settings are:

1) Noisy, reverberant classrooms **(Sanders, 1965; Mieber, 1975; Ross & Giolas, 1972)** which may affect the ability to under-

stand speech **(Nabalek & Pickett, 1974; Ross & Giolas, 1971)** and

2) Amplification systems which often are non-functional, misused or are of limited value **(Gaeth & Lounsbury 1966; Porter, 1973; Ross & Giolas 1971)**.

Many communicative situations are filled with distractions and interference that can seriously degrade the integrity of the process even for those individuals with "normal" hearing. The effects of unwanted background noise, distance from the desired sound source, poor room acoustics, and reverberation can compound these problems, creating insurmountable obstacles for the hearing-impaired listener. All these factors pose as a hindrance in the calssroom as well and thus affect the learning process drastically. Hearing should be considered as a dynamic interactive process. It is maximized only when the relationship between the individuals can be exploited, to its maximum. The primary overriding educational objective of amplification, therefore is to permit the teacher and the pupil complete freedom in the development of that interpersonal relationship within the teacher-learning environment.

Second, we must consider the various means by which teaching and learning take place within the learning environment. This factor includes the use of individualized teaching on a one-to-one basis, small group work, and whole class teaching. It also includes the use of programmed learning methods such as audiovisual teaching casettes, the use of films, film strips, and T.V.

Finally, we need to take into account the various environments in which learning takes place, including the classroom, learning centers, special subject rooms(Music, art), library, auditorium, laboratory and gymnasium. In addition, instruction is given in outdoor environments such as the playground, sports field and on field trips.

The ideal overall objectives for educational amplification, therefore, are to provide each hearing-impaired child with maximal audibility and clarity of the speech of the instructor and participating students, to permit monitoring of the child's own speech, and to make this provision for each of the learning environments encountered.

The purpose of using amplification at all is to develop and increase auditory based communication skills; the greater success we achieve with this purpose, the greater will be the child's ability to contribute more internal information to the comprehension of speech.

But in most schools at present, we do not see all these factors being given their due importance with respect to the education of the hearing impaired. Most of the schools are unable to achieve the acceptable levels of noise or their amplification equipment is out of order due to which the hearing-impaired children can't avail of the available facilities. Others are unaware of the important parameters which need to be taken into consideration at the time of constructing and organising the schools for the deaf.

Hence, the present study was undertaken.

Purpose of the Study:-

1) To make the professionals aware of the various factors, which need to be taken into consideration while constructing a classroom for the hearing impaired.

2) To emphasize the effect of these factors on the classroom environment; and

3) To emphasize the ill-effects on the hearing-impaired children when these factors are ignored or cannot be considered due to one or the other reason.

Factors taken into consideration in the present study:-

(a) Classroom acoustics and Architectural design.

(b) Classroom Illumination.

(c) Classroom amplification.

(d) Other factors: These include;

- (i) Teacher-to-child ratio
- (ii) Space guidelines for classroom
- (iii) Seating arrangement
- (iv) Budget for maintainance and replacement.

Classroom Acoustics and Architectural Design:-

I. Acoustic environment

-External noise

-Internal noise and classroom noise

II. Reverberation

-Signal -noise ratio.

III.Physicial concepts of speech communication in classrooms fo the deaf.

CLASSROOM ACOUSTICS;-

The acoustic environment or climate may be defined as that mixture of background noise and useful sounds in which we continually find ourselves. A good acoustic environment may be defined as that situation in which the noise that is irrelevant to us is suppressed as far as possible, while the useful sounds, those that interest us, stand out clearly and are truly and easily distinguishable **(Borrild, 1959)**-

The acoustic climate in a room of normal shape and size, such as a room traditionally used in teaching, is determined essentially by three factors:

1. Noise transmitted from other rooms or from outside (external noise);
2. Noise produced in the room itself; and
3. The reverberation time of the room.

The acoustic environment in which a hearing impaired child listens has a significant effect on auditory functioning. The work of **Tillman, Carhart & Olsen (1970); Finitzo-Hieber & Tillman (1978); Bess & Mc Connell (1981)** & others have demonstrated that noise has a greater relative impact on the speech perception skills of hearing-impaired than on normal hearing people. Hearing impaired people may require speech levels to be as much as 20 dB greater than the background noise if speech perception is to be maximized.

Bess, Sinclair & Riggs (1984) conducted a study to examine the ambient noise levels in 19 classrooms for the hearing-impaired. The average classroom noise levels found in this study [56 dB(A)] exceeded acceptable criteria [30 dB(A)] by 26 dB; however, some of the rooms exceeded acceptable criteria by as much as 36 dB. A significant component to the overall noise level was created by the occupants and occurred primarily in the speech frequentcy range.

Markides (1986) reported noise levels in classrooms, the average level of background noise varied from 46.1dB (A) (quasi-stationary noise) to 61 dB (A) (non-stationary noise) and to 76.5 dB (A) (short duration noise). The S/N ratio varied during lessons between -18.8 and + 11.4.dB while the teachers were speaking and between-23.3 dB and + 6.8 dB while the pupils were speaking.

1. EXTERNAL NOISE:

The first factor, noise, which is transmitted from other rooms or from outside, can be dealt with, in many ways, some of which will be quite costly. The cost of acoustic treatment can be drastically reduced by choosing an appropriate location.

Location: When beginning the project of a new shcool, the acoustic planning should be started simultaneously with the selection of the location **(Knudsen & Harris, 1950).**

According to **Finitzo (1988)**, a quiet residential street away, from traffic noise, railroads and airports is ideal. He suggested three considerations to be made when evaluating classroom location. They are:

1) A classroom located near concentrated student activity, such as locker room, will tend to have greater sound levels throughout the day than one located farther away from the noise source.

2) A classroom near a high noise area, such as maintenance or mechanical room, cafetaria or playground is not acceptable.

3) Classes for hearing impaired children should not be near or in open-plan areas with minimal sound isolation from suspended ceilings, temporary partitions, or sliding walls or doors.

Sources of External Noise:-

The various sources which have been identified are street noise, rail-noise, aircraft, traffic noise, adjacent industry, playgrounds and sports grounds, power stations etc.,One important point which should not be forgotten is to make the acoustician as much a part of the school project as the architect, to perform a long range registration of the noise level at the contemplated site.

2. INTERNAL NOISE:

Noise can be generated within the school building but outside a given classroom from areas adjacent to mechanical equipment (venting); metal, wood working and tailoring workshops. Flourescent lamps are also contributory because the ballast can produce an extremely annoying noise.

