Poor acoustical environment: an architectural barrier to people with hearing loss

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Architects and designers typically are not aware that the ability to understand speech develops over time in children, and schools may be built that meet the needs of normal hearing adults but are inadequate for children and individuals with hearing loss. In the United States and elsewhere, school buildings are used for regular school instruction during the day and for adult learning activities in the evenings. Thus, these facilities may be used by individuals with hearing loss where the acoustic environment poses challenges to speech perception and learning (see Figure 1).

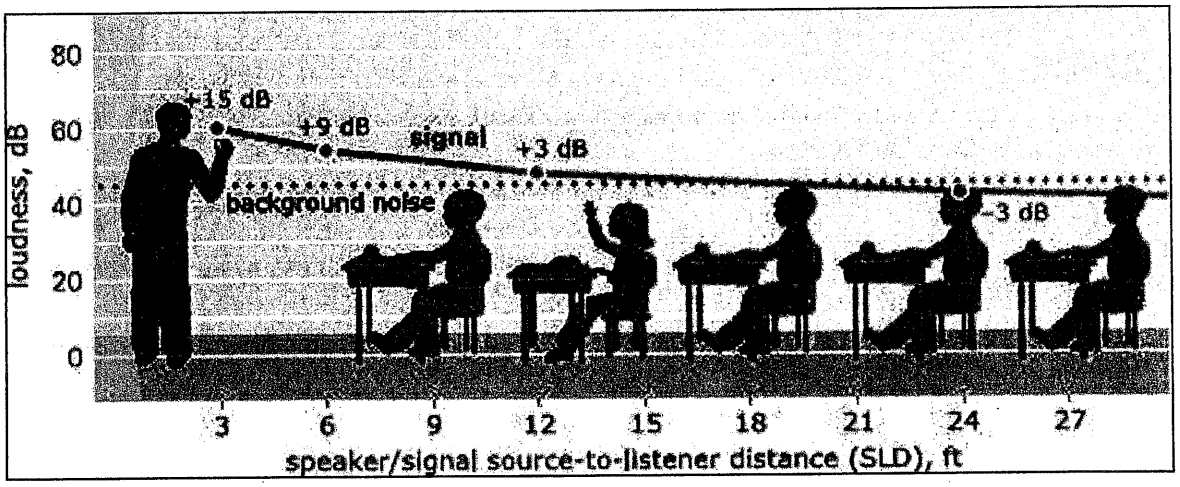

Figure 1: Speaker to listener signal-to-noise ratio

Noise in learning environments such as classrooms is unwanted sound usually caused by heating, ventilating, and air-conditioning equipment (HVAC), noise from outside the building leaking through windows and doors, and noise from adjacent rooms and hallways coming through walls and doors (see Figure 2). Reverberation is the persistence of sound after its source quiets and arises from sound reflecting from hard walls, floors, and ceilings (see Figure 3).