3. **CLASSROOM NOISE:**

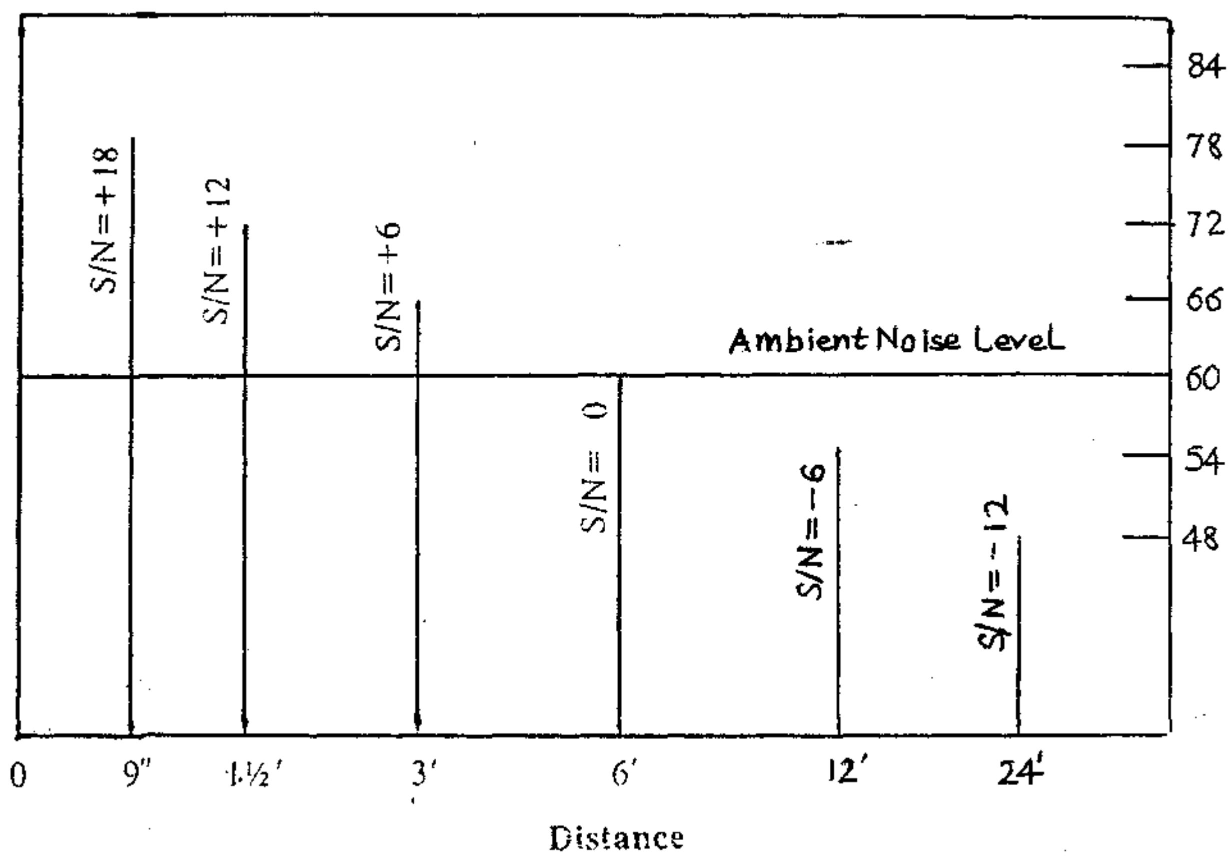
Refers to noise generated by classroom activities: furniture noise dropping of hard objects on the floor, normal footsteps, shuffling of steps, chalkboards and fans.

4. **Signal-to-Noise (S/N) Ratio:**

The S/N ratio is the difference in dB between the speech signal and the extraneous background noise in the environment. **Gengel (1971), Gengel and Foust (1975)** found that the S/N ratio had to be atleast +10 dB and preferably +20dB for hearing impaired children to function effectively in the classroom.

Ross(1977) suggested the use of a short microphone distance but it should not be so close as to obscure the view of the mouth or to amplify breath sounds or other distracting and undesirable mouth noises. A distance of 4-8 inches would appear to be optimal.

SIGNAL -TO- NOISE RATIO RELATIONSHIPS IN A NONREVERBERANT ROOM HAVING A 60dB SPL AMBIENT NOISE LEVEL



Distance and signal -to- noise ratios.

EFFECT OF NOISE ON SPEECH INTELLIGIBILITY:

Noise has been found to have a very grave effect on speech comprehension. This is supported by the various studies which have been conducted by a number of investigators. They found the following effects:

(i) The profoundly deaf children achieved their maximum Audio Visual scores only at a higher S/N ratio than that for the severely hearing impaired group (0 dB), who in turn required a higher S/N ratio for maximum AV recognition than did the normals (-10 dB). **(Erber, 1971).**

(ii)Classroom noise has a significant adverse effect on lip-reading ability in hearing subjects. Deterioration was the result of the interference of background noise with the cognitive processes involved in the integration of signals from the auditory, visual and Kineasthetic/tactile modalities.(Markides,1989)

(iii) Average room noise (55-65 dB(A)) causes masking of speech and the masking effect is greater at the frequencies 500-5,000 Hz. **(Pekkarinen** & **Viljanen 1990).**

As noise has an adverse effect on speech intelligibility, many investigators have set maximum permissible levels not exceeding 40 dB.

Based upon the desire for a S-N ratio of not less than 10 dB, the maximum permissible noise level is set at 35 dBSPL or frequency balanced in octave bands **(Johansson, 1968):**

Hz	125	250	500	1K	2K	4K
Max dBlevel	30	30	30	30	25	20.

Moreover, there are regulations set by the **Danish (1977)** which need to be fulfilled in the schools for special education of the handicapped.

A horizontal minimum airborne sound insulation index (la) of 48 dB and a vertical minimum la of 51 dB is required between the classrooms. la >/ 60dB is required between classrooms used for particularly noisy activities, and other classrooms.

Floor partitions and floors on the ground must be constructed so that the impact sound level does not exceed impact sound insulation index of 68 dB. Moreover, the impact sound level in adjacent rooms should not exceed 58 dB.

Unfortunately, most of the schools outside India fail to meet these standards. **(Sanders 1965; Ross** & **Giolas, 1972).** This could be due to limited budget and inappropriate planning. There is no evidence which highlights the Indian conditions. This itself shows the lack of attention given to the classroom environments in schools. If we are unable to begin planning at the time of site selection, still, we can take a number of steps to improve the situation. What then are the available means to attain the desired acoustic environment in a classroom?

Mainly there are three possible ways by which we can achieve a good acoustic environment. They are:-

(i) Reduction of noise at source.

(ii) Sound treatment

(iii) Sound insulation.

a) **Steps to reduce external noise**:-

1. Sound reduction due to distance from the source depends on the inverse square law reduction of 6 dB for every doubling of the distance. When the listening position is close to the noise, quite a small increase in distance will give a worthwhile reduction in noise, but when it is far off, further reduction by distance is generally impractical.

In 1978, **Knud Borrild** suggested concentrating noise-producing rooms in one group, and rooms with a low noise level in another, without close contact between the groups. Moreover, areas in which high levels of noise are produced can be made to face the strongest outdoor source of noise.

2. A portion of the outdoor sound will be transmitted inside the building, while another portion will be absorbed by the wall and a third portion will be reflected from the wall. A wall or a large mound of earth in front of the school building will serve as a partial barrier and absorb sound that is enroute to the class, provided the school is within the shadow of the barrier.

1

3. Planting noise abating trees and shrubs will also deflect unwanted external sounds. Both deciduous and evergreen trees should be grown for it to be effective in both summer and winter. (Finitzo, 1988). Reduction due to trees varies from 3 dB/100 m at 125 Hz to 11 dB/100 m at 2,000 Hz. Trees must be closely spaced and have a height between 6 and 12m. Additional reduction due to grass beyond that for distance alone increases from 1 dB/100 m at 125 Hz to 3 dB at 500 Hz but then falls again to 1 dB/100 m at 2,000 Hz. At high frequencies above 2,000 Hz, the sound reduction of the air begins to take effect and adds about another 2 dB/100 m.

4. Solid concrete walls are superior to lighter partitions or to large expanses of glass. Double wall structures with air spaces between them can be used in reducing, particularly, the transmission of HF noises (structurally independent). Filling the space, with an absorbent material results in maximum efficiency. Double-pane glass windows are better than single-pane in reducing outdoor noise.

5. Long straight corridors should be avoided as it is going to lead to reverberations. Corridors should be sound treated with particular attention paid to floors.

b) Measures to reduce internal noise:-

1. Some services can often be provided in a building which can be situated to form a valuable baffle between a source of external noise and the main school (Euring, 1963).

2. The distance between the teaching area and the source of noise can be increased (Fourcin et al, 1980). This will help in reduction of SPL according to the inverse square law.

3. Storage rooms can be placed next to the sound source rather than the classrooms for hearing impaired children so that the room acts as a sound insulator.

4. Partitions between classrooms, and between corridors and classrooms should provide an insulation of about 45 dB. A 4 1/2 inch brick wall plastered on both sides is satisfactory as it has a transmission loss of 40-45 dB.

Other means-

-> Compound Walls- Formed of two leaves, which may be of light weight materials, each structurally isolated from the other. The insulation provided by this type can be improved by hanging an absorptive blanket in the space between the leaves, but it is important that the space should not be filled with any solid material. (More economical)

-> Eight inch concrete blocks filled with sand.

Partitions must extend from floor to solid ceiling above and not just to suspended ceilings.

5. Door should fit the door frames snugly. A tight seal can be obtained by lining the door frame with felt and rubber.

6. Direct air paths between classrooms or corridor and classroom through cracks and openings around pipes or ventilation ducts must be avoided. Air circulation ducts should be large to allow air exchange at low velocity and minimum turbulence, have flexible joints and be fitted with noise traps to avoid noise transmission from room to room via duct work.

7. Temporary thin partitions, folding doors and sliding doors are not recommended because the gaps at the floor and ceiling provide direct air paths of sound transmission.

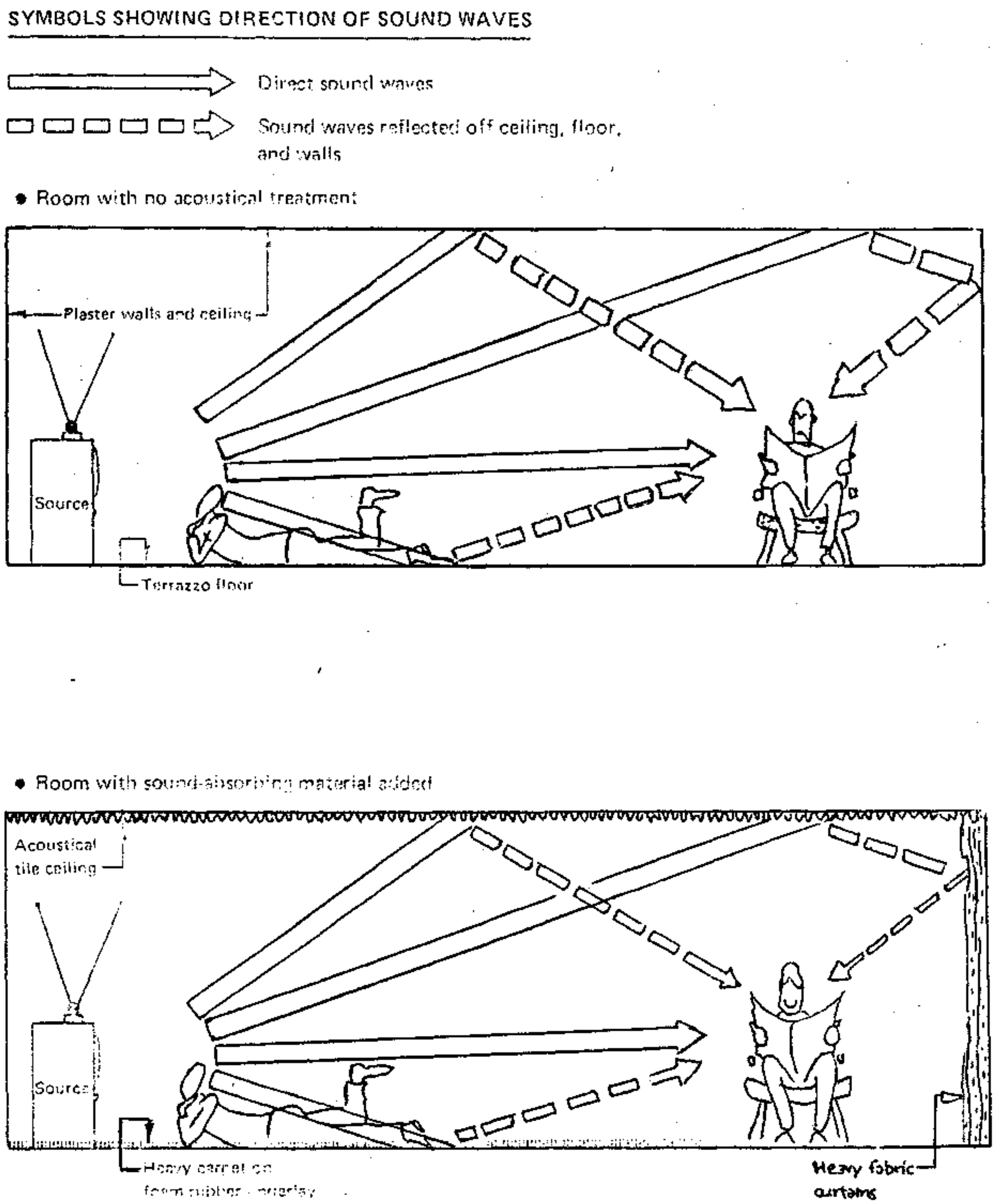
8. Impact noise can be controlled by dis-continuous construction e.g. a beam, instead of being rigidly fixed may be supported on a resilient pad or spring. All classrooms, corridors and internal circulation area floors should be finished with a resilient material. Sheet rubber on a sponge rubber underlay, though expensive, is probably the best covering. Linoleum, laid on hair felt, and rubber studded files act as good substitutes.