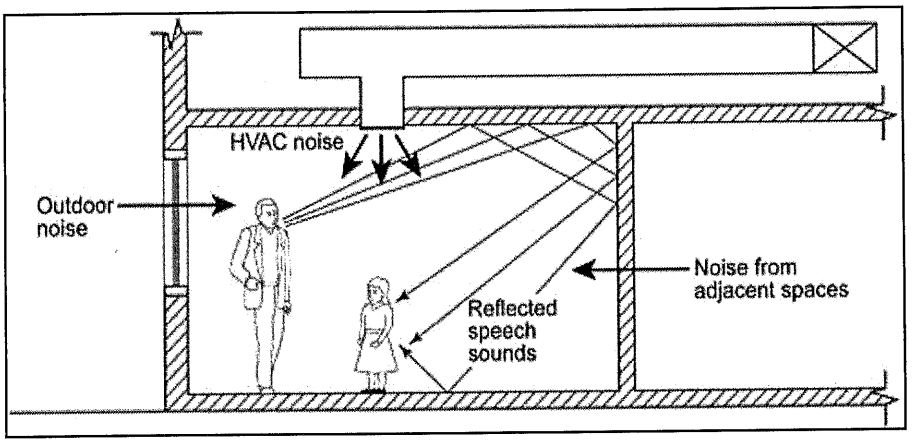

Figure 2: Classroom Noise Sources

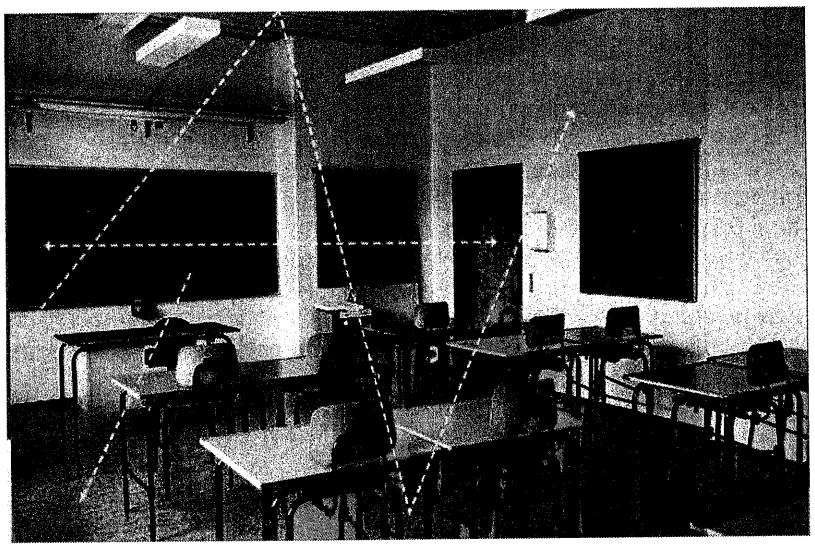

Figure 3: Classroom Reverberation

The American Speech-Language-Hearing Association (ASHA) has been actively involved for more than 15 years in the development of standards for school acoustics and in advocacy efforts designed to bring this issue to the attention of consumers and policy-makers.

Table 1 demonstrates the extensive engagement of ASHA with other organizations, governmental agencies and private organizations over the course of almost 20 years in an effort to achieve a policy adopted in the U.S. that assures an appropriate acoustic environment in classrooms throughout the country.

Table 1: Classroom Acoustics Standard Timeline

1994	Consortium of organizations, including ASHA, submits comments to U.S. Access Board on proposed Rulemaking for State and Local Government Facilities. Comments stressed that a poor acoustical environment is an architectural barrier to people with hearing and visual impairments.
1995	ASHA published "Guidelines and Position Statement for Acoustics in Educational Settings," which calls for background noise levels not to exceed 30 dB, reverberation times of 0.4 seconds or shorter, and an overall teacher speech-to-competition ratio of + 15 dB.
1996	Same consortium, with the addition of the Acoustical Society of America (ASA) and Educational Audiology Association (EAA), again submits comments to the U.S. Access Board on amendments to its ADA Accessibility Guidelines (ADAAG) and the Department of Justice's Standards (ADA standards) for Accessible Design to provide specifications for building elements designed for use by children.
1997	A parent of a child with hearing impairment writes a Petition for Rulemaking to the U.S. Access Board, expressing the same concern as the 1994 consortium of organizations and professionals. ANSI Accredited Standards Committee (ASC) S12 (Noise) establishes a new working group to draft classroom acoustics standards.
1998	A Request for Information (RFI) is published in the *Federal Register* (June 1) by the U.S. Access Board requesting information on acoustics in classrooms.
1999	Access Board publishes a Notice of Proposed Rulemaking to revise and update guidelines for new construction and alterations covered by the ADA and the Architectural Barriers Act (ABA) to harmonize with the International Code Council's International Building Code/American National Standards Institute (ANSI) A117.1
2001	ASC S12 votes on a draft of S12.60, which receives two negative votes, one of which was reversed. The second negative (by Air-Conditioning, Heating and Refrigeration Institute) is sustained and is the subject of appeals continuing through 2002-2003. The Access Board applies to the ICC to amend the International Building Code (2003 edition) to include portions of or reference to the standard (still in draft).
2002	Access Board publishes request in the *Federal Register* for public review of draft guidelines revising the ADA and ABA Accessibility Guidelines. ANSI approves ANSI S12.60-2002 *American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools* (June).
2006	In response to a Modular Building Institute (MBI) proposal, ASC S12 creates a new working group, Acoustical Performance Criteria for Relocatable Classrooms.
2007	ASC S12 votes on reaffirmation of ANSI S12.60-2002 with no proposed changes. Various parties raise objections. A plan is established to revise ANSI S12.60-2002 after the completion of the work regarding relocatable classrooms and other related projects.
2008	S12 approves a new working group, Revision of S12.60, which will not begin work until the relocatable project is substantially complete.
2009	ANSI approves the reaffirmation and re-designation of the standard, now designated ANSI/ASA S12.60-2002 (R 2009). Work begins (September) on the revision of ANSI/ASA S12.60-2002 (R 2009). The Access Board applies to the ICC (September) to amend the International Building Code to include references to the new editions of the classroom acoustics standards, both of which were in drafts at the time of the initial application. The ICC disapproves the application of the Access Board (November) because the documents are not available, and reschedules the application for May 2010. ANSI approves *ANSI/ASA S12.60-2009/Part 2, American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools—Part 2: Relocatable Classroom Factors* (December).