(C)Measures to reduce classroom noise:-

1. Cover the tops of desks with resilient material.
2. Chalkboards should be rigidly attached to walls as they are less noisy.
3. Rubber feet on legs of desks and chairs are of immense value.
4. Fans should be of the type designed for quiet operation.

d) SOUND ABSORPTION.

Effect of adding sound absorbing material to a room.



If sound-absorbing material is added to the room, the reader will hear considerably less reflected sound. Consequently, the sound level in his part of the rooms will be reduced **(Egan, 1972)**.

Effect of room surface sound-absorbing treatment:**(Pietrasanta, 1955).**

The addition of ceiling sound absorption to a 20' by 20' by 10' high room reduces the sound level by 10dB in the reverberant field. However, close to the sound source, the reduction is only about 3dB. If the ceiling and all four walls are treated with sound-absorbing material, the sound level in the reverberant field drops an additional 6 dB, but the sound level near the source, in the free field remains unchanged.

Measurements for absorption:-

The effectiveness of any material as a sound absorber can be expressed by its absorption co-efficient a. Theoretically, it can vary from 0 (no sound absorption) to 1.0 (all incident sound absorbed). Absorption co-efficients for building materials normally vary from about 0.01 to 0.99. Materials having large or appreciable sound absorption co-efficients (usually greater than about 0.20) are referred to as "sound absorbers", whereas those with small absorption co-efficients are called "sound reflectors".

The absorption co-efficient for most materials varies with frequency. For practical purposes, it is conventionally specified for frequencies between 125 and 4,000 Hz. The amount of absorption is determined by the porous absorber's actual physical properties of (1) thickness (2) density, (3) porosity, and (4) fiber orientation.

Noise reduction co-efficient (NRC) is an adequate index of sound-absorbing efficiency, where LF absorption is not an important factor. It is the arithmetical average of a materials's sound absorption co-efficients at 250, 500, 1,000 and 2,000 Hz carried to the nearest 0.05 .

Sound absorption and sound reflecting materials:- Egan (1972)

1) Walls- (depending upon the absorption co-efficient)

Sound-reflecting:

-Brick, unglazed and painted is one of the best.

Sound-absorbing:-

(i) Medium weight drapery-14oz/square yard, draped to half area.

(ii) Heavy weight drapery-18oz/sq. yard, draped to half area,

(iii) Carpet, heavy, on 5/8 inch perforated mineral fiberboard with airspace behind.

2) Floors:

Sound-reflecting:

-Concrete or terrzo

Sound-absorbing

-Carpet, heavy on foam rubber.

3) Ceilings:-

-Sound-reflective: Concrete

-sound-absorbing : Suspended acoustial tile, 3/4 inch thick.

Thus, based upon the absorption co-efficient values we can choose different materials according to our requirements.

Relative effectiveness of wall and ceiling absorption treatment:-

High-efficiency absorptive treatment of walls can be more effective in smaller rooms, whereas treatment of ceilings is more effective in larger rooms.

Suggested sound-absorbing treatment for secondary classrooms:

Preferred NRC range	:	0.65-0.75
Ceiling treatment	:	Partial
Wall treatment	:	Yes.

Checklist for effective absorption of sound:-

a) Never put sound-absorbing material on a surface that is needed for useful sound reflections, which may help in improving speech intelligibility

b) Place sound-absorbing material on any surface that can be expected to produce annoying echoes or to focus sound.

c) In general,cover ceilings for noise reduction within rooms, unless the floor is carpeted and the room is filled with draperies and heavily upholstered furniture.

d) In long, narrow, or very high rooms, consider using absorption on the walls. In very large rooms with low ceilings, wall absorption is rarely beneficial.

e) The actual method of mounting is important since it will control absorption efficiency e.g. sound-absorbing materials applied with adhesive are poor LF absorbers check carefully, so that the mounting used is best suited for the absorption desired.

f) The amount of treatment is determined by the absorbing material already in the room, plus the size of the room.

All these measures can be taken into consideration with respect to Indian conditions and the cost can be drastically reduced by planning before the construction itself.

Reverberation:

It is persistence of sound in an enclosed space as a result of multiple reflections after the sound source has stopped (ANSI, 1960).

The reverberation time (RT) in a room is defined as the period of time, in seconds, that elapses from the moment a sound source is stopped until the sound level has dropped 60 dB. It is normally frequency dependent.

$$T = \frac{0.05V}{a} \quad \text{(Sabine's formulla)}$$

Where V= Room Volume

a= Total room absorption

RT tends to be longer below 500 Hz.

Effect of reverberation on speech Intelligibility:

Do the repetitions of the same sound waves over a given time period enhance or disrupt comprehension of speech messages?

Reflections or repetitions of speech sounds over a period of 0.02 to 0.03 sec. enhance speech understanding (as reported by **Lochner and Burger (1961, 1964)** and **Nabalek and Robinette(1978)**).

Unfortunately, hearing-impaired subjects do not seem to benefit from rapid repetitions of the acoustic cues in speech over even 0.02 sec.

Small changes in RTs from 0.3 to 0.6 sec. can result in poorer scores on word identification tasks. **(Nabalek and Pickett,**

1974).

In reverberant conditions, confusion for initial consonants of the test items increased by about 5% and final consonant errors increased by about 9% when heard in the 0.8 sec RT. The most common errors were errors of place, but errors of manner also occured. **(Gelfand and Silman, 1979).**

Effect of noise and reverberations:-

Adding noise to the same reverberation conditions decreased the word recognition scores considerably, more so with increasing RTs **(Houtgast and Steeneken/ (1973); Nabalek and Pickett (1974) and Chan (1980)).**

Impulsive noise with prolonged reverberation is more detrimental to speech reception than quasi-steady noise. Thus, noise when combined with reverberation makes the envoirnment even worse.

Taking all these factors into consideration, we should strive for the minimum reverberation time.

Johansson (1968) has set the following standards at maximum:

Hz	125	250	500	1K	2K	4K
Sec.	0.6	0.5	0.5	0.5	0.5	0.6

According to **Forcin et al (1980),** RT should be 0.5 sec.

Hence, to make the classroom environment acoustically suitable for the hearing impaired, we should try to achieve atleast a reverberation time of 0.5 sec. But, how can we achieve our target?

Measures to reduce reverberation:

The need to control reverberation is greatest in rooms in which individual aids are used and priority should be given to these rooms.

In a classroom for the deaf, it is desirable to have all listeners, in a sound field that is controlled by direct sound. This setting requires a large critical distance, which in turn requires a large amount of acoustic absorption. The distance from the source at which the direct and reverberant SPLs are equal is called the critical distance.

In the analysis and design of rooms for audition, first reflected sounds are probably the most important. The design strategy suggested is:

1. Making the ceiling and front wall reflective, will provide strong early reflections to the auditors which improves the speech understanding.

2. The intensity of sound from shuffling feet and falling books can be reduced by carpeting the floor.

3. If both the front and rear walls are reflective, they can result in undesired room resonances. So it is better to cover the rear wall with an acoustical absorbent, although the rear wall may provide useful reflected energy to auditors in

the rear.

4. Absorbent patches on the side walls are acoustically efficient as they increase sound diffusion and yet they allow some desirable specular reflection.

5. Sound treatment should be provided for as many vertical surfaces as possible.

6. Blackboards should be solidly mounted probably glass or painted blackboard. Tilting blackboards at a 6degree angle may be useful if they are opposite a hard, untreatable area like the locker area.

7. A good acoustic ceiling is effective. Corkboard on walls and heavy drapes on windows are also helpful.

8. Large windows on opposite walls are not desirable as they increase reverberation.

9. Book shelves, portable room dividers and acoustic panels can reduce this problem by redirecting and absorbing sound.

10. RT of corridors and halls should be hied as low as possible, because these strongly noise-producing areas may otherwise result in the use of disproportionately heavy and therefore costly wall and door constructions (Mark, Ross and Giolas, 1978).

Physical concepts of speech communication in classrooms for the deaf:

Physical features of the classroom communication system relate to the speaker, the environment and the listener. Each element in the system is significant in affecting the transmission of speech and each interacts with the others.

a) The speaker - The speaker can be imagined to be a directional sound source that emits an acoustical signal that varies with time in both amplitude and frequency. The speaker's directional properties and the frequency spectra of both the speech waveform and its envelope are the important features.

Directivity- A speaker becomes more directional with increasing frequency. In marginal listening situations, a 3dB change in S/N ratio can make the difference between intelligibility and unintelligibility, and with the turn of the talker's head, he can lose his audience.

The speech signal and envelope- Assuming a simple reciprocal relationship between response time and bandwidth, the onset and decay times of speech brusts should be 40 msec or greater.

b)The environment- In general, the response of the room to the speech envelope depends on its RT, on the ratio of direct-to-reverberant sound, and on whether the onset or decay of the signal is considered. However, if the listener is in the reverberant sound field, then only the room RT controls the rise and decay times.

c)The listener

Directivity- Each ear of the listener was found to be most sensitive to sound coming from a direction 30 to 60 on the side of the ear concerned. Moreover, a directional hearing aid in creases the directivity of the impaired listener only at low and middle frequencies.

Effects of hearing impairment-

A hearing impairment can affect adversely, depending upon the degree of impairment and the response of the hearing aid if one is used.

The communication system:-

The speech signal, with power spectrum that lies below 8 KHZ, has a signal rise time of 125 micro sec. It would be desirable for each element of the classroom communication system to have bandwidths for signal and envelope greater than 8 KHz and 25 Hz respectively, and to have response times that are less than 125 micro sec for the speech wave and 40 msec for the envelope.

Classroom Illumination:

-Role of illumination

-Effect of angle, distance and illumination on visual speech perception of the profoundly deaf.

-Suggestions to the problems faced in the classroom.

-Illumination designs in classrooms for the deaf.

CLASSROOM ILLUMINATION

Hearing impaired pupils very often require a visual presentation of the subject matter. The lighting of a teaching area must be carefully considered in order to achieve a situation in which:

a) the pupils can lipread their teacher and each other without difficulty;
b) Group presentation of written language on blackboard or over head projector can be easily read, and?
c) T.V. screens and daylight projection screens can be seen clearly by all the pupils. (Fourcin et al, 1980).

The aim should be to achieve good natural lighting in the area, to minimise the occasions when shadows will be formed or when the light will be extremely bright. Lighting systems chosen must not introduce acoustic or magnetic noise into the teaching area.

While teaching areas will require especially good lighting, it must not be overlooked that hearing impaired children use their vision in understanding speech in all areas of the school, including play areas, corridors etc., Lighting in these areas must be carefully planned.

Various investigators have demonstrated that a variety of angle, distance and illumination variables can influence visual communication in the classroom.

Neely and Wurrtemberger (1956) found 0 horizontal viewing angle (mouth level) slightly superior to one of 45 (interme diate) on the contrary, **Larr (1959) and Nikano (1961)** found 45 to be superior to 0. These differences can be attributed to differences in illumination or to differences in the phonetic composition of the stimulus materials.

Regardless of the angle of incidence of light, mean scores obtained from 0 or 45 horizontal viewing angles diminish with distance in an approximate linear fashion: 0.8 to 1.6% per foot.**(Erber,1974)**. However, this relationship does not appear to hold true for a 90 viewing angle (overhead) as a plateau in mean scores occurs for distances nearer than about 12 feet, and a further reduction in distance does not produce substantial improvement in lip-reading.**(Erber, 1974).**

Erber (1974) studied the effects of facial and background luminance on visual reception of speech by profoundly deaf children. He concluded that given a light source at mouth level (which provides similar oral and facial illumination), visual word-recognition is affected only minimally by varying the intensity of light throughout a wide range. When facial luminance is decreased from 0.03 to 0.01 fL, mean lipreading performance drops sharply. It is not an illuminated background itself which makes lipreading difficult, but rather it is the ratio of background to facial-luminance (contrast) that is important.