2010	ANSI approves *ANSI/ASA S12.60-2010/Part 1, American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools—Part 1: Permanent Schools* (May) The International Code Council upheld the prior disapproval of the application of the U.S. Access Board (May). The policy board of the U.S. Access Board votes unanimously in support of rulemaking to reference the new ANSI/ASA S12.60-2009/2010 in the ADA and ABA guidelines. A Notice of Proposed Rulemaking (NPRM) will be the next step towards an enforceable rule (July).

This presentation highlights the advocacy and educational efforts put forth by ASHA designed to achieve classroom acoustics standards applicable to building codes for new school buildings and for renovation of existing school buildings. This advocacy effort has been designed to improve the listening and learning environment in classrooms for both children and individuals with hearing loss.

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Perception of classroom acoustics and listening tests – a web-based survey

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INTRODUCTION

Poor listening conditions in classrooms impair speech comprehension, (Klatte et al. 2010) memory (Kjellberg et al. 2008; Ljung et al. 2009; Ljung & Kjellberg 2009) and increase annoyance and the mental effort needed to listen (Shield & Dockrell 2003). Listening conditions are determined by a number of factors but can mainly be attributed to room acoustic qualities, and the background sound determined by outdoor or indoor noise sources. In assessing listening conditions there are several indexes based on room acoustic measures, however, these require measurements on site and are hence expensive and time consuming to carry out. Furthermore a good rating alone may not sufficiently quantify a favorable communication according to Morimoto et al. (2004), that introduced the subjective rating of listening difficulty.

This study was carried out to see whether poor listening conditions could be assessed on a large scale using speech in sound tests, subjective ratings of the classroom acoustics and and/or the teachers' description of the physical room, all administered on the net. We also wanted to find out more on how the pupils experienced their sound environment and whether poor listening conditions could be predicted by their perception of the classroom acoustic and/or the teachers' description of the physical room.

METHOD

The instructions, questionnaires, and listening test were administered via the internet.

Listening tests

The pupils listened to sentences with low semantic redundancy (Hagerman 1982) in two signal-to-noise ratios, -3 dB and -6 dB and at two distances.

The choice of signal to noise ratios were selected on the basis of a pilot study carried out in two classes not taking part but of the same age group to get a response around 50 % of the psychometric response scale.

The sentences were played back though loudspeakers connected to a computer or MP3 player, using the schools own playback systems. The loudspeakers were placed at a position where the teacher usually stands when she/he teaches the class. The volume was chosen beforehand to give a comfortable listening level. Before the tests the students were given information and the opportunity to hear one set of the sentences without noise.

Four wave files each with 10 sentences were played back, two had a signal to noise ratio of -3, and two a signal to noise ratio of -6 dB. For the test, the class was divided