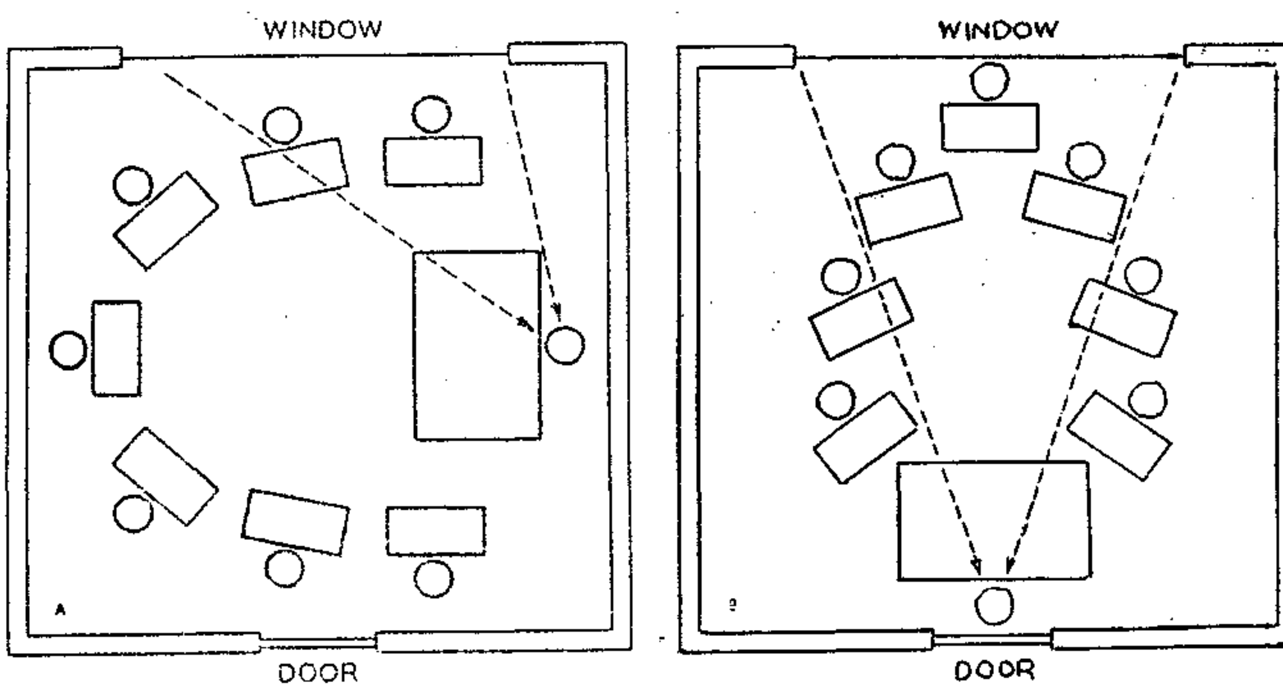
Minor variations in vertical viewing angle do not influence visual intelligibility. Erber (1974) suggested that the teacher should speak at the child's eye level to insure maximum intelligibility.

Erber, 1974 concluded that regardless of the illumination conditions, deaf children achieve their best visual word-recognition performance when they can observe the speaker from within the horizontal range of 0 to 45.

Windows at the side of the room and fluorescent or incandescent fixtures mounted on the ceiling generally shadow the interior of the teacher's mouth and obscure many postdental tongue articulations. So what are the alternatives to this arrangement?

1. The teacher should face the window to achieve similar oral and facial illumination and the desk pattern should be compressed so that all children observe the teacher from favourable positions and smaller distances compensate fro more extreme angles.

The only drawback is that some students occassionally may find it difficult to observe one another. This arrangement is shown in the figure below:



a) Typical classroom arrangement. The pupils desks are arranged in a semicircle around the teacher, and several children must observe her from extreme horizontal angles. Because the major light sources are beside and above the teacher, her oral cavity may be shadowed. (b) Alternate classroom arrangement. The desk pattern is compressed, so that all children observe the teacher from favorable positions. The teacher faces the window, which provides good oral and facial illumination.

2. Special lighting or reflective surfaces can be used at the level of the teacher's mouth.
3. A swivel chair can be provided for each child.
4. Classes should be divided into small groups for conversational purposes.
5. The surface behind the teacher and the area which surrounds the teacher should be properly organized to help minimize distracting influences in the classroom.

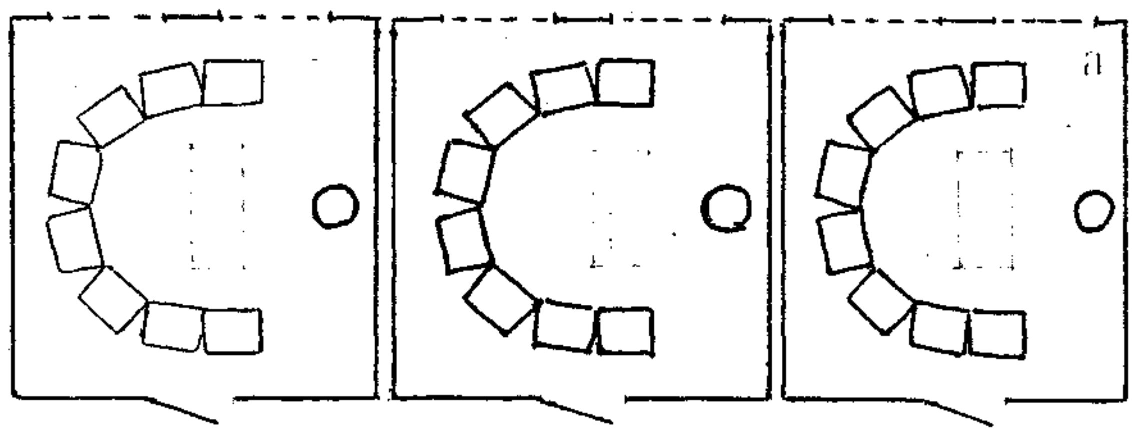
Erber (1979) studied the illumination factors in the design of classrooms for deaf children. He suggested the following:

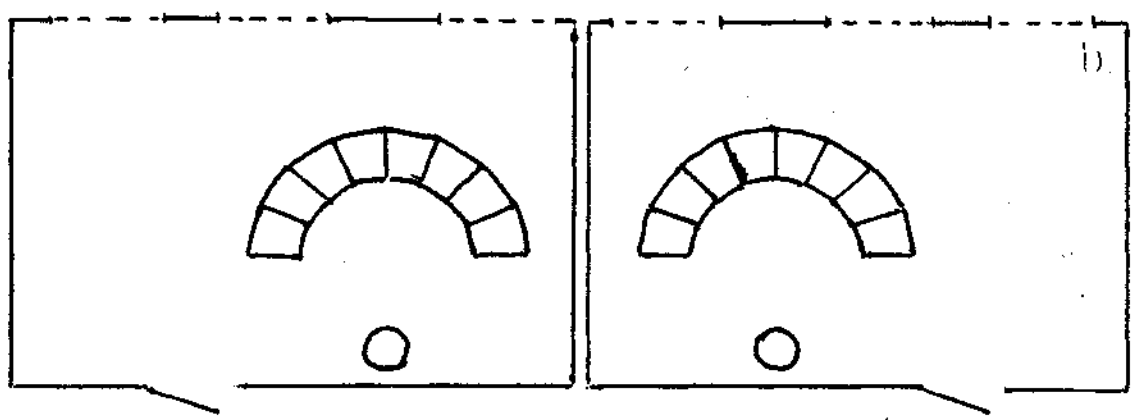
1. Lowering the angel of light incidence increases the amount of light on the mouth cavity relative to that on the facial surface. It improves visibility of the most post-dental tongue articulations.
2. More light is provided both within the mouth (7fL) on the face when back wall illumination is used. This results in a glare on extreme upper portion of the front chalkboard. The solu tion is not to write on the upper 10-12 inches of the chalkboard.
3. In order to maximize the line visibility against an illuminat ed projection screen, blue (60:175 fL) or black (75:175fL) pens should be used. Red and green should be used only for emphasis, underlining or background shading.

4. Both overhead and back wall lighting should be used.

5. Direct sunlight is beneficial to general interior illumination and is valuable for lipreading, desk work and other visual tasks.

6. Shade screen can be used to avoid glare. Both sides of the screen surface can be sprayed with non-reflecting point.





EXPERIMENTAL CLASSROOMS, (a). Arrangement of three rooms beforee modification with sunlight entering from the side and overhead illumination (dotted lines).
(b) Arrangement of two rooms after extensive remodeling, with teachers from windows and peripherral fluorescent lighting in place (dotted lines).

Shepard and Lillis (1981)-Gave the following guidelines:

1. Use yellow chalk on black, tan or green chalkboards.
2. Furniture and equipment should have non-glare surfaces.
3. A spotlight can be used to illuminate that teacher's face and body when a teacher basically remains in one place in a classroom.
4. Room lights can be easily connected to dimmer switches to adjust the light levels to alternative settings.
5. Light switches should control room areas, not rows of light fixtures.

CLASSROOM AMPLIFICATION:

(i) What are assistive listening devices?

(ii) What are the types of ALDS?

(iii) How to select an amplification system?

(iv) Design requirements of Group hearing aids,

(v) Suggestions.

CLASSROOM AMPLIFICATION:

What are Assistive listening devices?

Assistive devices are products designed to solve one or more specific listening problems created by a hearing loss. The primary goal of ALDs is to offer the user "direct amplification" which delivers the sound to the ear in order to overcome the problems of background noise, distance and echo. The primary differences between listening devices and the hearing aids are that assistive devices are designed to help in only one, or a few, listening environments and are only for temporary use, whereas hearing aids are designed for use in a wide range of listening environments and are primarily for full-time use. In sum, the role of assistive devices is adjunctive to HA fitting.

Boothroyd (1984) and others have reported that the auditory channel, even when severely damaged, provides better access to more speech features than any non-auditory channels, either alone or in combination.

Types of ALDs:-

ALDS are divided into two main types- wireless and hard-wired. Wireless systems are divided into three primary types:

FM

Induction loop

Infra-red.

All wireless systems have two essential components, a transmitter and a wireless receiver. The transmitter picks up the desired signal through a direct electrical connection to the sound source or through a microphone placed near the sound source. Once the sound is picked up, the transmitter changes it into an electrical signal sent through the air on a radio wave or invisible light. This signal is then picked up and converted into sound by the wireless receiver worn by the listener. The listener can attach the receiver directly to earphones or to a hearing instrument.

In wired systems (sometimes called "hard wire" systems) the signals are distributed to students by direct electrical wiring. The microphone signals are also connected by wire to the amplifier, although a wireless microphone may be used for greater teacher mobility. Students remove their personal aids and listen through headsets which are plugged into the system.

FEATURES	PERSONAL	WIRED	FM SYSTEM	IIA	INFRA RED
a) Signals & S/N Ratio	If ft (98dB and anbient noise level is (68 dB, the criteria can be met	Optimal signal cond-ition for all speech inputs as well as other audio inputs.	Excellent S-M ratio	Optimal signal level and S-N ratio for the teacher's speech	Good quality
b) Adaptability	Satisfactory if students are properly fitted	Unlimited opportuni-ties for individual adjustments	Host flexible	Determined by their personal aids	Not flexible
c) Extraneous signals !	Not subject to electrical inter-ference	Few interference problems	Potential for outside interfere-nce froa certain paging systens	Interference from electric motors computers,dimmer switches etc.	Interference from sunlight & fluorescent lights.
d) Sinplicity S Riliability	Siaple but reliabili-ty is poor.	day be complicated depending upon individual adjustnents	Simple and Reliable	No serious maintenance problems problems	Complicated 1 1
e) nobility	Highly mobile	Restricted nobility	Highly mobile	Excellent with in the classroom	Nobility within a particular room
f) Affordability	Least expensive	!Less expensive than wireless. Fewer maintenance costs	Costs 2-3 times the price of an individual ! personal HA i	Very economical	

g) Other advantages		-Easy to use -Large controls -Immediate flexibi-Hty of modifying the system for other input sources such as TV, Video casettt recorder.etc. -Sturdier & capable of withstanding daily wear	-Portable -Battery operation -Can be used indoor or outdoors -Not dependent upon weather conditions -Easy installation --Consistent trans-mission -Overall speech is more intense with the addition of FH system to a BTE transducer !	-Easy to use -Can hear both environmental sounds and the teacher through MT setting	Unique ability to isolate the signal within the confines of the room
h) (Limitations)	-Classroom noise and reverberation have an effect on the fidelity of speech -Known to suffer an unacceptably high incidence of mal-function	-Limited by design -Optimal performance directly dependent upon the appropriate placement of the microphone - Complex combinations of equipment	-FCC has allocated freqs. in the 72-76MHz range. As the nutber of radio freq. commu-nications occupy-ing this band, increases, the potential for interference fro* other transaission in the same locale will increase. Operating two or more FN system transmitters on the same freq.in close proxisity to 1 each other will produce the same effect	-Signal strength within the loop varies. -Possibility of dead spaces -ftetal weakens the signals -Positioning within the loop is impor-tant. -Spill over -Limited freq. response -Only monophonic listening conditions	-Infra red light travel in the straight line. Any obstruction can affect the quality of received signal -A lot of energy is required to produce a sufficiently power-ful signal. -Limited use as portable system.

How to select an Amplification System?

Considerations for system selection:

Fourcin et al (1980) suggested the following:

(a) Possible future changes in the use of an area.

(b) The age of the children.

(c) The degree of hearing loss.

(d) The degree of mobility needed within the area.

(e) Relative merits and possible future development of hearing aid systems.

Freeman, Sinclairs and Riggs(1981) suggested three

general areas of selection criteria:

1. School factors; and
2. Equipment factors; and
3. Listener factors.

1. School Factors:- There are five school factors:

a) Identifying the acoustic environmental conditions of the classroom;

b) Identifying the educational needs of the school program;

c) Providing for in-service training;

d) Development of equipment monitoring programs and

e) Identifying the personnel involved in selection of auditory equipment.

2. Equipment factors:- The amplification equipment factors include:

a) Type of system required,

b) Service record of the manufacturer,

c) Ease of equipment operation,

d) Flexibility of the equipment, and

e) Budgetary considerations.

Listener factors-These include:

a) Coupling requirements of the unit to the child,

b) Frequency gain considerations,

c) Monaural versus binaural amplification,

d) Potential over-amplification and trauma to residual hearing and auditory discomfort and

e) Age of the listener.

Bess and Gravel (1981) said that the selection of an amplification arrangement must allow for consistency, comfort and reliability while providing enhanced message-to-competition ratios in all environments.

Design requirements of Group hearing aids:

a) Signal level and S/N ratio:

-System should provide a high input signal level (upto 80 or 90 dB SPL)

-High signal-to-noise ratio (30 dB or more) for the teacher's speech, student's own speech and classmate's speech.

b) Adaptability:

Each student should receive a signal that matches his own auditory characteristics in terms of threshold, discomfort level, frequency range, intrastimulus masking. The option must exist for independent adjustment of gain, SSPL, and frequency response.

c) Extraneous signals:

Especially in case of wireless systems, the system should exclude extraneous signals from other users of the air waves or from electrical equipment.

d) Simplicity and reliability:

The equipment should be simple to operate, easily monitored, seldom out of action, and speedily repaired.

e) Mobility- The equipment should not limit the movement of the teacher and students within or outside the classroom.

f) Affordability- Finally, the equipment should be affordable.

Suggestions: Keeping all these points in mind, FM system should be the ideal classroom amplification system. The only negative point is that it is expensive.

Considering the Indian conditions, we can go in for an Induction Loop Amplification System. Hendricks and Lederman (1991) have developed a three-dimensional induction assistive listening system. It gives excellent uniformity of the signal, regardless of orientation over the mat. Moreover, spill over can be minimized by cloverleaf arrangement (Borrild, 1964). Pearson (1968) has suggested superimposition of two rectangular form loop arrangements. The only disadvantage would be the restriction of mobility to within the classroom.

Other factors-

a) Teacher-to-child ratio:-

Ross (1972), Hieber (1975) and Sanders (1965) described an ideal classroom, which had the following features:-

-Noise level of 34 dB

-RT 0.5 Sec.

-24 X 32 feet, all windows were draped.

-Ceilings were covered with acoustic tile and most walls with cork.

-Room was arranged with portable dividers, bookcases and furniture so that there were few flat, hard surfaces facing each other.

-6-10 children in the room, with a teacher and an aide present at all times.

When they compared the ideal classroom to one having higher noise levels and longer RTS, they found the second classroom to be better than the ideal classroom. They concluded that the noise levels created by the children in a classroom can be so high that they reduce the effectiveness of a room considered to have "ideal" acoustical treatment for the control of ambient noise and shout RTs. The number of children should be less.

Finitzo (1988) found that the best classroom was a self-contained class for hearing impaired children. This class had five students and only one teacher.

b) Space guidelines for classrooms:

Abend et al (1979) indicated square foot guidelines for a structured learning environment in which the handicapped students are grouped for services.

Preschool and elementary: 70 sq.feet/student for 7 to 10 students. For each additional student upto twenty, 30 sq. feet/student should be added.

Secondary classrooms-70 sq.feet/student for 4 to 6 students. For each additional student upto twenty, add 35 sq. feet/student.

c) Seating arrangement:

Generally, a semicircular seating arrangement is recommended but **Erber (1974)** reported that such an arrangement required several children to lipread the teacher from an extreme horizontal angle, that is greater than 45, regardless of the direction in which the teacher faces.

d) Budget for maintenance and replacement:-

A sum of 10% of inflation corrected capital cost should be allocated annually for the maintenance of equipment.

A budget for the replacement of equipment over an agreed period of time e.g. 7 years should be estimated.

CONCLUSION

Now, that we are aware of the various factors which need to be considered while constructing a classroom, we realize that planning a classroom for the normal or the hearing impaired population is not an easy task. The hearing impairment makes it all the more difficult as the normal conditions or the environment are not favourable for such children.

Though all the factors mentioned need consideration for an ideal classroom, practically it may not be feasible. This may be due to the financial restrictions mainly. The only alternative we have is to lay less emphasis on some factors. At the same time, the essential factors like the acoustic environment should not be overlooked or compromised. We have to plan such that maximum factors can be considered, perhaps by compromising a single one. But that compromised factor should be chosen accordingly that it does not have such a drastic effect that it nullifies the effects of the other factors considered. For example, we can choose a reasonable amplification system but provide with a good acoustic environment and good illumination.

Hence, by planning at the right time, choosing the right people and the right factors, we can achieve more with the same budget and thus succeed in providing a favourable acoustic environment to the hearing impaired, thus progressing towards a better education and a better future.

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